Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

UNPROTECTED/NON PROTÉGÉ

ORIGINAL/ORIGINAL

CMD: 16-M43

Date signed/Signé le : SEPTEMBER 02, 2016

Annual Program Report

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

Public Meeting

Scheduled for:

November 9 2016

Submitted by:

CNSC Staff

Rapport annuel sur les programmes

Rapport de surveillance réglementaire des installations de traitement nucléaire, des installations dotées d'un petit réacteur de recherche et des installations de catégorie IB dotées d'un accélérateur: 2015

Réunion publique

Prévue pour :

Le 9 novembre 2016

Soumise par :

Le personnel de la CCSN

e-Doc 4973151 (WORD)
e-Doc 5015366 (PDF)

Summary

This Commission Member Document (CMD) is on the *Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities: 2015* and is presented to the Commission.

There are no actions requested of the Commission. This CMD is for information only

The following document is attached:

- École Polytechnique (French version)

Résumé

Ce document à l’intention des commissaires porte sur le *Rapport de surveillance réglementaire des installations de traitement nucléaire, des installations dotées d’un petit réacteur de recherche et des installations d’accélérateurs de catégorie IB : 2015* et est présenté à la Commission.

Aucune mesure n’est requise de la Commission. Ce CMD est fourni à titre d’information seulement.

La pièce suivante est jointe :

- École Polytechnique (version française)

Signed/signé le

September 02, 2016

Haidy Tadros

Director General

Directorate of Nuclear Cycle and Facilities Regulation

Directrice générale de la

Direction de la réglementation du cycle et des installations nucléaires

This page was intentionally left blank.

TABLE OF CONTENTS

This page was intentionally left blank.

EXECUTIVE SUMMARY

The operating performance of uranium and nuclear substance processing facilities, small nuclear research reactors, and Class IB particle accelerator facilities regulated by the Canadian Nuclear Safety Commission (CNSC) is presented in this *Regulatory Oversight Report for Nuclear Processing, Small Research Reactor and Class IB Accelerator Facilities: 2015*. The information 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 the small nuclear research reactor facilities are included in the reporting cycle. In order 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 the uranium and nuclear substance processing facilities. Previously, the Class IB particle accelerator facilities were reported in the *Regulatory Oversight Report on the Use of Nuclear Substances in Canada.*

The 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. The 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 the 2015 calendar year, the performance in all 14 SCAs for the facilities was as follows:

- Uranium processing facilities was rated as "satisfactory" or better.
- Nuclear substance processing facilities was rated as "satisfactory" or better, with the exception of Best Theratronics, which received a "below expectations" rating in emergency management and fire protection.
- Small nuclear research reactor facilities was rated as "satisfactory" or better.
- Class IB particle accelerator facilities was rated as "satisfactory" or better, with the exception of Canadian Light Source, which received a "below expectations" rating in human performance management.

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

CNSC staff conclude that in 2015, each of the regulated facilities discussed in this report made adequate provision for the health and safety of workers, the protection of the public and the environment, as well as Canada's international obligations.

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's assessment of the safety performance of the following licensees:

- uranium processing facilities
    - Cameco Corporation (Cameco): Blind River Refinery (BRR) in Blind River, ON (FFOL-3632.00/2022)
    - Cameco Corporation (Cameco): Port Hope Conversion Facility (PHCF) in Port Hope, ON (FFOL-3631.00/2017)
    - Cameco Fuel Manufacturing Inc. (CFM) in Port Hope, ON (FFOL-3641.00/2022)
    - GE Hitachi Nuclear Energy Canada Inc. (GEH-C): Peterborough facility in Peterborough, ON (FFOL-3620.00/2020)
    - GE Hitachi Nuclear Energy Canada Inc. (GEH-C): Toronto facility in Toronto, ON (FFOL-3620.00/2020)
- nuclear substance processing facilities
    - SRB Technologies (Canada) Inc. (SRBT), in Pembroke, ON (NSPFOL-13.00/2022)
    - Nordion (Canada) Inc., in Ottawa, ON (NSPFOL-11A.00/2025)
    - Best Theratronics Limited (BTL), in Ottawa, ON (NSPFOL-14.01/2019)
- small nuclear research reactor facilities
    - McMaster Nuclear Reactor (MNR) at McMaster University in Hamilton, ON (NPROL-01.00/2024)
    - four Safe LOW Power Kritical Experiment (SLOWPOKE)-2 facilities located at:
        - University of Alberta (U of A) in Edmonton, AB (NPROL-18.00/2023)
        - Saskatchewan Research Council (SRC) in Saskatoon, SK (NPROL-19.00/2023)
        - Royal Military College of Canada (RMCC) in Kingston, ON (NPROL-20.00/2023)
        - École Polytechnique de Montréal (ÉPM) in Montréal, QC (PERFP-9A.01/2023)

- Subcritical Assembly at École Polytechnique de Montréal (ÉPM) in Montréal, QC (PERFP-9A.01/2023)

- Class IB particle accelerator facilities
  - TRIUMF Accelerators Inc. (TRIUMF) in Vancouver, BC (PAIOL-01.00/2022)
  - Canadian Light Source Inc. (CLS) 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 CNSC staff's regulatory focus-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. These three SCAs 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, small nuclear research reactors and Class IB particle accelerator facilities in order 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, 35 onsite inspections were conducted by the CNSC at uranium and nuclear substance processing facilities, small nuclear research reactors and Class IB particle accelerator facilities. 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 that:

- radiation protection measures are effective and radiation doses to workers remain as low as reasonably achievable (ALARA), taking into account social and economic factors
- the environmental protection programs are effective and releases remain ALARA
- conventional health and safety programs continue to protect workers from injuries/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 SCA is sub-divided into specific areas that define its key components. For a complete list of the SCAs and specific areas used in this report, see appendix A.

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

- FS: Fully satisfactory
- SA: Satisfactory
- BE: Below expectations
- UA: Unacceptable

A full definition of the four ratings is provided in appendix B, Rating Methodology and Definitions. 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 the 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 that resources are appropriately allocated, and controls are applied based on the complexity of the facility, the hazards and magnitude of the potential impact (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 that 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 that a licensee provides in their annual compliance reports.

The SCAs (radiation protection, environmental protection, and conventional health and safety) focused in this report 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 (LTIs).

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.

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, and 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 results are provided at the CNSC's IEMP webpage. The 2015 IEMP results indicate that the public and the environment in the vicinity of these facilities are protected and safe and that there are no adverse environmental and health effects as a result of site operations. These results are consistent with the results submitted by the licensee's, demonstrating that the licensee's environmental protection program protects the health and safety of people and the environment.

SECTION I: URANIUM PROCESSING FACILITIES

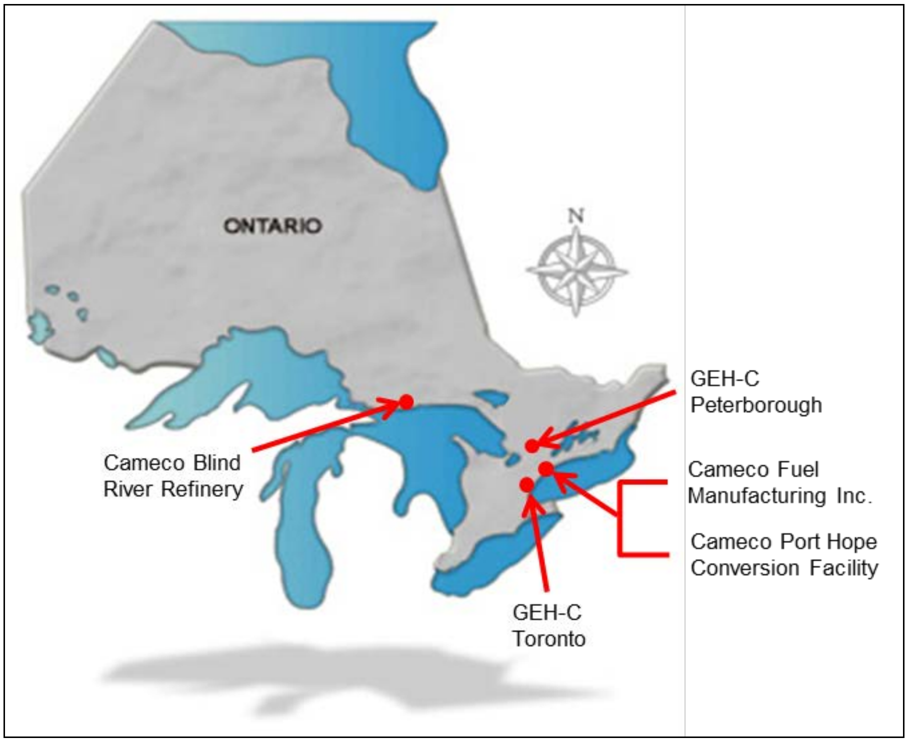
2 OVERVIEW

Part I of this report focuses on the five uranium processing facilities in Canada. They are:

- Cameco Corporation (Cameco): Blind River Refinery (BRR) in Blind River, ON
- Cameco Corporation (Cameco): Port Hope Conversion Facility (PHCF) in Port Hope, ON
- Cameco Fuel Manufacturing Inc. (CFM) in Port Hope, ON
- GE Hitachi Nuclear Energy Canada Incorporated (GEH-C): Peterborough Facility in Peterborough, ON
- GE Hitachi Nuclear Energy Canada Incorporated (GEH-C): Toronto Facility in Toronto, ON

The three Cameco facilities operate under separate operating licences, which were issued in March 2012. The BRR and CFM facilities licences expire in February 2022, and 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 and expiring 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 uranium processing facilities in 2015. Table 2-1 below presents the licensing and compliance effort from CNSC staff for uranium processing facilities during the reporting period.

Table 2-1: CNSC regulatory oversight licensing and compliance activities for uranium processing facilities in 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 licensee 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 of the uranium processing facility licensee is required, as 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 SCA, and details related to environmental, radiological and safety performance, including any events and associated corrective actions.

CNSC staff review these reports as part of its 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 SCA of conventional health and safety. Appendix C contains the SCA ratings from 2011 to 2015 for each facility.

Table 2-2: Uranium processing facilities-SCA performance ratings, 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 the facilities are listed in appendix D.

2.1 Radiation Protection

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

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”, which is unchanged from the previous year.

Uranium Processing Facilities-2015 ratings for radiation protection

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

Application of ALARA

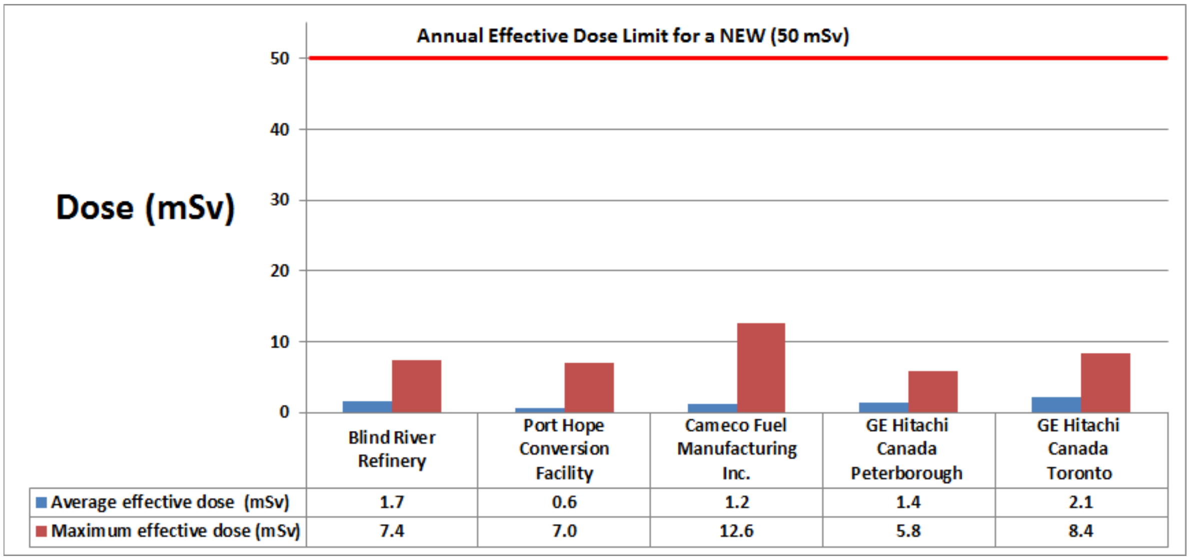
During 2015, all uranium processing facility licensees continued to implement RP measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be well below regulatory dose limits.

Worker Dose Control

The design of RP programs, including the dosimetry methods and the determination of workers who are identified as Nuclear Energy Workers (NEW), 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 RP 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 millisievert (mSv) to 12.6 mSv, which is well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 2-2: Uranium processing facility licensees-average and maximum effective doses to NEWs, 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 their RP program.

Radiation Protection Program Performance

CNSC staff conducted regulatory oversight activities in the area of RP at all uranium processing facilities during 2015, in order to verify compliance of the licensees' implementation of their RP programs with regulatory requirements. This regulatory oversight consisted of desktop reviews and RP-specific compliance verification activities including onsite inspections. Through these oversight activities, CNSC staff confirmed that all uranium processing facilities have effectively implemented their RP programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the uranium processing facility licensees' RP programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of their RP 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, to restore the effectiveness of the RP 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 RP program. Action levels which 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 their program performance and to prevent reoccurrence. In 2015, there were a total of four (4) 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 the 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 the 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 low and well below the regulatory annual public dose limit of 1 mSv in 2015.

Table 2-3: Uranium processing facilities-public dose comparison table (mSv), 2011-2015

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	

*Prior to 2012, GEH-C did not report public dose results. 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 the estimated annual public dose.

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

2.2 Environmental Protection

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

This SCA encompasses the following specific areas:

- Effluent and Emissions Control (releases)
- Environmental Management System (EMS)
- Assessment and Monitoring
- Protection of the Public
- Environmental Risk Assessment

The rating for the Environmental Protection SCA for all uranium processing facility licensees in 2015 was “satisfactory”.

Uranium Processing Facilities-2015 ratings for environmental protection

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

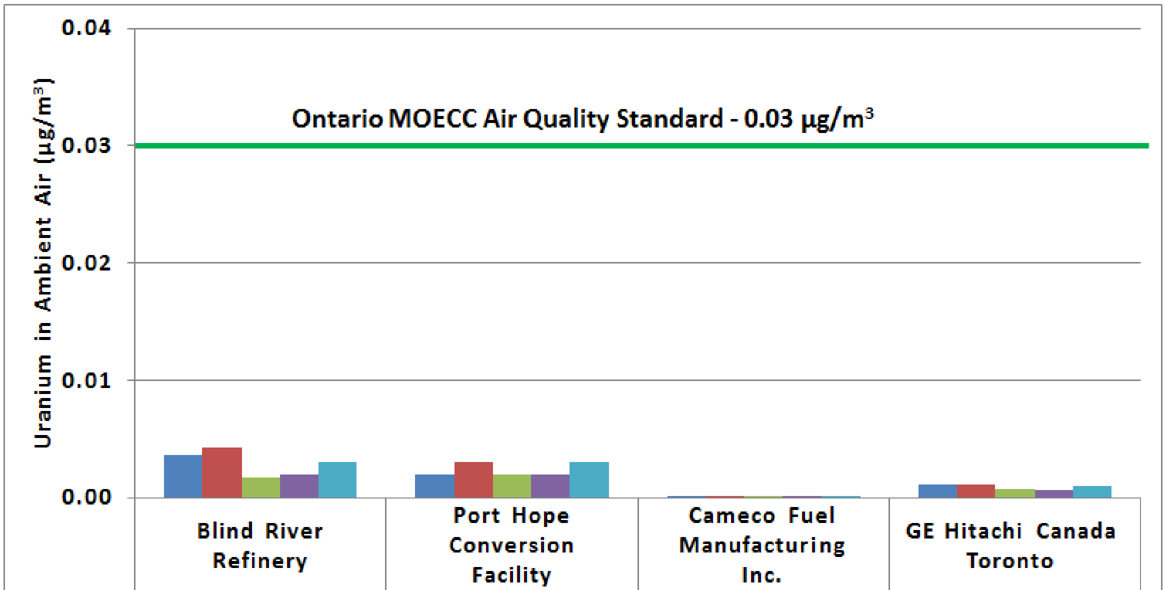
Uranium in Ambient Air

All the uranium processing facilities, except GEH-C Peterborough, operate "high-volume" air samplers at the perimeter of the 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 (TSP) 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), 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/m^3, previously reported as 0.0030 µg/m^3. This is a correction to the results reported in *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2014.*

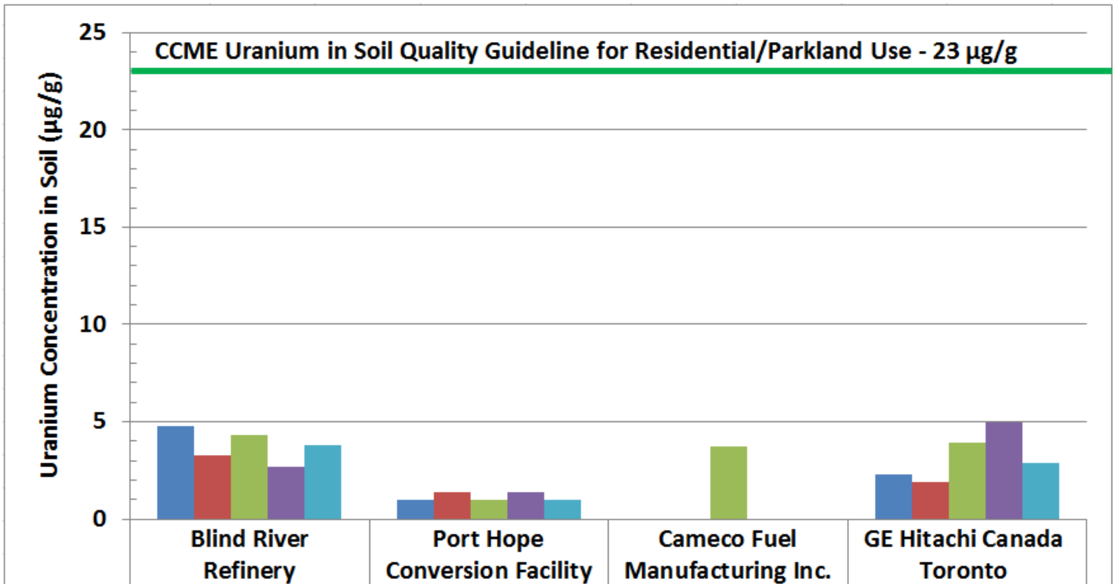
Uranium in Soil

The three Cameco facilities and GEH-C Toronto have soil monitoring programs. Uranium releases from GEH-C's 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 and as such, uranium-in-soil monitoring is not warranted at GEH-C's Peterborough facility.

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 land use of 23 µg/g of uranium.

Figure 2-4: Uranium concentration in soil (annual average), 2011-2015



	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 soil at CFM are due to 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 have been implementing their environmental 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

The “Conventional Health and Safety” SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

This SCA encompasses the following specific areas:

- Performance
- Practices
- Awareness

The 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 “fully satisfactory”. This is unchanged from the previous year.

Uranium Processing Facilities-2015 ratings for conventional health and safety

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 the Part II of the *Canada Labour Code.*

The regulation of conventional health and safety at uranium processing facilities involves both the Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with regulatory requirements. On rare occasions, 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: Fuel cycle facilities lost-time injuries (LTIs), 2011-2015

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 have been implementing 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 as per RD/GD-99.3*: Public Information and Disclosure*. These programs are supported by disclosure protocols, which outline the type of information on the facility and its activities that will be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. The objective is to ensure that 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.

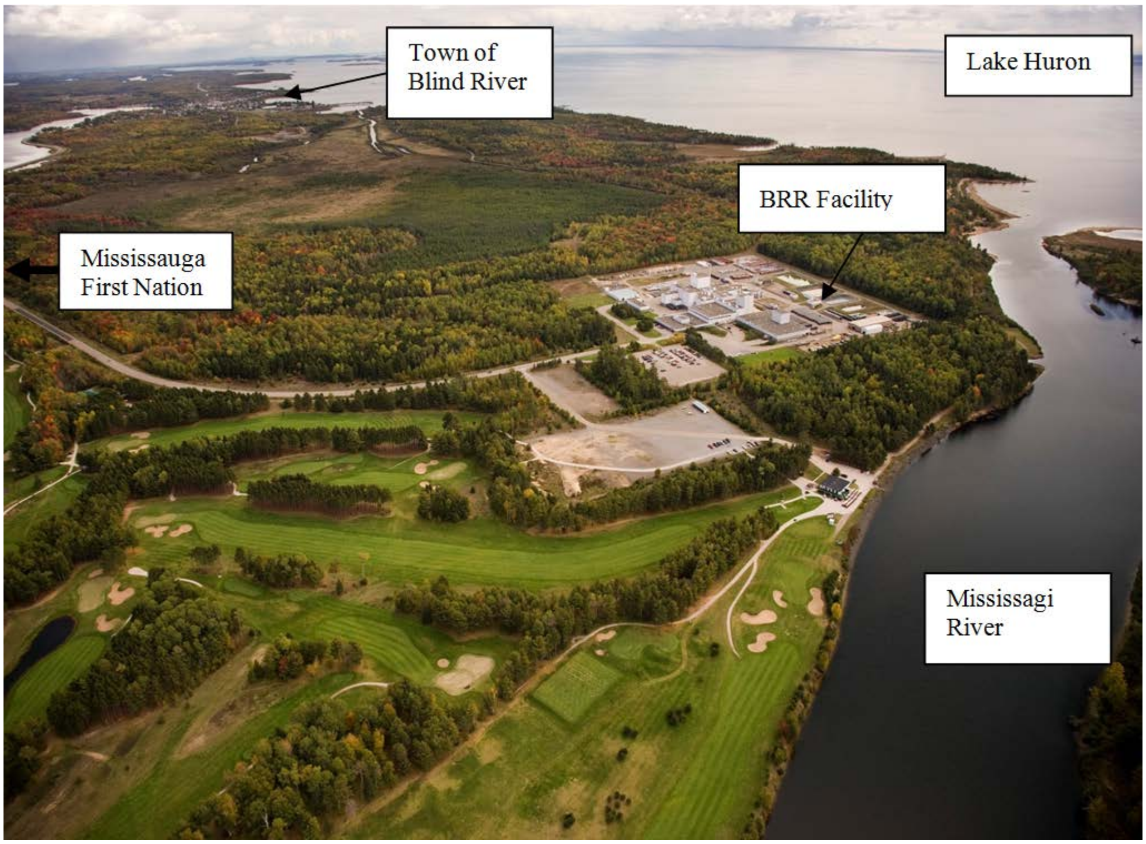
In 2015, CNSC staff evaluated licensees' implementation of the programs and determined that all licensees were in compliance with RD/GD-99.3 *Public Information and Disclosure*. They provided information on the status of their facilities through numerous activities. CNSC staff reviewed the communications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

The uranium processing facility licensees have been implementing 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 BRR facility is located about five kilometers west of Blind River, as shown in figure 3-1. The Mississauga First Nation 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, 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 NSCA and its regulations, its operating licence and the programs used to meet regulatory requirements. The inspections focused on the areas of management system, emergency management, waste management, radiation protection, environmental protection and conventional health and safety. 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 as per the Cameco BRR radiation protection program requirements. Details are provided in section 3.2 Radiation Protection, under Radiation Protection Program Performance.

On October 6, 2015, CNSC staff met with the Mississauga First Nation's (MFN) Lands and Resource Committee, staff and community elders. CNSC staff gave a presentation including information on BRR's operational performance for 2014 and the results of CNSC staff's 2013 and 2014 IEMPow the 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 in their community to discuss MFN's current air quality sampling program, capabilities for interpreting the results of their sampling program, MFN's concerns regarding sampling locations and changes to the Ontario Ambient Air Quality standard for uranium. Following the meeting, CNSC staff and MFN discussed ideas for future sampling campaigns that would include their 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 the Mississauga First Nation for the meetings summarized above.

3.2 Radiation Protection

Blind River Refinery-overall compliance ratings for radiation protection

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 RP objectives and targets at BRR with the goal to reduce worker doses and in-plant uranium-in-air concentrations, as examples. In addition, a separate ALARA committee is in place at BRR. This committee met regularly to review and discuss RP-related issues, and make recommendations for improving RP at BRR. 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

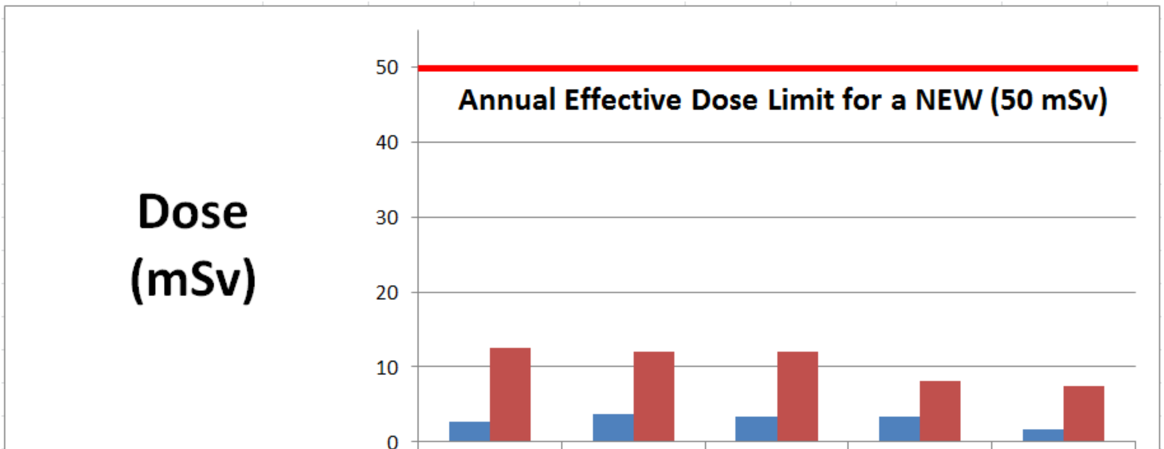
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker's radiation exposure reported by BRR exceeded the CNSC's regulatory dose limits.

Cameco ascertains external doses using whole body and extremity dosimetry. For internal radiological exposures, Cameco's Fuel Services Division (FSD) 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 of NEWs over the years 2011-2015 at BRR.

Figure 3-3: Blind River Refinery-effective doses of nuclear energy workers, 2011-2015



	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

During the years 2011-2015, average and maximum effective doses at BRR are relatively stable, 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 --7 and E-15, appendix E. In 2015, the maximum skin dose received by a NEW at BRR was 28.1 mSv, which is approximately 6 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 3 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. During the years 2011-2015, average and maximum equivalent doses at BRR were relatively stable, 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 <0.1 mSv, which is well below the annual regulatory dose limit of 1 mSv.

Radiation Protection Program Performance

CNSC staff assess RP program performance at BRR in 2015 through various CNSC 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 RP 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 RP program. In 2015, no radiological action levels were reached at BRR.

In 2015, there was one RP-related incident reported to the CNSC as per the Cameco BRR RP program requirements. In February 2015, four Cameco workers received uranium intakes while performing a work activity, due to deficiencies in work planning, communication and administrative controls, coupled with complacency towards the radiological hazards posed by uranium dust. The work was being 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 which contains 252 Nomex® filter bags. These filter bags collect the uranium concentrate dust from the area dust collection system, filtering the dust and allowing the 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 eleven workers involved in performing the baghouse filter change-out received uranium intakes, necessitating dose assessments and the placing of the workers on restricted status temporarily. 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, and other improvements to work practices and procedures. In March 2016, CNSC staff performed an RP-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 which improved the RP of workers during the conduct of similar work activities.

Radiological Hazard Control

Radiation and contamination control programs are established at BRR as 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, 2011-2015

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

Blind River Refinery-overall compliance ratings for environmental protection

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 the 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)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 (NOx) and particulates released from the facility 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: Blind River Refinery-air emissions monitoring results (annual averages), 2011-2015

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 as "<".

Liquid Effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, storm water runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to 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: Blind River Refinery-liquid effluent monitoring results (annual averages), 2011-2015

Parameter	2011	2012	2013	2014	2015	Licence Limit
Uranium (mg/l)	0.02	0.01	0.01	0.02	0.02	**20**
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	**Min 6.0**
pH (Max)	8.2	8.2	8.4	8.4	8.4	**Max 9.5**

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

Environmental Management System (EMS)

Cameco has developed and maintains an EMS which provides a framework for integrated activities with respect to the protection of the environment at the BRR facility. BRR's EMS is described in its Environmental Management Program Manual; it 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 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 that 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. The program also provides data for estimates of annual radiological dose to the public to make sure that the public dose attributable to the Cameco's BRR operations is well below the annual regulatory dose limit of 1 mSv and ALARA. The principal monitoring activities, as described in the following paragraphs, 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 facility continue to be consistently low. In 2015, the highest annual average concentration (amongst 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

Currently, a total of 43 monitoring wells exist in and around the BRR (17 wells located inside the perimeter fence and 26 wells located 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 have an increasing trend. 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 the Guidelines for Canadian Drinking Water Quality although the groundwater in the area is not used for drinking water. The maximum individual result from the rest of the monitoring wells was 4.4 µg/L. Further, the average uranium result from all other monitoring wells at BRR was 0.6 µg/L, the same as in 2014, if BH #22 is removed from the calculation.

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 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 their 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 to monitor uranium concentrations in an upper (15 cm) layer of surface soil to demonstrate that there are no long-term effects of air emissions since there is no accumulation of uranium in soil in the vicinity of 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 uranium (i.e., residential and parkland land use). Essentially, uranium soil concentrations do not appear to increase in the area surrounding the facility. This confirms 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 Blind River attributable to the 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 golf course (critical receptor location) to ensure that 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 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 that 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 CNSC's Independent IEMP. The results are provided at the CNSC's IEMP webpage. Results obtained by the CNSC confirm that the public and the environment in the vicinity of BRR are protected from the releases from the facility.

Protection of the Public

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

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 CNSC staff reviews of the programs at BRR, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental Risk Assessment

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

Blind River Refinery-overall compliance ratings for conventional health and safety

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 confirm 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 resulted in the ability to keep its workers safe from occupational injuries; no lost-time injuries (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. As per table 3-4, the number of LTIs remains zero in 2015. BRR has not had an LTI in the past nine years.

Table 3-4: Blind River Refinery-lost-time injuries (LTIs), 2011-2015

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

Practices

In addition to the NSCA and its associated regulations, Cameco's activities and operations are required to comply 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 (FHSC) that inspects the workplace and meets monthly to resolve and track any safety issues. CNSC staff frequently review the FHSC monthly 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 at the site. 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 PHCF under an operating licence that expires on February 28, 2017. PHCF is located in the municipality of Port Hope, ON; it is situated on the north shore of Lake Ontario, approximately 100 kilometers east of Toronto. An aerial photograph of the site is shown in figure 4-1.

Figure 4-1: Port Hope Conversion Facility Site 1 (looking north)

PHCF primarily converts UO_3 powder produced by Cameco's BRR 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, howeve, 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 PHCF operating licence 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, PHCF made no significant changes to the processes it uses to ensure that the physical design of the 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. In addition, over the summer, PHCF started its 2015 clean-up project 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, in 2015, PHCF experienced a number of events or incidents that were reported to CNSC staff:

- In May 2015, PHCF staff recognized that a small spool section feeding potassium hydroxide (KOH) 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, dry 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 wastewater 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 (i.e., for a skin dose and for a routine uranium in urine pre-shift sample). These two action level exceedances are described in more detail in section 4.2 Radiation Protection, under Radiation Protection Program Performance.

In addition to these reportable events or incidents, Cameco notifies CNSC staff of the regulatory reports it makes to Environment and Climate Change Canada (ECCC), the 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 which will be carried out during the next licensing period.

In 2015, CNSC staff conducted five planned compliance inspections to verify PHCF's compliance with the NSCA and its regulations, its operating licence, and the programs used to meet regulatory requirements. These planned onsite inspections focused on the areas of waste management, environmental protection, training, and there was a dedicated onsite inspection to follow up on the corrective actions associated with the events that occurred in 2014. Furthermore, in 2015, 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 to the environment.

4.2 Radiation Protection

Port Hope Conversion Facility-overall compliance ratings for radiation protection

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the "Radiation Protection" SCA at Cameco's 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 RP measures at PHCF in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Annually, RP objectives and ALARA targets are established. These objectives and targets include worker dose reduction initiatives and other projects which examine ways to reduce in-plant uranium-in-air concentrations. In 2015, Cameco achieved the majority of their ALARA targets at PHCF, focused on radiation doses to workers, and achieved a high compliance rate for bioassay submissions by workers.

Worker Dose Control

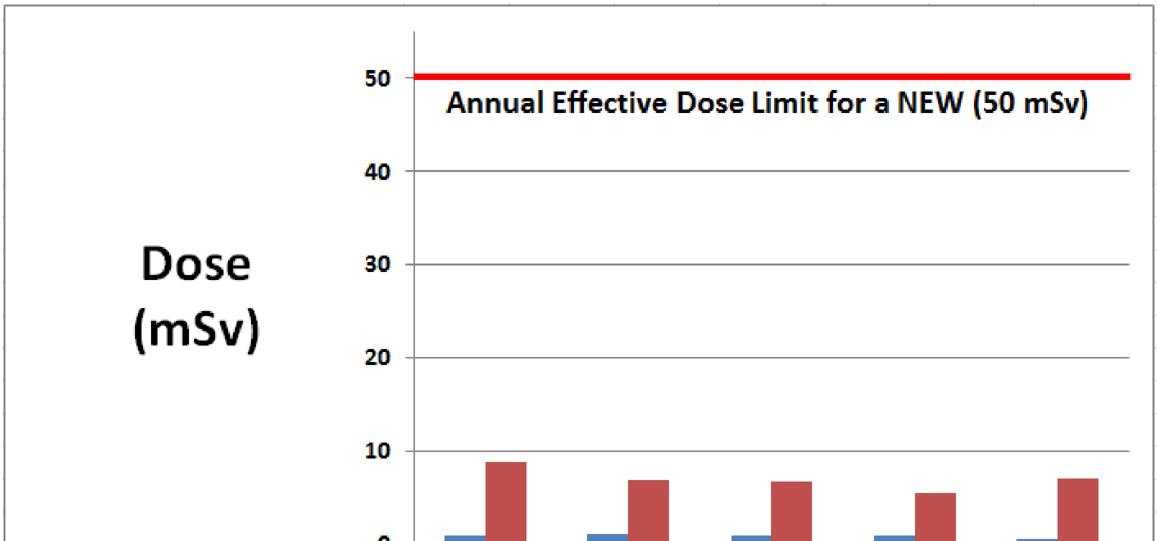
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at PHCF, reported by Cameco, were well below the CNSC's regulatory dose limits.

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 which 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 2011-2015, 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 of NEWs over the years 2011-2015 at Cameco's PHCF.

Figure 4-2: Port Hope Conversion Facility-effective doses of nuclear energy workers, 2011-2015



	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 over the years 2011 to 2014 have 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 2011-2013 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).

During the years 2011-2015, average and maximum effective doses at PHCF were relatively stable.

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 5 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. During the years 2011-2015, the maximum annual equivalent (skin) dose received by a NEW was 181.4 mSv in 2011, as a result of an 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 <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

RP program performance at PHCF 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 acceptable.

Action levels for radiological exposures are established as part of the Cameco PHCF RP 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 RP 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 which was at the 65 microgram uranium/litre (µg U/L) action level for uranium in urine. 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. Cameco completed an investigation, and it is suspected that the worker's respirator seal was compromised or that the worker removed the respirator too soon after completing work such that the respirator was not effective 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 workers onsite outlining the proper methods for removing (doffing) PPE. Cameco has a number of initiatives which are expected to improve protection of workers in the UF_6 plant, including a review of PPE requirements for operators working in the UF_6 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, but 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 RP 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 at PHCF 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 2011 to 2015 maximum effective doses to a member of the public are shown in table 4-1. Doses to the public are well below the PHCF Operating Release Level (ORL) of 0.3 mSv/year. The CNSC regulatory dose limit for a member of the public is 1 mSv/year.

Table 4-1: Port Hope Conversion Facility-maximum effective dose to a member of the public, 2011-2015

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

Port Hope Conversion Facility-overall compliance ratings for environmental protection

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 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)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 the facility. 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: Port Hope Conversion Facility-air emissions monitoring results (annual averages), 2011-2015

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 PHCF. 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, acceptable, and concluded that the licence requirement not to discharge process waste water effluent has been met.

Environmental Management System (EMS)

Cameco has developed and is maintaining an EMS which provides a framework for integrated activities with respect to the protection of the environment at the 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 that 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. The program also provides data for estimates of annual radiological dose to the public to make sure that the public dose attributable to the Cameco's PHCF operations is below the annual regulatory dose limit of 1 mSv and ALARA. The principal monitoring activities, as described in the following paragraphs, 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 samplers 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) that were captured in the pump-and-treat wells and removed before they reached the harbor 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 changes as 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 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 land use of and 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. These samples are analyzed for fluoride content. The results in 2015 continued to be well below the MOECC’s Upper Limit of Normal guideline of 35 parts per million (ppm). 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 the PHCF operations is due to gamma radiation sources. Therefore, it is essential to monitor gamma radiation effective dose rates at the fencelines of the PHCF main site and the Dorset Street site to ensure that 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 PHCF main site was 0.007 µSv/h in 2015. The ORL for the PHCF 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 Independent IEMP. The results are provided at the CNSC’s IEMP webpage. Results obtained by the CNSC confirm 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, the licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the facility. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

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 CNSC staff reviews of the programs at the PHCF, CNSC staff conclude 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 standard N288.6-12. The ERA conclusions and recommendations, as well as guidance outlined in CSA standard N288.4-10 *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* and CSA standard 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

Port Hope Conversion Facility-overall compliance ratings for conventional health and safety

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 confirm 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 conventional health and safety SCA is the number of LTI 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 (LTIs) at PHCF, 2011-2015

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

Practices

In addition to the NSCA and its associated regulations, Cameco's activities and operations at the PHCF site must comply with Part II of the *Canada Labour Code*.

Conventional health and safety efforts at PHCF are supported by the Conversion Safety Steering Committee (CSSC), 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 the PHCF site.

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

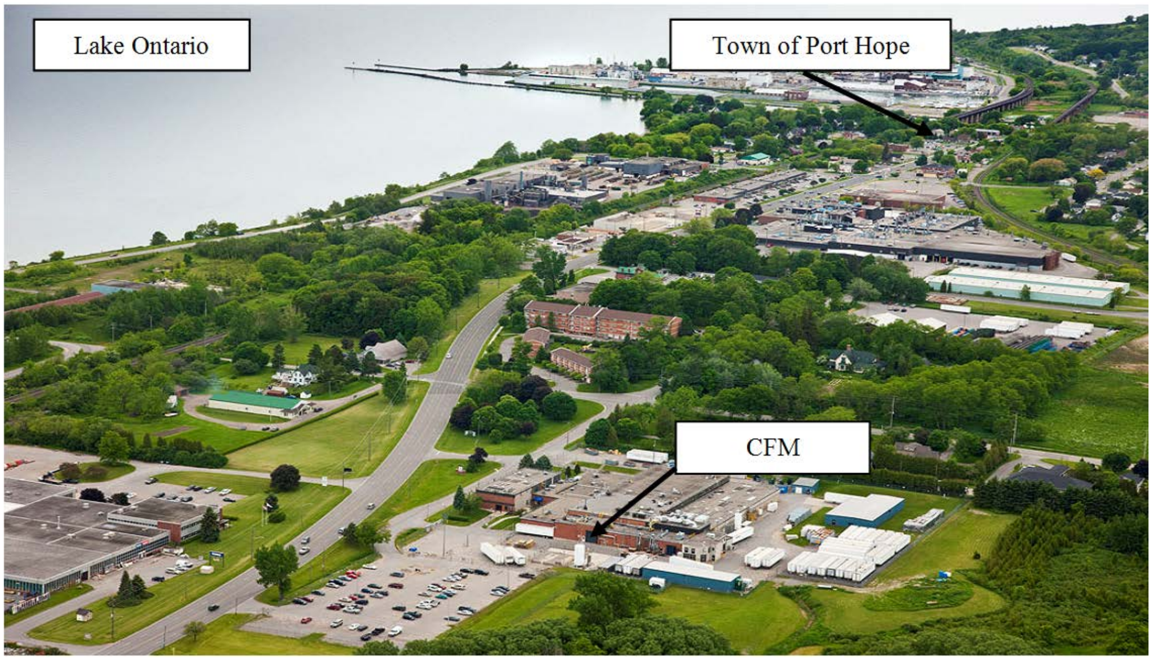
Awareness

Cameco continues to develop and maintain a comprehensive Occupational Health and Safety Management Program for the PHCF site. During 2015, Cameco advanced several initiatives to improve occupational health and safety at the site. 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, and 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 Cameco Fuel Manufacturing in Port Hope, ON



The CFM facility is located in Port Hope, ON, and 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 shutdown 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 commissioning of the new powder receiving and powder 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 Radiation Protection, under Radiation Protection Program Performance.

In 2015, CNSC staff conducted three onsite inspections to verify Cameco's compliance with the NSCA and its regulations, its operating licence and the programs used to meet regulatory requirements. The 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

Cameco Fuel Manufacturing Inc.-overall compliance ratings for radiation protection

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

Annually, Cameco establishes ALARA initiatives and dose targets at CFM. 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, with a main goal 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 uranium for whole body, skin, and extremity doses.

Worker Dose Control

Radiation exposures are monitored to ensure compliance with CNSC's 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.

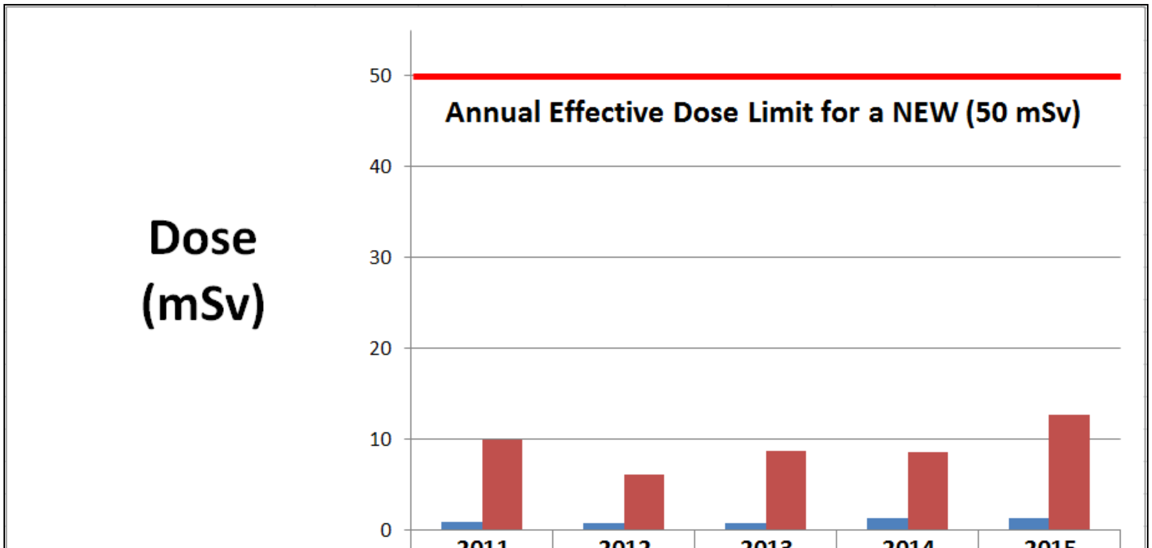
Cameco ascertains external doses using whole body and extremity dosimetry at CFM. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence which authorizes Cameco to provide in-house internal dosimetry services at CFM. Internal dose is assessed and assigned 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 2011-2015, 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 of NEWs over the years 2011-2015 at CFM.

Figure 5-2: Cameco Fuel Manufacturing Inc.-effective doses of nuclear energy workers, 2011-2015



	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 the 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; discussed in detail under the specific area Radiation Protection Program Performance.

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, which is approximately 17 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. During 2011-2015, average and maximum equivalent doses to workers have been relatively stable.

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

RP program performance 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 RP 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 RP 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, which exceeded 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 and therefore, the dose reported was not representative of the dose to the worker's extremity. As such, 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, which exceeded the CFM internal dose action level of 0.8 mSv/quarter. As a result, the worker was removed from further work in production areas in order to prevent additional exposure while an investigation was conducted. Cameco's investigation identified a number of potential causes of the intake; however, it is suspected that a likely cause 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 corrective action implementation. Based on the findings of the onsite 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 CNSC staff's inspection report and have committed to implement 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. It is noted that 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: Cameco Fuel Manufacturing-maximum effective dose to a member of the public, 2011-2015

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

Cameco Fuel Manufacturing Inc.-Overall compliance ratings for environmental protection

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)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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: Cameco Fuel Manufacturing Inc.-air emissions monitoring results, 2011-2015

Parameter	2011	2012	2013	2014	2015	Licence Limits
Total uranium discharge through stacks (kg/year)	0.02	0.02	0.03	0.01	0.01	**14**
Total uranium discharge through building exhaust ventilation (kg/year)	0.57	0.57	0.48	0.40	0.45	

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: Cameco Fuel Manufacturing Inc.-liquid effluent monitoring results, 2011-2015

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 (EMS)

Cameco has developed and maintains an EMS which provides a framework for integrated activities with respect to the protection of the environment at CFM as per CNSC regulatory requirements. 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 that 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. The program also provides data for estimates of annual radiological dose to the public to make sure that the public dose attributable to the CFM operations is below the annual regulatory dose limit of 1 mSv and ALARA. The principal monitoring activities, as described in the following paragraphs, 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 (amongst 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 has a network of 75 groundwater monitoring wells located onsite (59) and offsite (16) within the immediate area of the CFM facility. These wells are screened within the overburden (soil) and some are within the underlying bedrock. The monitoring wells have a dual purpose. Their primary purpose is to investigate the extent of historical uranium in groundwater on the licensed property. They also serve 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

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

Uranium concentrations in all surface water samples collected in 2015 met the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic Life 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 guidelines for uranium of 15 µg/L.

CNSC staff will continue to oversee Cameco's monitoring at locations around 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 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 round is scheduled for 2016. Soil sampling results are provided in table F-8, Appendix F.

Gamma Monitoring

A significant portion of 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 that 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 (DRL) for the CFM main site sets a licensed limit for fenceline gamma dose rates of 0.35 µSv/h at the critical receptor located at station 1 (fenceline on west side of site). These measurements indicate that gamma dose rates are effectively 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 are provided at the CNSC's IEMP webpage. Results obtained by the CNSC confirm 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, the licensee shall demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to hazardous substances released from the facility. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

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

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

Environmental Risk Assessment

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

Cameco Fuel Manufacturing Inc.-overall compliance ratings for conventional health and safety

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 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 LTI occurring in 2015. A description of the 2015 LTI is provided in table G-2, appendix G.

Table 5-4: Lost-time injuries (LTIs) at Cameco Fuel Manufacturing 2011-2015

	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 (E/OH&S) program that is consistent with Cameco's corporate policy and is modeled on the Occupational Health and Safety Assessment Series (OHSAS) 18001 standard.

Cameco maintains a Joint Health and Safety Committee (JH&SC) at CFM. The committee investigates all safety-related incidents in the facility including not only events which 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. The JH&SC 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 like safety meeting attendance, percentage of monthly safety inspections completed, performance of the JH&SC 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. (GEH-C)

GE Hitachi Nuclear Energy Canada Inc. (GEH-C) operates two Class IB nuclear facilities to manufacture nuclear reactor fuel bundles for use at Ontario Power Generation's (OPG) Pickering and Darlington Nuclear Power stations under one licence (FFOL-3620.00/2020). One site in Toronto produces uranium dioxide fuel pellets and the other site in Peterborough manufactures the fuel bundles using the fuel pellets from Toronto and 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.

The primary hazard at these facilities is the inhalation of airborne UO_2 particles apart from conventional industrial hazards. 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 as 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 (LCH) to incorporate written notification requirements which aligns the facility's regulatory oversight with 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 that has been accepted by CNSC staff. The revised LCH, incorporating 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 for transfer of the current licence due to the sale of GEH-C to BWXT Nuclear Energy Canada Inc. (BWXT). CNSC staff are in the process of evaluating this request with a recommendation to the Commission on this issue expected by the end of 2016.

6.1 Performance

For 2015, CNSC staff rate 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 & CEO and subsequently of 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 of Senior Manager-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 presence during community outreach events in 2016. For 2015, CNSC staff assess 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 a total of 19 internal audits to ensure compliance and conduct of operations in a safe manner.

In 2015, improvements to plant equipment and processes included upgrades to the loading dock in the Peterborough facility, and natural gas supply upgrades including heater 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 wherein a sprinkler water pipe burst resulting in dousing of certain sections of the warehouse with water at the Toronto facility. No nuclear material was involved. GEH-C conducted a root-cause analysis of the event and determined ice buildup due to unusually cold weather resulted in the pipe's fracture. GEH-C has implemented several corrective actions associated with this event that was reviewed and accepted by staff.

In October 2015, GEH-C reported an event wherein 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 subsequently seven corrective actions were put in place to address this event which 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 Toronto facility for the years 2013, 2014 and 2015 due to a correction of software error based on CNSC staff findings from 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 were reported for 2015.

In 2015, CNSC staff conducted four inspections to verify GEH-C's compliance with the NSCA and its regulations, its operating licence and the programs used to meet regulatory requirements. The inspections focused on conventional health and safety, environmental protection, 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

GE Hitachi Nuclear Energy Canada-overall compliance ratings for radiation protection

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 RP measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Annually, GEH-C establishes RP program goals and initiatives, and GEH-C's ALARA Committee meets quarterly at a minimum to discuss dose and internal audit results as well as employee RP-related concerns. 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 achieving over 95 percent compliance with respect to surface contamination swipes below the internal control levels in Peterborough.

Worker Dose Control

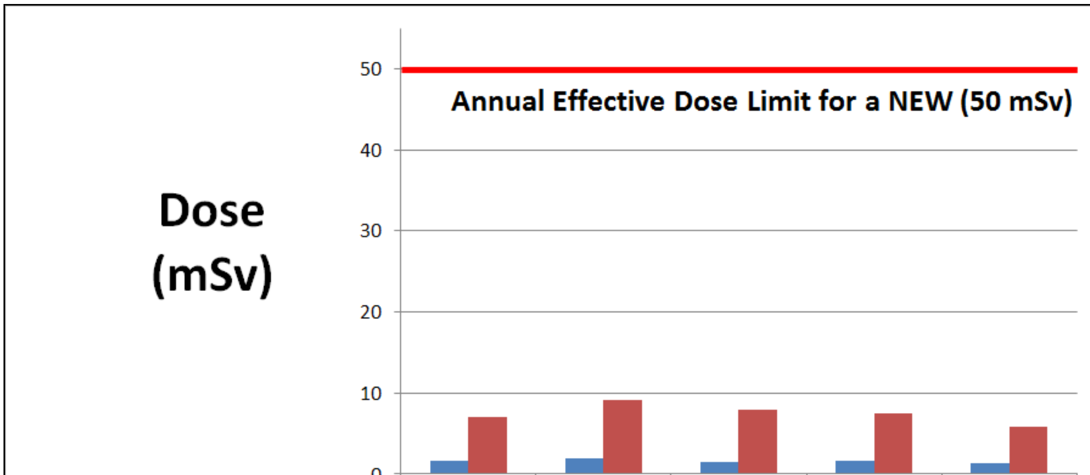
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker's radiation exposure reported by GEH-C exceeded the CNSC regulatory dose limits.

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 compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA.

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.

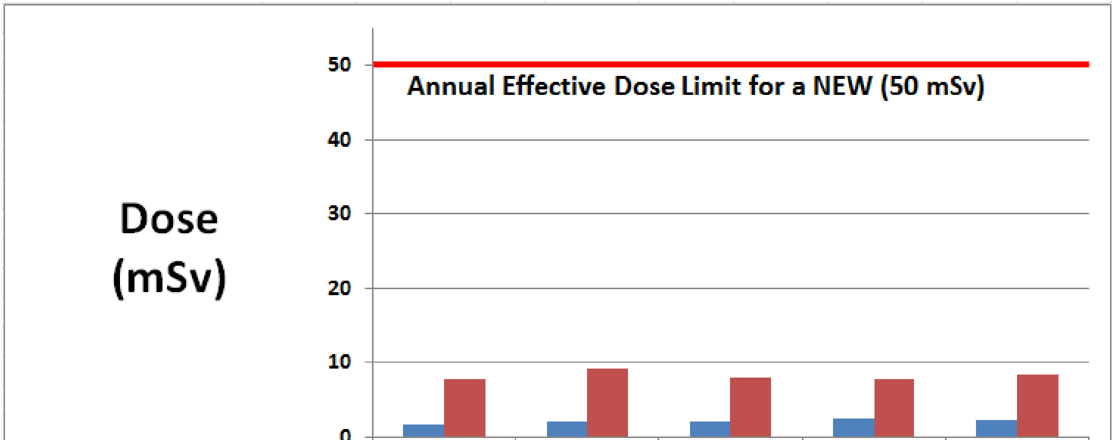
Figure 6-3: GEH-C Peterborough-effective doses of nuclear energy workers, 2011-2015



	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: GEH-C Toronto-effective doses of nuclear energy workers, 2011-2015



	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 that 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 2011-2015 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 2011-2015 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 (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, as opposed to the Toronto facility, where this practice is considered routine. At the Peterborough facility, except in the end cap welding station, all pellets are shielded in zirconium tubes, bundles or boxes.

Radiation Protection Program Performance

Action levels for radiological exposures, urinalysis results and contamination control are established as part of the GEH-C RP 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 RP program. In 2015, there were no action level exceedances at GEH-C.

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 monitoring results in 2015.

Estimated Dose to the Public

The 2011-2015 maximum effective doses to a member of the public are shown in table 6-1. The doses are for the Toronto facility. 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: GEH-C Toronto-maximum effective dose to a member of the public, 2011-2015

Maximum Effective Dose to a Member of the Public-Toronto						
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 *Atmospheric Emissions*.
* 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

GE Hitachi Nuclear Energy Canada-overall compliance ratings for environmental protection

2011	2012	2013	2014	2015
FS	FS	FS	FS	SA
For 2015, CNSC staff rate the environmental protection SCA at the GEH-C facilities as "satisfactory". 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 as per regulatory requirements. Additional details related to the change in ratings are provided below in the "Atmospheric Emissions" section. All Uranium and hazardous substance releases from GEH-C facilities to the environment continue 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)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 are 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 environmental protection focused inspection 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 the 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 as 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 the GEH-C 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 (EMS)

GEH-C staff developed and are maintaining an EMS which provides a framework for integrated activities with respect to the protection of the environment at the GEH-C facility. GEH-C's EMS is described in its Environmental Management Program Manual. GEH-C's 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 compliance verification activities, CNSC staff review the safety meeting minutes and follows up on any outstanding issues with GEH-C staff. The results of this review demonstrate that GEH-C is conducting an annual management review as per CNSC requirements and that identified issues are being addressed.

Assessment and Monitoring

GEH-C's environmental monitoring program serves to demonstrate that the site emissions of nuclear and hazardous materials are properly controlled. The program also provides data for estimates of annual radiological dose to the public to make sure that the public dose attributable to GEH-C's Toronto and Peterborough operations are well below the annual regulatory dose limit of 1 mSv and ALARA. The principal monitoring activities, as described in the following paragraphs, are focused on monitoring the air and soil at GEH-C Toronto and gamma radiation around both 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 (amongst 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 program. In 2015, samples were taken from 49 locations and analyzed for uranium content. The samples were collected on the GEH-C site, on commercial property located along the south border of the site, and in the nearby residential neighborhood. In 2015, the average soil concentration of uranium for residential locations was 0.7 µg/g while the maximum concentration of uranium in soil for 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 uranium of 23 µg/g (i.e., residential and parkland land use). 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. Therefore, it is essential to monitor gamma radiation effective dose rates at the fencelines of the GEH-C Toronto site to ensure that 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 under 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 that the public is protected.

For GEH-C Peterborough, environmental dosimeters were put in place at the Peterborough 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 facilities under the CNSC's IEMP. The results are provided at the CNSC's IEMP webpage. Results obtained by the CNSC confirm 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, the licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the facility. CNSC licensees are required to ensure that adequate provision is made for protecting the health and safety of the public. The effluent and environmental monitoring programs currently conducted by the licensee are used to verify that releases of hazardous substances do not result in environmental concentrations that may affect public health.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the GEH-C licence and LCH. 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 CNSC staff reviews of the programs at the GEH-C Toronto and Peterborough facilities, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental Risk Assessment

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

6.4 Conventional Health and Safety

GE Hitachi Nuclear Energy Canada-overall compliance ratings for conventional health and safety

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 at GEH-C confirm that GEH-C continues to view conventional health and safety as an important consideration.				

Performance

GEH-C's conventional health and safety program incorporates various elements including training, contractor safety, fall protection, electrical safety, hot work, cranes and hoists, chemical management and others aspects. GEH-C staff conducts 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 the Toronto and Peterborough facilities for 2011 through 2015.

Table 6-2: Lost-time injuries (LTIs) for GEH-C-Toronto

	2011	2012	2013	2014	2015
Lost-Time Injuries	0	1	0	1	0

Table 6-3: Lost-time injuries (LTIs) for GEH-C-Peterborough

	2011	2012	2013	2014	2015
Lost-Time Injuries	0	0	0	0	0

Practices

GEH-C's program practices in this reporting period is in transition to GE's new environment health and safety framework (Framework 2.0) which covers all aspects of worker safety and environmental protection elements including leadership and accountability, regulatory applicability, Environment, Health and Safety (EHS) 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 which include the Health and Safety Policy Committee, the Workplace Safety Committee (WSC) and the Ergonomics Committee.

Awareness

In 2015, GEH-C conducted a total of 31 WSC inspections and investigations at its Toronto facility and a total of 66 WSC inspections and investigations at its Peterborough facility. Such assessments help to ensure compliance and continuous improvement of its conventional health and safety program. Performance metrics are regularly reviewed by management for each facility and these are summarized in the licensee's annual report. The top 5 finding categories from the WSC inspections at the Peterborough facility were equipment safety, emergency response/preparedness, housekeeping, documents and fall protection. The top 5 finding categories from the WSC inspections at the Toronto facility were housekeeping, personal protective equipment, facilities, emergency 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

Part II of this report deals with three nuclear substance processing facilities located in Ontario. They are:

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

The operating licences for both SRBT and Nordion were renewed by the Commission following public hearings held in 2015. The Commission issued SRBT a licence in July 2015 that expires in June 2022. The Commission issued Nordion a licence in November 2015 that expires in October 2025.

The Commission issued BTL a Class IB licence in July 2014 after a Commission hearing held on May 2014. BTL manufactures medical equipment including cobalt-60 (Co-60) radiation therapy units, as well as cesium-137 (Cs-137) blood irradiators under this licence. 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 nuclear substance processing facilities in 2015. Table 7-1 presents the licensing and compliance effort from CNSC staff for nuclear substance processing facilities during 2015.

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

For 2015, CNSC staff performed two onsite inspections at SRBT, four onsite inspections at Nordion, and three onsite inspections at BTL. 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. The reports 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.

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

- SRBT's performance in fitness for service and conventional health and safety was rated as "fully satisfactory"
- Nordion's performance in environmental protection and security was rated as "fully satisfactory"
- BTL's performance in emergency management and fire protection was rated as "below expectations"

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

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

Safety and control area	SRB Technologies Inc.	Nordion (Canada) Inc.	Best Theratronics
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 is further discussed in section 10.1
**N/A: There are no safeguard verification activities associated with this facility.

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 the facilities are listed in appendix D.

7.1 Radiation Protection

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

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”, which is unchanged from the previous year.

Nuclear Substance Processing Facilities-2015 ratings for radiation protection

SRBT	Nordion	BTL
SA	SA	SA

Application of ALARA

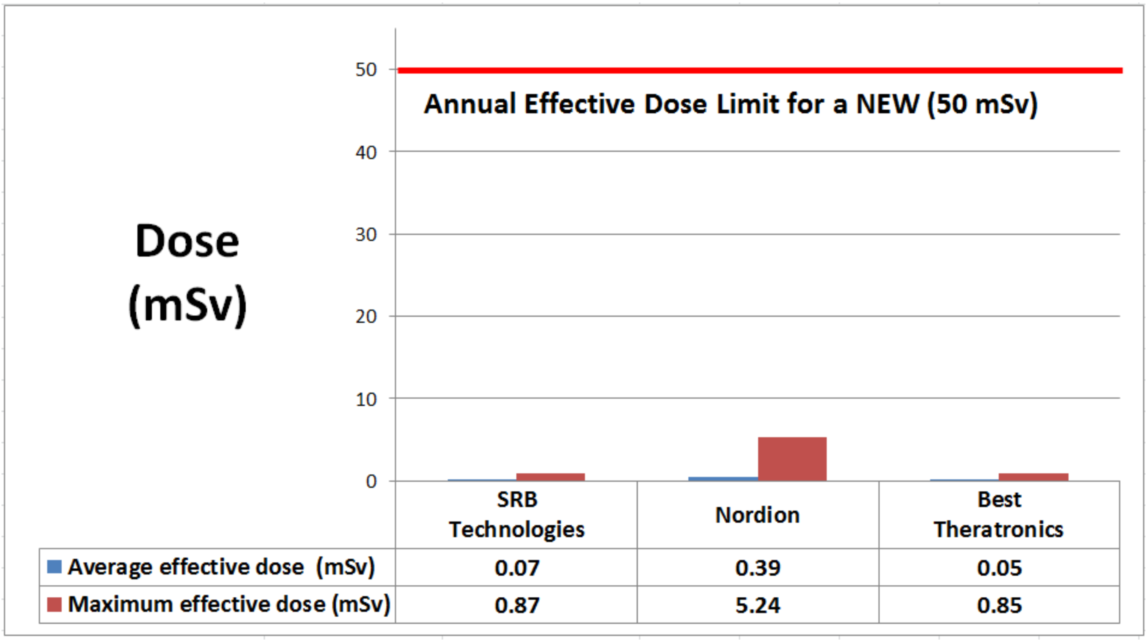
During 2015, all nuclear substance processing facility licensees continued to implement RP measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be well below regulatory dose limits.

Worker Dose Control

The design of RP programs, including the dosimetry methods and the determination of workers who are identified as 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 RP 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 mSv to 5.24 mSv, which are well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 7-2: Nuclear substance processing facility licensees-average and maximum effective doses to NEWs, 2015



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 their RP program.

Radiation Protection Program Performance

CNSC staff conducted oversight activities in the area of RP at all nuclear substance processing facilities during 2015 in order to verify compliance of the licensees' implementation of their RP programs with regulatory requirements. This regulatory oversight consisted of desktop reviews and RP-specific compliance verification activities including onsite inspections. Through these oversight activities, CNSC staff confirmed that all nuclear substance processing facilities have effectively implemented their RP programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the nuclear substance processing facility licensees' RP programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of their RP 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, to restore the effectiveness of the RP 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 RP program. Action levels which 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 their program performance and to 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 the facilities.

Estimated Dose to the Public

The maximum dose to the public from licensed activities at SRBT is calculated using monitoring results while that for 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 requirement for licensees to apply ALARA principles ensures that they 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 low and well below the regulatory annual public dose limit of 1 mSv in 2015.

Table 7-3: Nuclear substance processing facilities-public dose comparison table (mSv), 2011-2015

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 RP programs during 2015 to ensure the health and safety of persons working in their facilities.

7.2 Environmental Protection

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

This SCA encompasses the following specific areas:

- Effluent and Emissions Control (releases)
- Environmental Management System (EMS)
- Assessment and Monitoring
- Protection of the Public
- Environmental Risk Assessment

The rating for the environmental protection SCA for all nuclear substance processing facility licensees in 2015 was "satisfactory", except for Nordion, which was given "fully satisfactory". This is unchanged from the previous year.

Nuclear Substance Processing Facilities-2015 ratings for environmental protection

SRBT	Nordion	BTL
SA	FS	SA

Licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 have been implementing 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

The “Conventional Health and Safety” SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment. This SCA encompasses the following specific areas:

- Performance
- Practices
- Awareness

The rating for the Conventional Health and Safety SCA for all nuclear substance processing facility licensees in 2015 was “satisfactory”, which is unchanged from the previous year

Nuclear Substance Processing Facilities-2015 ratings for conventional health and safety

SRBT	Nordion	BTL
SA	SA	SA

The regulation of conventional health and safety at these facilities involves both the Employment and Social Development Canada (ESDC) and the CNSC. CNSC staff monitor compliance with CNSC regulatory reporting requirements. On occasion, 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 illness or injury incurred or possibly incurred as a result of licensed activity. The number of recordable 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: Nuclear substance processing facilities lost-time injuries (LTIs), 2011-2015

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

*Best Theratronics was not required to report LTI statistics prior to 2014 under its pervious licence.

The nuclear substance processing facility licensees have been implementing 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 as per RD/GD-99.3: *Public Information and Disclosure*. These programs are supported by disclosure protocols, which outline the type of information on the facility and its activities that will be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. The objective is to ensure that 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 the programs and determined that all licensees were in compliance with RD/GD-99.3 *Public Information and Disclosure*. They provided information on the status of their facilities through numerous activities. CNSC staff reviewed the communications activities during this period and noted a variety of methods were used to share information. Examples of communications activities varied from providing information on the licence renewal process, updates to elected officials, facility tours, ongoing website updates and use of social media channels. Licensees also issued information in accordance with their public disclosure protocols.

The nuclear substance processing facility licensees have been implementing 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 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 SRB Technologies (Canada) Inc., Pembroke, ON

The facility has been in operation since 1990. It processes tritium gas to produce gaseous tritium light sources (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 SRB Technologies (Canada) Inc.

In 2015, there were no licence amendments, 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 Gigabecquerel (GBq) of tritium; resulting in 1,150 shipments of self-luminous products to customers in 16 different countries including Canada. SRBT receives expired self-luminous products for reuse and disposal. In 2015, SRBT received a total of 598 consignments for a total of 20,200 returned devices. The resulting total tritium activity received in 2015 was 4715 terabecquerels (TBq). The GTLS from the expired signs were re-used or packaged, secured and sent to a Canadian Nuclear Laboratories (CNL) licensed 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, Environmental Protection.

In 2015, CNSC staff conducted two onsite inspections at SRBT to ensure compliance with the NSCA and its regulations, its 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.* As such, 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 (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 the findings, CNSC staff directed SRBT to review and revise its shipping and management oversight procedures to ensure that 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 is satisfied with the corrective measures taken by SRBT to prevent future reoccurrence of shipment irregularities. 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

SRB Technologies-overall compliance ratings for radiation protection

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 RP measures at its facility in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Annually, SRBT establishes RP Program improvements and SRBT's Health Physics Committee meets regularly to discuss various aspects of the RP program including worker doses, radiological hazard monitoring results and internal audit results. SRBT's Health Physics Committee also sets annual ALARA targets for the average and maximum effective doses to workers, to continuously work towards reducing workers doses even though they are already very low. 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 with keeping radiation doses ALARA. In 2015, radiation exposures at SRBT were well below CNSC regulatory dose limits.

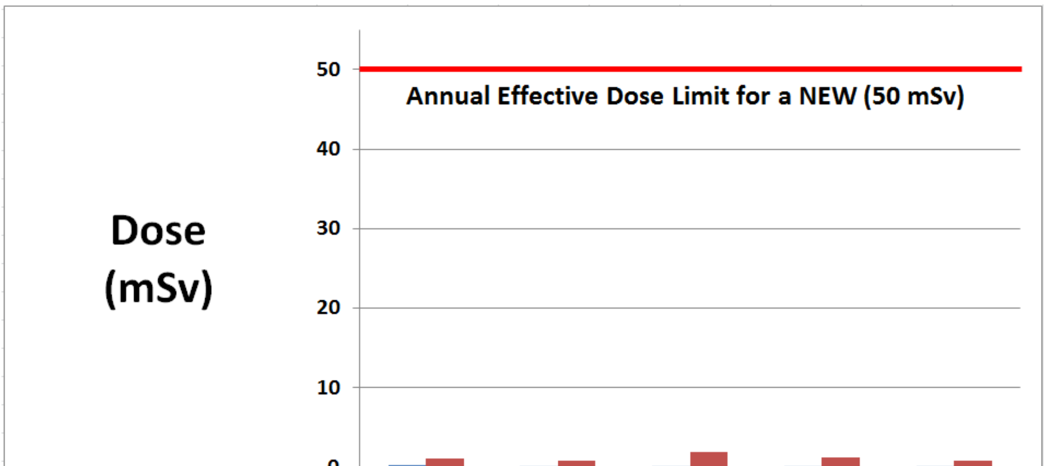
Inhalation, ingestion or absorption of tritium are the main radiological hazards at SRBT. SRBT ascertains internal tritium exposures through a urine analysis program which is part of SRBT's CNSC-licensed internal dosimetry service.

All workers employed at SRBT are identified as NEWs and radiation exposures are monitored as per regulatory requirements to ensure compliance with the CNSC's regulatory dose limits and to maintain doses ALARA. Contractors are not identified as NEWs and do not perform radiological work but are monitored as per regulatory requirements and are provided with training as necessary to ensure that doses remain less than the public dose limit of 1 mSv/year and ALARA.

In 2015, no worker's radiation exposure reported by SRBT exceeded CNSC regulatory dose limits; this included 47 NEWs. No contractor working at SRBT in 2015 (three persons) received a recordable dose. The maximum effective dose received by a NEW in 2015 was 0.87 mSv, or approximately 2 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 4 percent of the regulatory dose limit of 100 mSv per five-year dosimetry period.

Figure 8-3 provides the average and maximum effective doses of NEWs over the years 2011-2015 at SRBT.

Figure 8-3: SRB Technologies (Canada) Inc.-effective doses of nuclear energy workers, 2011-2015



	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

During the years 2011 to 2015, average doses have been relatively stable, with a slight downward trend since 2013. The maximum dose also experienced a downward trend since 2013.

Due to the nature of tritium, exposures to it 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 RP program performance at SRBT in 2015 through various CNSC 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 the SRBT's RP program. If reached, SRBT must establish the cause, notify the CNSC, and, if applicable, restore the effectiveness of the RP program. There were no action level exceedances reported by SRBT in 2015.

Improvements in RP program performance attributed to an overall 35 percent decrease in collective dose in 2015 compared to a decrease of only 2.5 percent in tritium processed.

Radiological Hazard Control

Contamination controls have been established at SRBT as per CNSC 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 of surface and airborne tritium concentrations to confirm the effectiveness of the 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: SRB Technologies (Canada) Inc.-maximum effective dose to a member of the public, 2011-2015

Maximum Effective Dose to a Member of the Public						
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

SRB Technologies (Canada) Inc.-overall compliance ratings for environmental protection

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". SRBT's radioactive releases continue to be effectively controlled and consistently well below the release limits prescribed in its 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 environment. SRBT continues to maintain an effective environmental monitoring program as per regulatory requirements. The principal monitoring activities focus on monitoring the air and groundwater around the facility. The program provides data for estimates of annual dose to the public. The calculated maximum dose to a member of the public from licensed activities remains very low; approximately 0.7 percent of the public dose limit of 1 mSv/year.

Effluent and Emissions Control (Releases)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 to air between 2012 and 2013 is due to a three-fold increase in tritium processing at SRBT (10,224 TBq/year and 30,544 TBq/year) during the same period.

The total tritium released to air decreased from 66.16 TBq in 2014 to 56.24 TBq in 2015. The percent of tritium released relative to tritium processed 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-June 2, 2015. The weekly action level for total tritium released is 7.753 TBq; 16.947 TBq was released to the atmosphere. The release represents 3.78 percent of the annual release limit for total tritium. SRBT conducted an investigation into this exceedance to identify contributing and root causes. SRBT's investigation concluded that the higher tritium emissions were caused by a service-related degradation of the packing on a process valve, and the operation of the valve during an inappropriate point in the process. SRBT's corrective actions include increasing the preventative maintenance frequency on process valves as well as incorporating procedural changes into their 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 the facility. The monitoring data for 2011 through 2015, provided in table F-15, appendix F, demonstrate that liquid effluent from the facility continues to be effectively controlled and that 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. The decrease was achieved by reducing the number of failed leak tests on the manufactured light sources and by implementing process improvements that reduced indoor air concentrations, which in-turn reduces air conditioner and dehumidifier drain water concentrations.

Environmental Management System (EMS)

SRBT currently maintains an EMS that describes the integrated activities associated with the protection of the environment at the 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*, which pertains to Environmental Management Systems. In the analysis, SRBT identified areas for improvement and an action plan. The CNSC continues to monitor the implementation of the action plan through the review of key documents and site inspections.

SRBT staff holds 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's staff.

Assessment and Monitoring

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

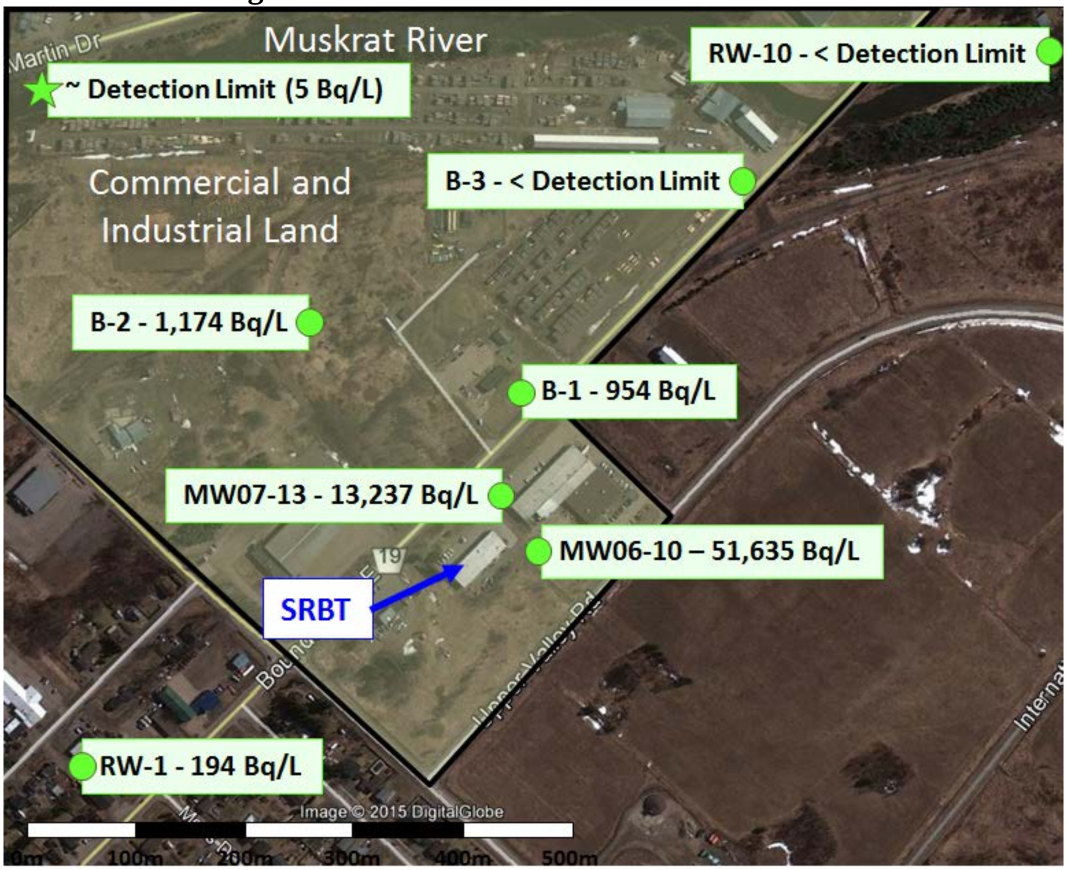
Tritium in Ambient Air

SRBT has a total of 40 passive air samplers located within a two-kilometre radius of the 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 currently sampled in 34 monitoring wells around the facility, and an additional 15 residential and business wells. At the end of 2015, only two wells showed tritium concentrations above the Ontario Drinking Water Quality Standard for Tritium of 7,000 Bq/L: megawatt (MW) 06-10 and MW 07-13, which are both 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 decrease significantly at locations further away from SRBT. Figure 8-4 shows locations of groundwater monitoring wells near the SRBT facility in 2015.

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



Since 2010, SRBT has conducted a groundwater study, which confirmed that the residential wells (with highest tritium concentration of 194 Bq/L for 2015) and the Muskrat River (with highest detectable tritium concentration of 7 Bq/L) are not at risk of exceeding the Ontario Drinking Water Quality Standard of 7,000 Bq/L. The highest tritium concentration in a potential drinking water well was found in business well B-2, averaging 1,174 Bq/L in 2015. SRBT continues to provide bottled drinking water to the business, even though the tritium concentrations are well below the Ontario Drinking Water Quality Standard.

CNSC staff's independent modeling assessment in 2010 (and the monitoring results to date) was in agreement with SRBT's conclusion that the elevated tritium concentrations at MW06-10 is mainly caused by high tritium concentrations in the soil due to historical practices. Overall, CNSC staff conclude that the tritium inventory in the groundwater system around the facility has been decreasing since 2006.

Other Monitoring

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. This monitoring complements the principal monitoring activities, which focus on air and groundwater. 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 facility under the CNSC's IEMP. The results are provided at the CNSC's IEMP webpage. Results obtained by the CNSC confirm 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, the licensee shall demonstrate that adequate provision is made for protecting the health and safety of the public from exposures to hazardous substances released from the facility.

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 CNSC staff reviews of the programs at the SRBT, CNSC staff conclude 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 SRBT's existing programs did not address the requirements of the standards.

On January 15, 2016, SRBT submitted its Gap Analysis and Action plan for several environmental protection standards, including CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. SRBT has indicated that it anticipates conducting an ERA 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 N288.6-12 to be acceptable. SRBT provided an action plan and a time frame for when the action would be implemented.

8.4 Conventional Health and Safety

SRB Technologies (Canada) Inc.-overall compliance ratings for conventional health and safety

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 at SRBT confirm 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. As per table 8-2, the number of LTIs remains zero in 2015.

Table 8-2: Lost-time injuries (LTIs) at SRB Technologies (Canada) Inc., 2011-2015

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

Practices

In addition to the NSCA and its associated regulations, SRBT's activities and operations must comply with Part II of the *Canada Labour Code.* As such, SRBT is required to report to ESDC incidents resulting in an injury.

SRBT has a Workplace Health and Safety Committee (WHSC) that inspects the workplace and meets monthly to resolve and track any safety issues. In 2015, SRBT's WHSC met 12 times. CNSC staff review the WHSC 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. (Nordion) 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 Inc. facility in Ottawa, ON.

Figure 9-1: Aerial view of Nordion, Ottawa, ON

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.

Nordion identified in its licence application that it had historical neutron sources for which it could not find a disposal pathway. As noted in the Record of Proceedings for the *Application to renew the Nuclear Substance Processing Facility Operating Licence for Nordion (Canada) Inc.*, the Commission requested that it be updated on the disposal of these sources when a way-ahead has been determined.

Nordion is working with Energy Solutions who is able to receive and dispose of these neutron sources. The CNSC requires Nordion to submit an application in order to obtain approval to transport these sources to Energy Solutions for disposal. Nordion has committed to provide the CNSC with an application for the transport of these sources by August 15, 2016. CNSC staff will provide the Commission with an update on the status of the review of this application during the presentation of this Regulatory Oversight Report.

Figure 9-2 shows a picture of 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 the year 2015, with the exception of environmental protection, and security, 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 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 that there was a fire on the roof of Nordion's facility. This event was reported to the Commission as an Event Initial Report (EIR) in August 19, 2015 and a status update was provided to the Commission in September 30, 2015 (CMD 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. There was no impact to persons or to the environment, and no injuries as a result of the fire. Both the air and water samples that were collected confirmed that no nuclear substances were released during this event. Nordion ensured that the building was safe before staff were permitted to re-enter. Nordion confirmed that all ventilation, and safety systems, including radiation protection monitoring equipment, security and fire protection systems, were functioning and performing as required prior to re-commencing operations. Nordion investigated the incident and identified corrective actions which have all been implemented. All actions related to this fire are closed and CNSC staff are satisfied with the measures that Nordion has put in place.

Nordion submitted a total of 22 reports to the CNSC on events or incidents that occurred in 2015 as required by the Act, Regulations, and Nordion's licence. CNSC staff reviewed these reports and conclude that none compromised the health and safety of persons and the environment. Of the 22 reports, 17 were related to packaging and transport. The number of packaging and transport reports is higher relative to the other processing facilities because Nordion transports approximately 10,000 packages containing nuclear substances per year. The majority of the packaging and transport reports are low risk and related to items such as incorrect shipping documents, errors in labelling and incorrect activity listed on labels or documents. The other 5 reports that were not related to packaging and transport included the fire described above, administrative issues related to export, 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 to ensure compliance with the NSCA and its regulations, its operating licence and the programs used to meet regulatory requirements. The inspections focused on management system, fire protection, security, operating performance, radiation protection, environmental protection and conventional health and safety. 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

Nordion Canada Inc.-overall compliance ratings for radiation protection

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 RP measures at its facility in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Nordion establishes annual RP program improvements and Environmental Health and Safety Committee meets regularly to discuss various aspects of the radiation protection program including worker doses, radiological hazard monitoring results and internal audit results. Nordion’s Environmental Health and Safety 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. Nordion did not achieve its newly-established internal target for thyroid monitoring compliance in 2015. Nordion reports that compliance in this area is continuously improving and continued to be monitored.

Worker Dose Control

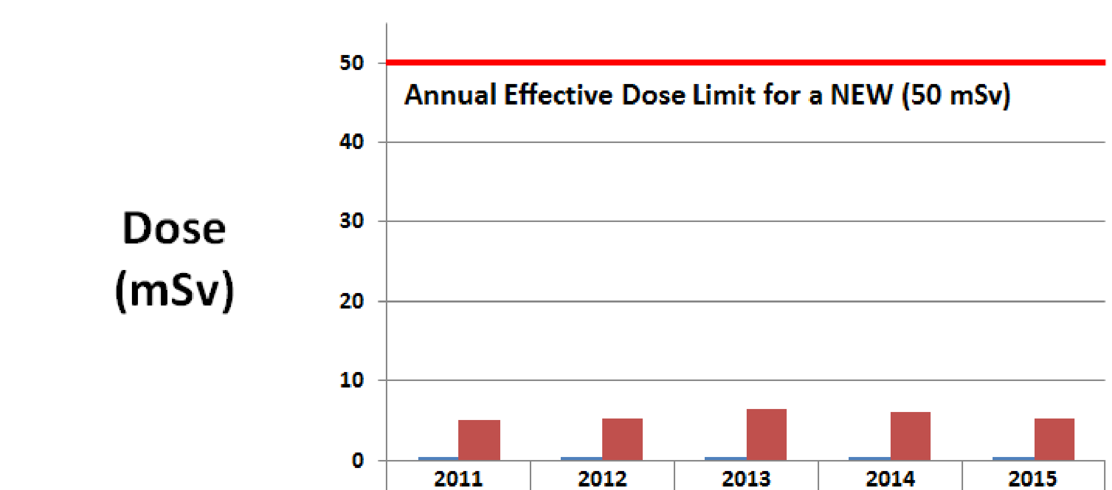
Radiation exposures are monitored to ensure compliance with the CNSC’s regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at Nordion were well below CNSC regulatory dose limits.

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 are the main radiological hazards to Nordion workers. 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 the 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 (active area) have a reasonable probability of receiving an occupational dose greater than 1 mSv/year and are thus identified as NEWs as 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 identified as non-NEWs. They are monitored as required and provided with relevant training to ensure that doses remain less than the regulatory dose limit of 1 mSv/year and ALARA.

In 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. These workers are all 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 of NEWs over the years 2011-2015 at Nordion.

Figure 9-3: Nordion Canada Inc.-effective doses of nuclear energy workers, 2011- 2015



	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.*

During the years 2011 to 2015, average and maximum effective doses were relatively stable.

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 1 and 2 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 RP program performance at Nordion through various CNSC 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 RP program. If reached, Nordion must establish the cause, notify the CNSC, and, if applicable, restore the effectiveness of the RP 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 as 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 is well below CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 9-1: Nordion Canada Inc.-maximum effective dose to a member of the public, 2011-2015

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

Nordion Canada Inc.-overall compliance ratings for environmental protection

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 as per regulatory requirements to control and monitor gaseous and liquid releases of radioactive substances from the facility into the environment. For the last 5 years, the gaseous emissions and liquid effluents were well below the DRLs 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)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 DRLs prescribed in its operating licence. No action levels were exceeded at any time in 2015. See table F-16, appendix F for Nordion radiological air emissions monitoring results for 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 DRLs prescribed in Nordion’s operating licence. No action levels were exceeded in 2015. See table F-17, appendix F, for Nordion radiological liquid emissions monitoring results for 2011 to 2015.

Environmental Management System

Nordion has developed and maintains an EMS to describe the integrated activities associated with the protection of the environment at the facility according to CNSC regulatory requirements. Nordion’s EMS is described in its Environmental Management System Manual and includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities.

The EMS is verified through Nordion’s annual management review which involves the evaluation of actions from the previous meeting, the Environmental Health & Safety Policy, adequacy of resources, environmental health and safety objectives and targets, changing circumstances 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. Nordion conducts groundwater monitoring, collects soil samples and measures environmental gamma radiation using thermoluminescent dosimeters (TLD) deployed on and offsite to demonstrate that emissions from the facility do not pose risks to the public health and to the environment. The monitoring results since 2011 are further described below.

Groundwater Monitoring

Currently, a total of nine monitoring wells exist around the Nordion site. Four of the wells are sampled for non-radiological parameters, and the other 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 that there are no significant changes in results since 2005. CNSC staff confirmed that for 2011 through 2015, the results of monitoring demonstrated that there were no significant changes for concentrations of hazardous substances in the groundwater relative to 2005 which were all near the background levels or the 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. Based on CNSC staff assessments, these results indicate that releases of radioactive and hazardous substances from the Nordion's facility have had no measurable impact on groundwater quality.

Soil Sampling

According to Nordion's environmental monitoring program, 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.

Environmental TLD Program

Nordion monitors environmental gamma radiation using TLDs. The dosimeters are deployed at locations to generally cover the points of a compass and preferentially to the east of the facility, which is the direction of the prevailing winds. TLDs are also placed in residences of Nordion employees. 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, the licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the facility. 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 CNSC staff reviews of the programs at Nordion, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental Risk Assessment

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

9.4 Conventional Health and Safety

Nordion Canada Inc.-overall compliance ratings for conventional health and safety

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 confirm 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 per table 9-2, there were no LTIs at Nordion in 2015.

Table 9-2: Lost-time injuries (LTI) at Nordion Canada Inc., 2011-2015

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

Practices

In addition to complying with the NSCA and its regulations, Nordion's activities and operations must also comply with 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. Nordion's Health and Safety Policy Committee met five times in 2015. Based on CNSC staff assessment of the Committee minutes, 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 continues to develop and maintain a comprehensive conventional health and safety management program. Nordion sets Environment, Health and Safety (EHS) objectives yearly, including targets for occupational incidents and LTIs. In 2015, the number of occupational incidents was four which was below Nordion's EHS target of six. These incidents were mostly related to ergonomics in lifting practices or working with the manipulators.

In 2015, Nordion made several additional improvements to the conventional health and safety program, including improvements to back safety training and creating new videos of stretches that employees can perform during their shifts.

10 BEST THERATRONICS

Best Theratronics Limited (BTL) owns and operates a facility in Ottawa 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, as well as cesium-137 (Cs-137) blood irradiators. Figure 10-2 shows an image of a radiation therapy unit (Co-60 teletherapy unit) manufactured by BTL.

Figure 10-1: Aerial view of Best Theratronics Limited, Ottawa, ON

Figure 10-2: Image of a teletherapy unit manufactured by Best Theratronics Limited

Licensed activities include the operation of a nuclear substance processing facility and a radioactive source teletherapy machine. The use of a cyclotron above 1 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 licence condition of the Commission-issued licence NSPFOL-14.01/2019 that imposes requirements on BTL to provide an acceptable financial guarantee by July 31, 2015. The intent of the order was to ensure that 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 CMD, 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 LCH. 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, which was rated "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 to verify BTL's compliance with the NSCA and its regulations, its 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 that 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 issued on October 6, 2015. 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

Best Theratronics Limited-overall compliance ratings for radiation protection

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 RP 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 the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at BTL were well below the CNSC's regulatory dose limits.

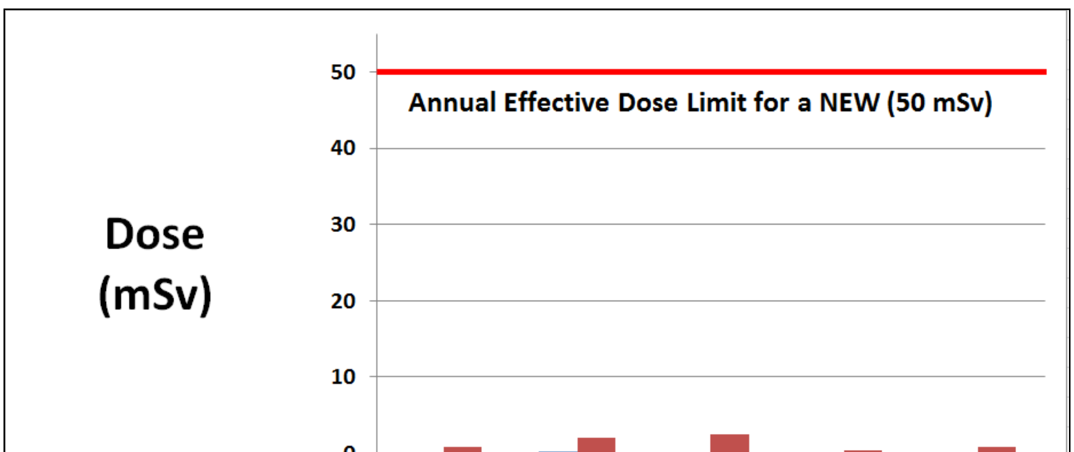
External exposure to sealed sources of radiation is the main radiological hazard to BTL workers. External whole body and equivalent doses are ascertained using dosimetry.

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. This radiation dose result represents 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 of NEWs over the years 2011 to 2015 at BTL.

Figure 10-3: Best Theratronics Limited-effective doses of nuclear energy workers, 2011 -2015



	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 the report.

Radiation Protection Program Performance

CNSC staff assessed the RP program performance at BTL in 2015 through various CNSC 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 in order 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 RP program. In 2015, there were no action level exceedances at BTL.

Radiological Hazard Control

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

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

Monthly dose rate measurements are also performed in all radiation areas. In addition, fixed dose rate monitors are in place with 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 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 un-measurable dose impact to members of the public due to BTL's current and proposed licensed activities.

10.3 Environmental Protection

Best Theratronics Limited-overall compliance ratings for environmental protection

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

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

Environmental Management System (EMS)

In 2015, BTL implemented a new EMS to conform to REGDOC 2.9.1: *Environmental Protection Policies, Programs and Procedure*, a requirement of its Class IB licence. 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 environmental protection onsite 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, the licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the facility.

The BTL facility only uses sealed sources. Therefore, the risk of radiation exposure to members of the public from normal operations is very low.

Environmental Risk Assessment

In 2011, BTL commissioned a Phase 1 Environmental Assessment (EA). The facility used the EA as a risk assessment. Potential environmental risks were identified for areas within and outside the facility and mitigation measures were put in place. CNSC staff reviewed and are satisfied with the measures that BTL has put in place for the protection of the environment.

In 2013, BTL contracted a third party to conduct modelling to support the facilities' MOECC Environmental Compliance Approval application. 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 impact the health and safety of the public or the environment.

10.4 Conventional Health and Safety

Best Theratronics Limited-overall compliance ratings for conventional health and safety

2014	2015
SA	SA
For 2015, CNSC staff continued to rate the conventional health and safety SCA at BTL as "satisfactory". Overall, the compliance verification activities conducted by CNSC staff at BTL confirm that conventional health and safety is viewed 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 per table 10-1, there was one LTI reported 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 (LTIs) at Best Theratronics Limited, 2014-2015

	2014	2015
Lost-time injuries	1	1

Practices

In addition to complying with the NSCA and its associated regulations, BTL's activities and operations must comply with Part II of the *Canada Labour Code*.

BTL has a Health and Safety Committee (HSC) that inspects the workplace and meets monthly to resolve and track any safety issues. CNSC staff review the monthly meeting minutes 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 the site. 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

Part III of this report deals with small nuclear research reactor facilities. They are:

- 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 École Polytechnique de Montréal (ÉPM) in Montréal, QC

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

The small nuclear research reactor facilities are low power reactors with thermal capacities ranging from 0.02 MW for the SLOWPOKE-2 reactors to 5 MW for MNR. École Polytechnique's subcritical assembly has a near-zero energy output (approximately 3 x 10^{-5} W) and is used for academic purposes. These reactors are designed with inherent safety characteristics and pose 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, MNR is a pool-type reactor using light water to moderate and cool the fuel, meaning that the live core can be observed safely from the top of the pool without any special protection. 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 of the dose to the public through airborne releases gives less than 1 µSv/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 (NRU) reactor (100 MW) and at a fraction of power reactors producing over 600 MW.

The small nuclear research reactors have been in the landscape within the academic communities for decades and have received broad public acceptance due to their low risk nature and benefits towards promoting research. The designs have not changed, usage and operations have been consistent over the years, and overall performance has been consistently satisfactory over the past years.

Although CNSC staff assess all 14 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 Subcritical Assembly in ÉPM 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 the ÉPM 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 for small nuclear research reactor facilities in 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 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 these findings presented an immediate or unreasonable risk to the health, safety and security of workers, Canadians, and the environment.

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

CNSC staff reviewed these annual compliance reports, revisions to licensee's programs, and licensee's responses to events and incidents, as well as observations during onsite inspections, to compile the 2015 performance ratings for the small nuclear research reactor facilities. CNSC staff ratings for all SCAs were "satisfactory" for the small nuclear research reactor facilities, and MNR was rated "fully satisfactory" in the SCA of security.

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

Table 11-2: Small nuclear research reactor facilities-SCA performance ratings, 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 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 the facilities are listed in appendix D.

11.1 Radiation Protection

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

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", which is unchanged from the previous year.

Small Nuclear Research Reactor Facilities-2015 ratings for radiation protection

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 RP 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 RP programs, including the dosimetry methods and the determination of workers who are identified as 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 considerations the inherent differences in the design of RP programs between licensees, the dose statistics for the SLOWPOKE-2 facilities 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 (0) to 3.22 mSv, which are 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 (0) to 0.16 mSv, which are well below the regulatory dose limit of 1 mSv/year for a non-NEW.

Table 11-3: Small nuclear research reactor facilities-effective doses on workers, 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 in the area of RP at all small nuclear research reactor facilities during 2015 in order to verify compliance of the licensees' implementation of their RP programs with regulatory requirements. This regulatory oversight consisted of desktop reviews and RP-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 RP programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the small nuclear research reactor facility licensees' RP programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of their RP 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, to restore the effectiveness of the RP 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 RP 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 small nuclear research reactor facilities and in-plant air monitoring systems for MNR. All small nuclear research reactor 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 the facilities.

Estimated Dose to the Public

The CNSC's requirements to apply ALARA principles ensure that the 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 for a member of the public

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

11.2 Environmental Protection

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

This SCA encompasses the following specific areas for the small nuclear research reactor facilities:

- Effluent and Emissions Control (releases)
- Assessment and Monitoring

CNSC staff assessed the rating for the environmental protection SCA for all small nuclear research reactor facility licensees in 2015 as "satisfactory", which is unchanged from the previous year.

Small Nuclear Research Reactor Facilities-2015 ratings for environmental protection

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

Licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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

The "Conventional Health and Safety" SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

This SCA 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", which is unchanged from the previous year.

Small Nuclear Research Reactor Facilities-2015 ratings for conventional health and safety

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 the ESDC and the CNSC. CNSC staff monitor compliance with CNSC regulatory reporting requirements. On occasion, 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 illness or injury 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: Small nuclear research reactor facilities lost-time injuries (LTIs), 2011-2015

Facility	2011	2012	2013	2014	2015
McMaster University	0	0	0	0	0
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
École Polytechnique Subcritical	0	0	0	0	0

The small nuclear research reactor facility licensees have been implementing 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 reactors are required to maintain and implement public information and disclosure programs as per RD/GD-99.3: *Public Information and Disclosure*. These programs are supported by disclosure protocols, which outline the type of information on the facility and its activities that will be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. The objective is to ensure that 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.

The CNSC staff recognize that small nuclear research reactors are low-risk facilities and 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 in order 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 including 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 have been implementing 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, and operated by McMaster University. This pool-type reactor uses Low-Enriched-Uranium as a fuel, and the reactor 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 front view of the MNR facility.

Figure 12-1: Aerial view of McMaster Nuclear Reactor facility at McMaster University, Hamilton, ON

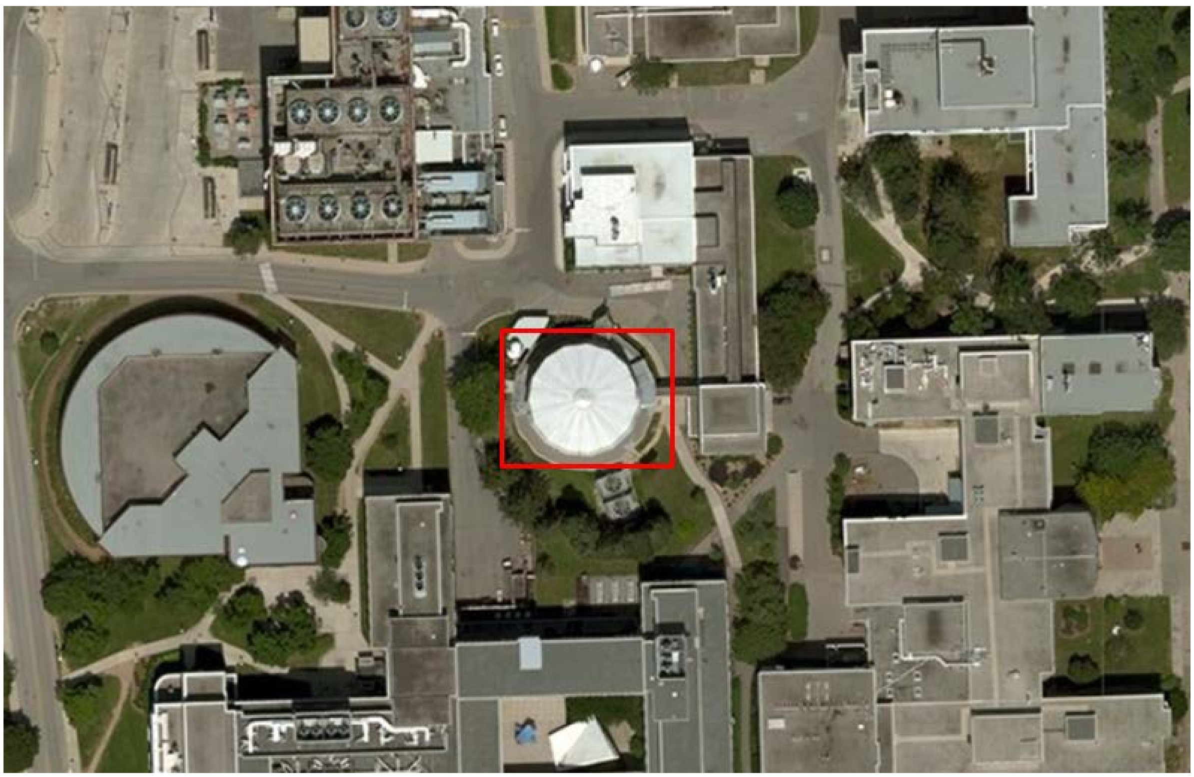


Figure 12-2: McMaster Nuclear Reactor building

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, but also exports to the U.S. and other countries. MNR is also used for neutron radiography, which is performed on a daily basis for testing of aircraft engine components. In addition to supporting research work of McMaster University students at the Bachelor, Master and Doctoral levels in physics and engineering, MNR is also used for the irradiation of over 10,000 mineral and other samples per year for various applications such as biomedical research, material science and geological surveys.

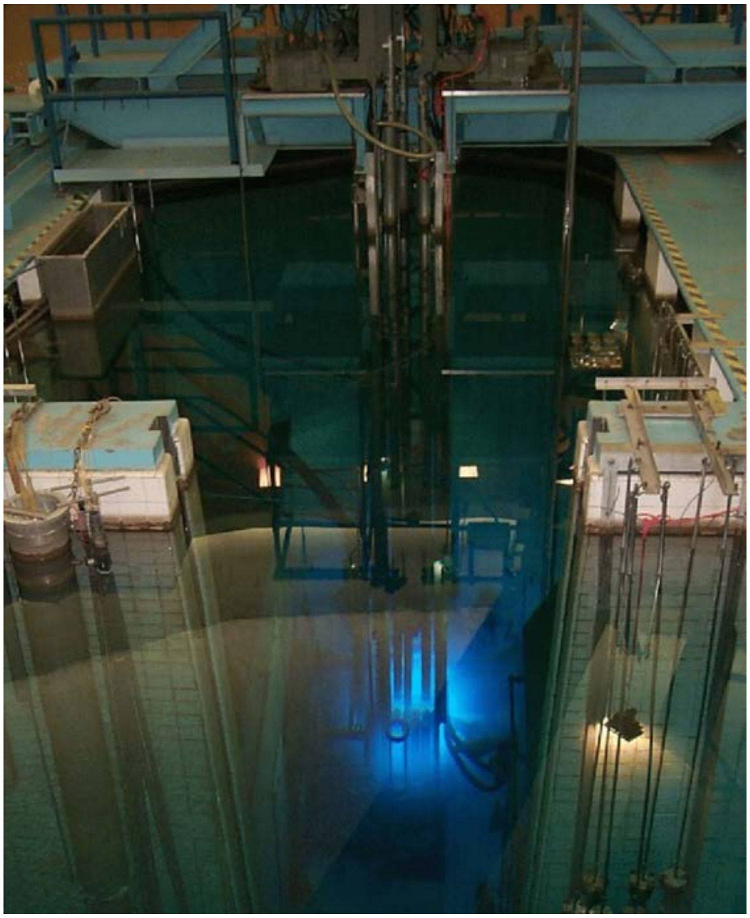
The current licence was issued by the Commission on July 1, 2014 for a period of 10 years further to a Commission Hearing held on May 8, 2014.

12.1 Performance

For 2015, CNSC staff continued to rate MNR’s performance as “satisfactory” in all SCAs, except security, which was rated as “fully satisfactory”. 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.

Over the period of calendar year 2015, MNR operated on a normal schedule of 16 hours a day, Monday to 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 McMaster Nuclear Reactor



During the annual maintenance outage, McMaster proceeded with the inspection of primary system piping and secondary tubes of the heat exchangers, with no abnormal degradation observed. McMaster 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 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 during an onsite inspection in September 2015. CNSC staff verified that the corrective actions developed to prevent recurrence of the event have been implemented.

MNR completed the root-cause analysis and corrective actions related to the 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 (EIR) on November 5, 2014 and the results of the root-cause analysis were presented at an update to the Commission on June 18, 2015. MNR developed a corrective action plan which included several changes to procedures, independent verification during fueling, human performance improvement tools, increased lighting in the pool, the installation of an underwater camera and a jib crane to facilitate fuel handling. CNSC staff observed the fueling process in March 2015, and performed an onsite inspection of the fueling process in September 2015. Corrective actions were verified as completed. No additional actions were required.

Design and preliminary construction work have progressed toward the installation of the new Positron and the Small Angle Neutron Scattering (SANS) facilities, for which a grant was awarded from the Canadian Foundation for Innovation (CFI). McMaster University expects to install these new experimental facilities between 2016 and 2017. These facilities are installed and authorized under the provisions of the current licence and 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 MNR.

12.2 Radiation Protection

McMaster Nuclear Reactor-overall compliance ratings for radiation protection

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

Application of ALARA

Annually, RP goals are established and measures are taken to enhance the performance in RP for MNR. Examples of RP goals established in 2015 include: establishment of collective dose targets for different work groups and maximum permissible airborne concentration at some locations. Some examples of measures taken in 2015 to reduce doses to workers were: installation of an automated chemical control/addition station for the secondary water system in a low dose rate area and transfer of active waste to less occupied areas for storage.

Worker Dose Control

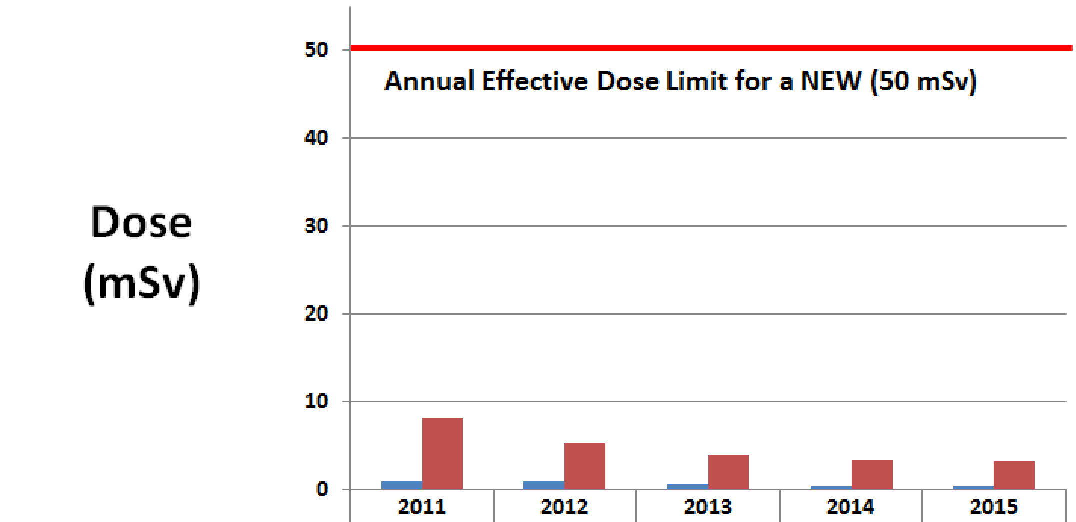
Radiation exposures are monitored to ensure compliance with CNSC's regulatory dose limits and to maintain doses ALARA taking social and economic factors into account. In 2015, no worker received a radiation exposure in excess of the regulatory dose limits or action levels established in the MNR's RP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

McMaster University ascertains external doses using whole body and extremity dosimeters. In addition, Electronic Personnel Dosimeters (EPDs) are used to monitor doses on a daily basis. Internal exposure is assessed at MNR through routine thyroid screening for the workers 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 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, the maximum effective doses to an individual, and the number of NEWs monitored from 2011 to 2015. 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 6 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. This radiation dose result represents approximately 20 percent of the regulatory effective dose limit of 100 mSv per 5-year dosimetry period.

Figure 12-4: McMaster Nuclear Reactor-effective doses of nuclear energy workers, 2011-2015



	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 MNR was 4.70 mSv and the maximum extremity dose was 36.39 mSv. These represent approximately 1 and 7 percent respectively, of the 500 mSv annual regulatory equivalent dose limits for the skin and extremity.

In 2015, the total effective dose was assessed for 2205 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 2 percent of the regulatory effective dose limit of 1 mSv in a one-year dosimetry period.

Radiation Protection Program Performance

CNSC staff assessed the RP program performance at McMaster in 2015 through CNSC compliance activities and desktop reviews. McMaster's compliance with the *Radiation Protection Regulations* and CNSC licence requirements was satisfactory.

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

Radiological Hazard Control

Radiation and contamination control programs have been established at 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 were consistent with expected radiological conditions.

Estimated Dose to the Public

Pursuant to the *Radiation Protection Regulations*, a licensee is required to ensure that the regulatory public dose limit of 1 mSv per year as a result of the licensed activity is not exceeded. Calculations to conservatively estimate the public dose to a representative person have been conducted, by comparing the emission monitoring results to the DRL. The two radionuclides released to the environment in any measureable quantities are Iodine-125 (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.

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: McMaster Nuclear Reactor-maximum effective dose to a member of the public, 2011-2015

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

McMaster Nuclear Reactor-overall compliance ratings for environmental protection

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA
For 2015, CNSC staff continued to rate the environmental protection SCA for MNR at McMaster University as "satisfactory". McMaster University continues to implement and maintain an environmental protection program as required by the licence.				

Effluent/Emissions Control and Monitoring

MNR's Effluent and Emission 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 that no unexpected radionuclides are present in the air stream.

There are no liquid releases to the environment. 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 that no leakage occurs.

Controls are in place to ensure that airborne releases of nuclear substances to the environment are minimized. These 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, is equal to the sum of the doses associated with I-125 and Ar-41 and 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.

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 which 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 MNR in 2015 or over the past five years. Table 12-2 shows the annual releases of Ar-41 and I-125 over five years.

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

Parameter	2011	2012	2013	2014	2015	Action Level (Bq/year)	Derived Release Limit (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 5 percent of the action level. Releases of I-125 in 2015 were similar to the previous year, corresponding to approximately 0.002 percent of the DRL and 2 percent of the action level.

Assessment and Monitoring

MNR's 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 MNR that could compromise the health and safety of persons and the environment.

12.4 Conventional Health and Safety

McMaster Nuclear Reactor-overall compliance ratings for conventional health and safety

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

Performance

A key performance measure for conventional health and safety SCA is the number of LTI 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 has been no LTI at MNR over the past five years.

Table 12-3: Lost-time injuries (LTIs) at MNR, 2011-2015

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

Practices

McMaster University has a comprehensive Health and Safety Program that complies with the requirements of the Ontario *Occupational Health and Safety Act*. A University Central Committee monitors activities and programs for the entire campus. A local committee, comprising workers and managers, is formed to promote and provide a safe work environment in MNR. 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 conclude that the program meets the compliance requirements.

Awareness

MNR continues to maintain an effective 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 McMaster University. CNSC staff continue to monitor the effectiveness of this program through regular onsite inspections.

13 SLOWPOKE-2 FACILITIES

The SLOWPOKE-2 reactors are 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. This 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 (HEU), in the case of University of Alberta and Saskatchewan Research Council or low-enriched uranium (LEU), in the case of Royal Military College of Canada and École Polytechnique de Montréal.

SLOWPOKE-2 reactors provide a source of neutrons to carry out neutron activation analysis, delayed neutron counting, radio-isotope production, as well as radiography and radioscopy, and support education and research at master's and doctoral levels 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 radiation protection, environmental protection, and conventional health and safety.

13.1 Radiation Protection

SLOWPOKE-2 Facilities-overall compliance ratings for radiation protection

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 worker 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

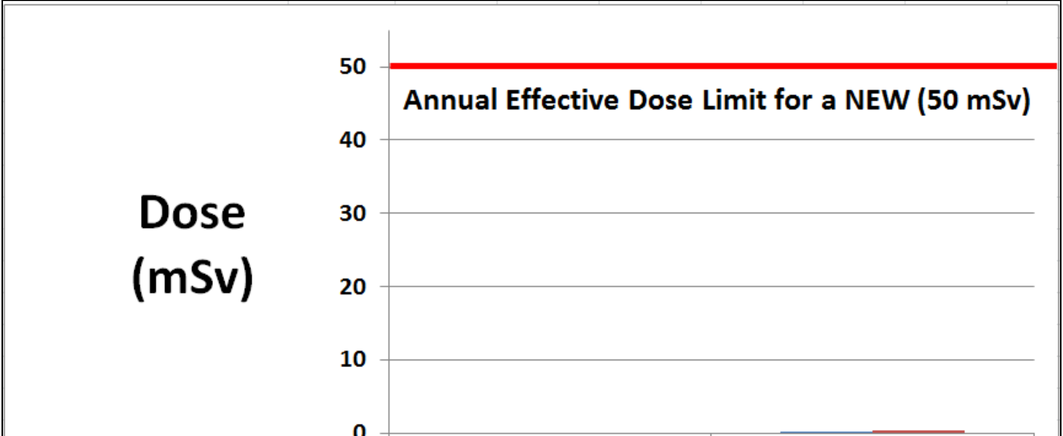
Radiation exposures are monitored by licensees to ensure compliance with the CNSC’s regulatory dose limits and to maintain radiation doses ALARA. In 2015, no worker received a radiation exposure in excess of the regulatory dose limits or action levels established in the SLOWPOKE-2’s RP program.

At SLOWPOKE-2, 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 and U of A decided to identify their workers as NEWs. Royal Military College of Canada has both NEWs and non-NEWs at its facility.

Figure 13-2 provides the average effective doses, the maximum effective doses to an individual, and the 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.

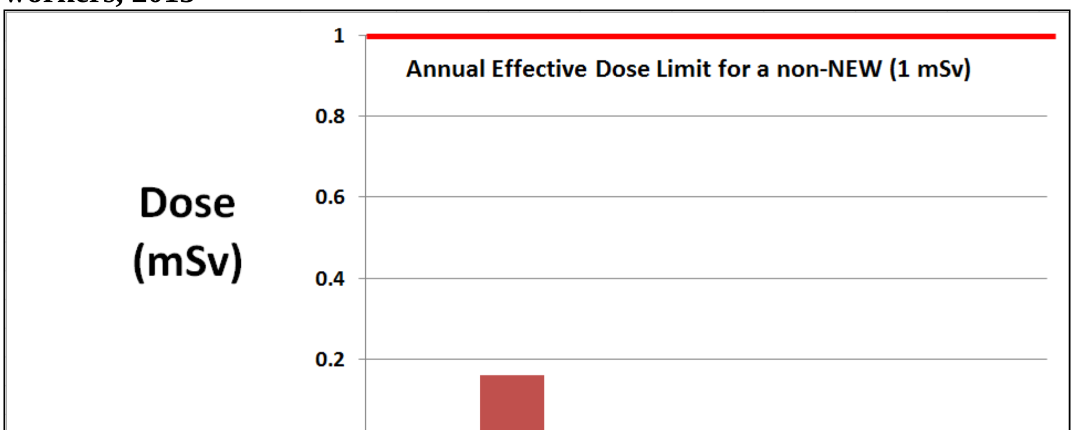
Figure 13-2: SLOWPOKE-2 Facilities-effective doses of nuclear energy workers, 2015



	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, the maximum effective doses to an individual, and the 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: SLOWPOKE-2 Facilities-effective doses of non-nuclear energy workers, 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, the maximum effective doses to an individual, and the number of persons monitored from 2011-2015 at each SLOWPOKE-2 facility, are presented in tables E-1 through E-6 of Appendix E. During those years, doses have been low and relatively stable.

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

Radiation Protection Program Performance.

RP program performance at SLOWPOKE-2 facilities was assessed in 2015 through CNSC staff 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 slowpoke facilities' RP 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 RP program. In 2015, no action levels were reached.

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, 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 have performed an independent assessment of the public dose due to all gaseous releases from SLOWPOKE-2 facilities. A very conservative evaluation of the dose to the public from the radioactive gases 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

SLOWPOKE-2 Facilities-overall compliance ratings for environmental protection

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 facility licensees continued to ensure that there were no hazardous liquid releases from the 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), Xenon-135 (Xe-135), resulting from the weekly purges of reactor head space, and Argon-41 (Ar-41), due to 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

SLOWPOKE-2 Facilities-overall compliance ratings for conventional health and safety

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 SLOWPOKE-2 facilities confirm that the facilities 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 ofLTI 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 through 2015.

Table 13-1: Lost-time injuries (LTIs) at SLOWPOKE facilities, 2011-2015

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 the 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.

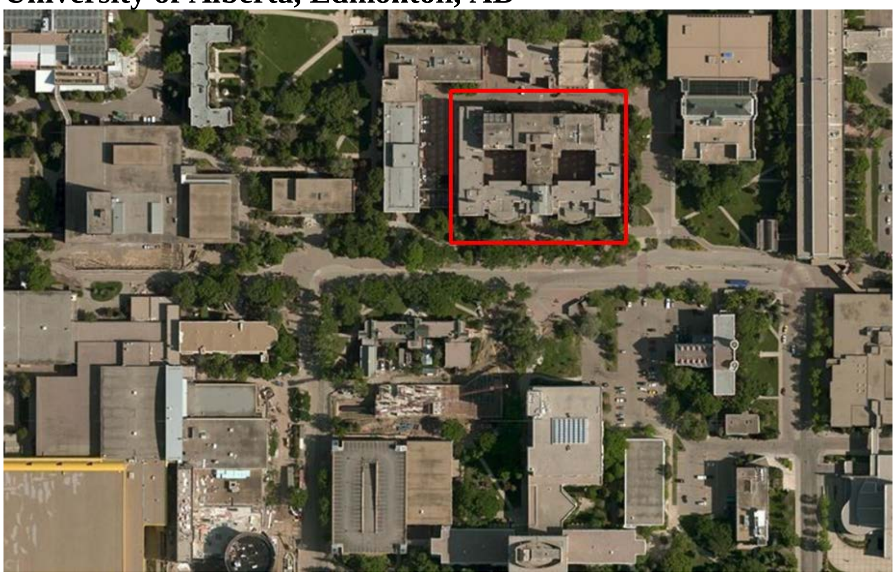
Awareness

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

13.4 University of Alberta

The University of Alberta SLOWPOKE-2 reactor is located in the Dentistry/Pharmacy Building on the campus of the university in Edmonton, Alberta. The facility consists of a reactor room, 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 SLOWPOKE-2 facility.

Figure 13-4: Aerial view of the Dentistry/Pharmacy Building at the University of Alberta, Edmonton, AB



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 fueled with Highly Enriched Uranium (HEU). Figure 13-5 shows the top of the SLOWPOKE-2 reactor covered by concrete blocks.

Figure 13-5: View of the top of the SLOWPOKE-2 reactor covered with concrete bricks

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, the licensee was compliant with the NSCA and its regulations and with its non-power reactor operating licence (NPROL-18.00/2023). During the same period, the University of Alberta operated in a safe and reliable way, did not report any operational challenges and did not require unplanned maintenance. 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 SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, its 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 to the environment.

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

13.5 Saskatchewan Research Council

The Saskatchewan Research Council (SRC) SLOWPOKE-2 facility is located within SRC's Environmental Analytical Laboratories at 102-422 Downey Road, Saskatoon, Saskatchewan, as shown in figure 13-6. The facility consists of a reactor room, with the reactor located within a concrete well, a 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 (HEU).

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

Figure 13-6: Aerial view of the SRC environmental analytical laboratories housing the SLOWPOKE-2 facility

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, the licensee was compliant with the NSCA and its regulations and with its non-power reactor operating licence (NPROL-19.00/2023). The licensee operated in a safe and reliable way, did not report any operational challenges and did not require unplanned maintenance. CNSC staff's review of records showed that the licensee 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 SLOWPOKE-2 facility to verify compliance with the NSCA and its regulations, its 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 to the environment.

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

13.6 Royal Military College of Canada

The Royal Military College of Canada (RMCC) SLOWPOKE-2 facility is located within the RMCC complex in Kingston, ON. Figure 13-7 provides an aerial view of the RMCC complex. The facility is housed in the Sawyer Science and Engineering Building, Module 5. The facility comprises of 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 RMCC complex with the SLOWPOKE-2 facility

The RMCC SLOWPOKE-2 facility is used for neutron activation analysis, analysis of fissile materials, neutron radiography and radioscopy, and education in radiation protection and programs at the postgraduate level. The reactor has been in operation since 1985. The core is fueled with Low-Enriched Uranium (LEU).

The licensee submitted a business plan for refueling the SLOWPOKE-2 reactor to the Department of National Defence for funding. If the funding is approved, the target completion date for refueling is March 2019.

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, the licensee was compliant with the NSCA and its regulations and with its non-power reactor operating licence (NPROL-20.00/2023). The licensee operated in a safe and reliable way, did not report any operational challenges and did not require unplanned maintenance. There were no changes that affected SSCs in meeting and maintaining their design requirements. CNSC staff's review of records showed that the facility performed scheduled routine inspections and maintenance activities to ensure that 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, its 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 to 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 plan to improve the quality of radiography operations.

13.7 École Polytechnique

(La version française de la présente section est disponible à la fin du document)

The École Polytechnique (ÉPM) SLOWPOKE-2 facility is located on the campus of the Université de Montréal, in Montréal, Quebec. More specifically, on the ground floor of the main building of École Polytechnique de Montréal (ÉPM), 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 fueled with LEU.

Figure 13-8: Aerial view of École Polytechnique de Montréal, Montréal, QC

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, its associated regulations and ÉPM's non-power reactor operating licence (PERFP-9A.01/2023). During the same period, the facility 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, its 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 to the environment.

ÉPM submitted an updated preliminary decommissioning plan and financial guarantee. CNSC staff are assessing the submissions and will be providing an update to the Commission during the presentation of this Regulatory Oversight Report.

13.8 École Polytechnique-Subcritical Assembly

(La version française de la présente section est disponible à la fin du document)

The École Polytechnique Subcritical Assembly is also located on the campus of the Université de Montréal, 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-occurring 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 SLOWPOKE-2 reactor 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 assembly is now consolidated into the SLOWPOKE-2 operating licence (PERFP-9A.01/2023).

Performance

For 2015, CNSC staff continued to rate the ÉPM-Subcritical Assembly's performance 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.

The licensee is required to notify CNSC staff of their intention to operate the facility with sufficient advance notice, allowing adequate coordination of the inspection by the 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

Part IV of this report deals with Class IB particle accelerator facilities. They are:

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

In order to provide consistent reporting across CNSC-licensed facilities, this is the first time that the Class IB particle accelerator facilities are reported along with similar Class I facilities. Previously, the Class IB particle accelerator facilities were reported 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 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 below presents the licensing and compliance effort from CNSC staff for Class IB particle accelerator facilities during the reporting period.

Table 14-1: CNSC regulatory oversight licensing and compliance activities for Class IB particle accelerator facilities in 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, and the environment.

The Class IB particle accelerator facilities are required, as part of their operating licence, to submit an annual compliance report by March 31. These reports contain facility performance information in all 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” in human performance management at CLS. This is discussed in detail in the performance section of 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: Class IB particle accelerator facilities-SCA performance ratings, 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 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 the facilities are listed in appendix D.

14.1 Radiation Protection

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

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 rating for the radiation protection SCA for all Class IB particle accelerator facility licensees was "fully satisfactory", which is unchanged from the previous year.

Class IB Particle Accelerator Facilities-2015 ratings for radiation protection

TRIUMF	CLS
FS	FS

Application of ALARA

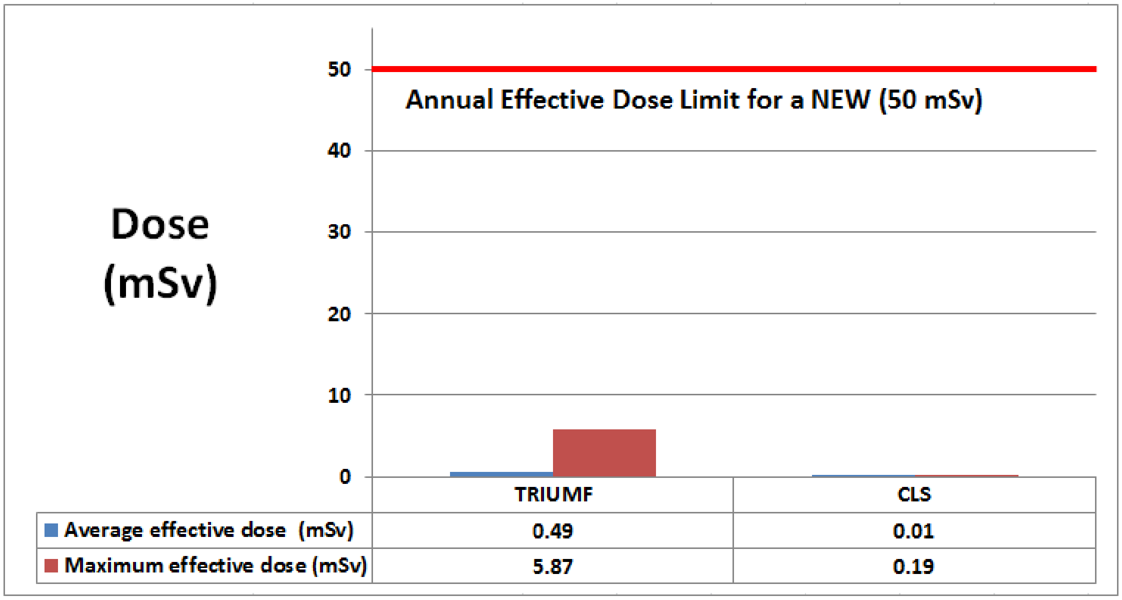
During 2015, CNSC staff determined that all Class IB particle accelerator facility licensees were very effective at implementing RP measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in doses to persons to be well below CNSC regulatory dose limits.

Worker Dose Control

The design of RP programs, including the dosimetry methods and the determination of workers who are identified as NEW, 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 RP 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 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 mSv to 5.87, which are well below the regulatory dose limit of 50 mSv/year for a NEW.

Figure 14-2: Class IB particle accelerator facility licensees-average and maximum effective doses to NEWs, 2015



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 licensee is in implementing their RP program.

Radiation Protection Program Performance

CNSC staff performed regulatory oversight activities in the area of RP at all Class IB particle accelerator facility licensees during 2015 in order to verify compliance of the licensees’ implementation of their RP programs with regulatory requirements. This regulatory oversight consisted of desktop reviews and RP-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 RP programs to control occupational exposures to workers.

Action levels for radiological exposures are established as part of the Class IB particle accelerator facility licensees' RP programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of their RP 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, to restore the effectiveness of the RP 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 RP program. Action levels which 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 their program performance and to prevent reoccurrence. There was one action level exceedance at TRIUMF reported to the CNSC in 2015 which 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. These measures include 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 the 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 the 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 in 2015.

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

14.2 Environmental Protection

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

This SCA encompasses the following specific areas:

- Effluent and Emissions Control (releases)
- Environmental Management System (EMS)
- Assessment and Monitoring
- Protection of the Public
- Environmental Risk Assessment

The 2015 rating for the environmental protection SCA for TRIUMF was "satisfactory" and "fully satisfactory" for CLS. This is unchanged from the previous year.

Class IB Particle Accelerator Facilities-2015 ratings for environmental protection

TRIUMF	CLS
SA	FS

Licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 satisfactorily 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

The "Conventional Health and Safety" SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

This SCA 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", which is unchanged from the previous year.

Class IB Particle Accelerator Facilities-2015 ratings for conventional health and safety

TRIUMF	CLS
SA	SA

The regulation of conventional health and safety at these facilities involves both ESDC and the CNSC. CNSC staff monitor compliance with CNSC regulatory reporting requirements. On occasion, 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 illness or injury incurred or possibly incurred as a result of licensed activity. The number of recordable LTIs reported by all facilities has remained low from 2014 to 2015.

Table 14-3 summarizes the number of recordable LTIs reported by Class IB particle accelerator facilities from 2014 to 2015. Further information is provided in facility-specific sections as well as appendix G.

Table 14-3: Class IB particle accelerator facilities lost-time injuries (LTIs), 2011-2015

Facility	2011	2012	2013	2014	2015
TRIUMF	N/A*	N/A*	N/A*	0	4
CLS	N/A*	N/A*	N/A*	0	1

*N/A: The information is not available for years 2011 to 2013.

The Class IB particle accelerator facility licensees have been implementing 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 transition to the requirements of regulatory document RD/GD-99.3, *Public Information and Disclosure*. The objective is to ensure that 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 websites, videos, social media, facility tours and participation in community events.

The Class IB particle accelerator facility licensees have been implementing 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, located on the University of British Columbia campus in Vancouver, is Canada's national laboratory for nuclear and particle physics research and related sciences. An aerial view of the TRIUMF site is shown in figure 15-1. TRIUMF is also a major producer of radioisotopes used for medical diagnostic procedures. It is owned and operated as a joint venture by a consortium of 18 Canadian universities. TRIUMF operates one 520 megaelectronvolt (MeV) cyclotron accelerator facility, shown in figure 15-2, 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 look of the 520 MeV cyclotron

In 2015, there were no licence amendments or changes to the TRIUMF LCH-TRIUMF-R005. 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, which was rated as "fully satisfactory". 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 having incurred dose in excess of the TRIUMF 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 root causes and implemented corrective actions. CNSC staff have reviewed and accepted the corrected actions that TRIUMF has implemented. There were four LTIs in 2015.

In 2015, CNSC staff conducted two compliance onsite inspections to verify TRIUMF's compliance with the NSCA and its regulations, its 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, and to the environment.

15.2 Radiation Protection

TRIUMF Accelerators Inc.-overall compliance ratings for radiation protection

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 RP measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors.

Worker Dose Control

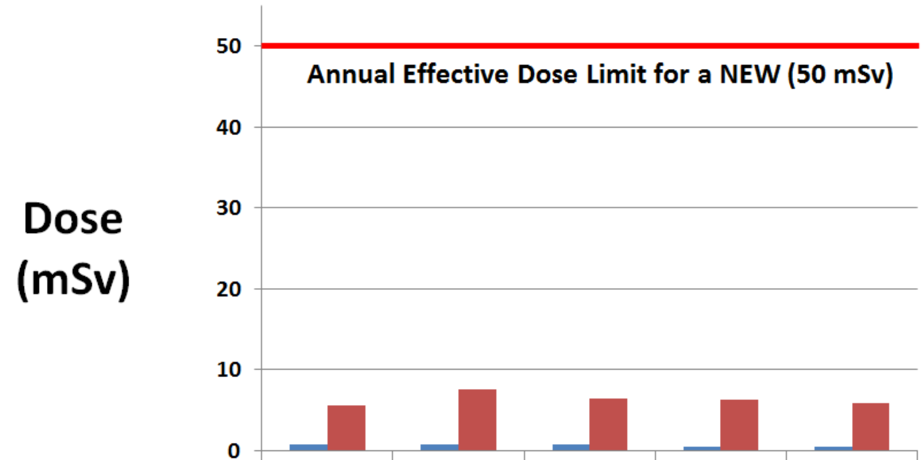
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at TRIUMF were well below CNSC regulatory dose limits.

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 depending on the type of research project a worker may be involved with. 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 per year. Radiation exposures to NEWs are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. 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. This radiation dose result represents 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 of NEWs over the years 2011 to 2015 at TRIUMF.

Figure 15-3: TRIUMF Accelerators Inc.-effective doses of nuclear energy workers, 2011-2015



	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, 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 been 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

Action levels for radiological exposures are established as part of the TRIUMF RP program as per regulatory requirements. 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 RP program. In 2015, there was one action level exceedance at TRIUMF, where a non-NEW worker received 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 indicating NEW status in order to avoid the potential for non-NEW workers gaining access to or working on projects with higher dose potential; as well as an acknowledgment that the affected worker be recognized as a NEW. CNSC staff have reviewed and accepted the corrective actions that TRIUMF has implemented.

Radiological Hazard Control

A thorough radiation dose area monitoring program has been established at TRIUMF. CNSC staff routinely verify the results and compare them to previous years' results. 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 component for the variation of these values is the 520 MeV cyclotron annual delivered beam charge. Reduced cyclotron operation 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: TRIUMF Accelerators Inc.-maximum effective dose to a member of the public, 2011-2015

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

TRIUMF Accelerators Inc.-overall compliance ratings for environmental protection

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 the operating licence and regulatory requirements. All the releases to the environment were well below regulatory limits during 2015. There were no releases of hazardous substances (non-radiological) to the environment in 2015. Environmental monitoring of water, vegetation, and gamma/beta measurements at the site boundary indicate that the public and the environment continue to be protected from facility releases.

Effluent and Emissions Control (Releases)

CNSC licensees are required to develop and implement policies, programs and procedures that comply with all applicable federal and provincial regulatory requirements, to control the release of radioactive and hazardous substances into the environment, and to protect the environment. 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 & particulate from the TRIUMF facility. In 2015, the total releases of airborne effluents represent a combined total of 0.94 percent of the 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 (EMS)

TRIUMF has developed and is maintaining an EMS which provides a framework for integrated activities with respect to the protection of the environment at the TRIUMF facility. TRIUMF's EMS is described in its Environmental Management System document and includes activities such as establishing annual environmental objectives and targets, conducting internal audits and an annual management review. CNSC staff conducted an environmental protection focused onsite inspection in 2015. It was identified that some EMS elements such as conducting internal audits and an 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 the site emissions of nuclear materials are properly controlled. The principal monitoring activities, as described in the following paragraphs, are focused on monitoring of storm sewer water, radio-assays of building drains and vegetation samples, as well as 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. Only natural background radioactive isotopes were detected. Storm sewer water was sampled in March and November at two locations, one upstream and one downstream of the TRIUMF site; 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 operation was Be-7, but its concentration was at such a low level that it may be due to cosmic radiation. Cs-137 has also been detected at low levels in some vegetation samples beyond the TRIUMF 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 TRIUMF'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 µSv/h 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

The licensee must demonstrate that the health and safety of the public are protected from exposures to hazardous substances released from the facility.

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

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

Environmental Risk Assessment (ERA)

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

15.4 Conventional Health and Safety

TRIUMF Accelerators Inc.-overall compliance ratings for conventional health and safety

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 per table 15-2, four LTIs were reported 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 consult with and educate employers and workers and enforce the provincial Occupational Health and Safety Regulation.

Table 15-2: Lost-time injuries (LTIs) at TRIUMF Accelerators Inc., 2011-2015

	2011	2012	2013	2014	2015
Lost-time injuries	N/A*	N/A*	N/A*	0	4

N/A*: The information is not available for years 2011 to 2013.

Practices

In addition to the NSCA and its associate regulations, TRIUMF's activities and operations must comply with Part II of the *Canada Labour Code* and the provincial *Occupational Health and Safety* (OHS) Regulation.

Changes to OHS in 2015 included a revision of TRIUMF Safety Note on personal protective equipment to align with Part 8 of the OHS Regulation and TRIUMF Safety Note on its work permit system, which included revised training for worker.

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 the improvement of the work permit system and the revision of all safety related signage to upgrade them to 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, Saskatchewan. Figure 16-1 shows an aerial view of the CLS facility.

Figure 16-1: Aerial view of Canadian Light Source Inc., Saskatoon, SK

The facility consists of three major accelerator systems: a 300 MeV linear accelerator, a booster ring that accelerates electrons up to 2.9 Giga-electron volts (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 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 look of the Canadian Light Source Inc. Research 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's performance as "satisfactory" or better in all SCAs with the exception of the human performance management SCA which was rated as "below expectations". This rating was based on an onsite inspection in May 2015 that found that there had been no progress on the Systematic Approach to Training (SAT)-based training system. As per the requirements of REGDOC-2.2.2, *Personnel Training*, the licensee is required to conduct an analysis to identify all performance requirements of a job or duty area related to licensed activities. The inspection noted that the required analysis had not been performed and further that the CLS 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 regulatory oversight report.

The CLS performance ratings for 2011 through 2015 are provided in table C-15, appendix C. CLS had no changes in operations, organization or operating policies in 2015.

There were no reportable action level exceedances in 2015. There was one LTIs in 2015.

In 2015, CNSC staff conducted two onsite inspections to verify CLS's compliance with the NSCA and its regulations, its 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, and to the environment.

16.2 Radiation Protection

Canadian Light Source Inc.-overall compliance ratings for radiation protection

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 RP measures in 2015 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. ALARA initiatives were planned for in 2014 and implemented in 2015, including the addition of local shielding to reduce gamma and neutron exposures.

Worker Dose Control

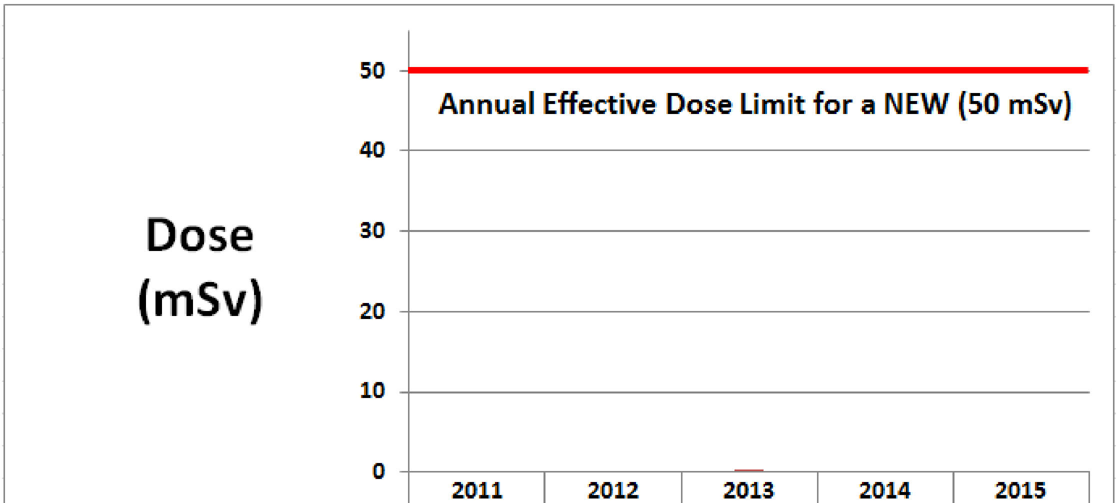
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2015, radiation exposures at CLS were well below CNSC regulatory dose limits.

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 worker 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. This radiation dose result represents 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 of NEWs over the years 2011 to 2015 at CLS.

Figure 16-3: Canadian Light Source Inc.-effective doses of nuclear energy workers, 2011-2015



	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 the report.

Radiation Protection Program Performance

Action levels for radiological exposures are established as part of the CLS RP 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 RP 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 previous years' results. 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, and CLS monitors environmental radiation levels outside of main CLS building which are at ambient background radiation levels. Therefore, the estimated dose to the public is at natural radiation background levels.

16.3 Environmental Protection

Canadian Light Source Inc.-overall compliance ratings for environmental protection

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. Since there are no releases to the environment, there are no data to present in this section.				

16.4 Conventional Health and Safety

Canadian Light Source Inc.-overall compliance ratings for conventional health and safety

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 per table 16-1, one LTI was reported in 2015. Details on the LTI are provided in table G-5, appendix G.

Table 16-1 Lost-time injuries (LTIs) at CLS, 2011-2015

	2011	2012	2013	2014	2015
Lost-time injuries	N/A*	N/A*	N/A*	0	1

N/A*: The information is not available for years 2011 to 2013.

Practices

In addition to the NSCA and its associate regulations, CLS's activities and operations must comply with Part II of the *Canada Labour Code*.

CLS Occupational Health and Safety Committee (OHSC) inspects the facility as required by the *Canada Occupational Health and Safety Regulations*. The inspections identify hazards and controls to mitigate the hazard. A reduction in the number of items on the list prior to the start of the next inspection was observed. In December 2014, there were eighteen 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. The review included a safety professional from TRIUMF, Louisiana State University Center for Advanced Microstructures and Devices (CAMD) 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 CNSC staff's assessment on the performance of uranium and nuclear substance processing, small nuclear research reactor and Class IB particle accelerator facilities in 2015. CNSC staff conclude that these facilities operated safely during 2015. This conclusion is based on assessment of licensee activities, which included site inspections, review of reports submitted by licensees, event and incident reviews with follow-up and general communication and exchange of information with the licensees.

For the 2015 calendar year, the performance in all 14 SCAs for the facilities are as follows:

- Uranium processing facilities was rated as "satisfactory" or better
- Nuclear substance processing facilities was rated as "satisfactory" or better, with the exception of Best Theratronics, which received a "below expectations" rating in emergency management and fire protection
- Small nuclear research reactor facilities was rated as "satisfactory" or better
- Class IB particle accelerator facilities was rated as "satisfactory" or better, with the exception of Canadian Light Source, which received a "below expectations" rating in human performance management

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 that the facilities continue to make adequate provision to protect the health, safety and security of workers, Canadians and the environment, as well as the implementation of Canada's international obligations on the peaceful use of nuclear energy.

A. SAFETY AND CONTROL AREA FRAMEWORK

The CNSC evaluates how well licensees meet regulatory requirements and CNSC expectations for the performance of programs in 14 SCAs that 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 (OPEX) ▪ Change management ▪ Safety culture ▪ Configuration management ▪ Records management ▪ Management of contractors ▪ Business continuity
	Human performance management	Covers activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.	▪ Human performance program ▪ Personnel training ▪ Personnel certification ▪ Initial certification examinations and requalification tests ▪ Work organization and job design ▪ Fitness for duty
	Operating performance	Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.	▪ Conduct of licensed activity ▪ Procedures ▪ Reporting and trending ▪ Outage management performance ▪ Safe operating envelope ▪ Severe accident management and recovery ▪ Accident management and recovery

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 the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.	▪ Deterministic safety analysis ▪ Hazard analysis ▪ Probabilistic safety analysis ▪ Criticality safety ▪ Severe accident analysis ▪ Management of safety issues (including R&D programs)
	Physical design	Relates to activities that impact the ability of structures, systems and components to meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.	▪ Design governance ▪ Site characterization ▪ Facility design ▪ Structure design ▪ System design ▪ Component design
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.	▪ Equipment fitness for service / equipment performance ▪ Maintenance ▪ Structural integrity ▪ Aging management ▪ Chemistry control ▪ Periodic inspection and testing
Core control processes	Radiation protection	Covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.	▪ Application of ALARA ▪ Worker dose control ▪ Radiation protection program performance ▪ Radiological hazard control ▪ Estimated dose to public
	Conventional health and safety	Covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.	▪ Performance ▪ Practices ▪ Awareness
	Environmental protection	Covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.	▪ Effluent and emissions control (releases) ▪ Environmental management system (EMS) ▪ Assessment and monitoring ▪ Protection of the public ▪ Environmental risk assessment
	Emergency management and	Covers emergency plans and emergency preparedness programs that exist for	▪ Conventional emergency preparedness and response

Functional area	Safety and control area	Definition	Specific areas
	fire protection	emergencies and for non-routine conditions. This area also includes any results of participation in exercises.	▪ Nuclear emergency preparedness and response ▪ Fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	▪ Waste characterization ▪ Waste minimization ▪ Waste management practices ▪ Decommissioning plans
	Security	Covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.	▪ Facilities and equipment ▪ Response arrangements ▪ Security practices ▪ Drills and exercises
	Safeguards and non-proliferation	Covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons*.	▪ Nuclear material accountancy and control ▪ Access and assistance to the IAEA ▪ Operational and design information ▪ Safeguards equipment, containment and surveillance ▪ Import and export
	Packaging and transport	Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.	▪ Package design and maintenance ▪ Packaging and transport ▪ Registration for use
Other Matters of Regulatory Interest			
▪ Environmental assessment ▪ CNSC consultation-Aboriginal ▪ CNSC consultation-other ▪ Cost recovery ▪ Financial guarantees ▪ Improvement plans and significant future activities ▪ Licensee public information program ▪ Nuclear liability insurance			

B. RATING METHODOLOGY AND DEFINITIONS

Performance ratings used in this report 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 area 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 area 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 is seriously compromised. Compliance within the overall area is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken, and no alternative plan of action has been provided. Immediate action is required.

C. TREND IN SAFETY AND CONTROL AREA RATINGS

Table C-1: Blind River Refinery-safety and control area summary

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: Port Hope Conversion Facility-safety and control area summary

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: Cameco Fuel Manufacturing-safety and control area summary

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: GEH-C Toronto and Peterborough-safety and control area summary

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: SRB Technologies-safety and control area summary

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**	N/A	N/A	N/A	N/A	N/A
Packaging and transport	SA	SA	SA	SA	SA

*N/A: There are no safeguard verification activities associated with this facility.

Table C-6: Nordion (Canada) Inc.-safety and control area summary

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 Best Theratronics-safety and control area summary

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: McMaster Nuclear Reactor-safety and control area summary

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: University of Alberta-safety and control area summary

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: Saskatchewan Research Council-safety and control area summary

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: Royal Military College of Canada-safety and control area summary

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: École Polytechnique de Montréal-safety and control area summary

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: ÉPM Subcritical Assembly-safety and control area summary

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: TRIUMF-safety and control area summary

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: Canadian Light Source-safety and control area summary

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	N/A*				
Packaging and transport	SA	SA	SA	FS	FS

*N/A: There are no safeguard verification activities associated with this facility.

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.

Table D-1: Uranium processing facilities-financial guarantees

Facility	Canadian dollar amount
Blind River Refinery	$38,600,000
Port Hope Conversion Facility	$101,700,000[1]
Cameco Fuel Manufacturing	$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: Nuclear substance processing facilities-financial guarantees

Facility	Canadian dollar amount
SRB Technologies	$652,488
Nordion (Canada) Inc.	$45,124,748
Best Theratronics Limited	$4,005,963

Table D-3: Small nuclear research reactor facilities-financial guarantees

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	N/A[1]
École Polytechnique de Montréal	$2,800,000[2]

1. The 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: Class IB particle accelerator facilities-financial guarantees

Facility	Canadian dollar amount
TRIUMF Accelerators Inc.	$10,800,00
Canadian Light Source Inc.	$7,500,300

E. WORKER DOSE DATA

Effective doses

SLOWPOKE-2 facilities

The following tables show the maximum and average effective doses for the SLOWPOKE-2 facilities for 2011 to 2015.

Table E-1: Saskatchewan Research Council-effective dose statistics for non-nuclear energy workers

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of non-NEWs monitored	14	13	19	16	23	**n/a**
Average effective dose (mSv)	0.013	0	0	0.01	0.01	**n/a**
Maximum individual effective dose (mSv)	0.14	0	0	0.11	0.16	**1 mSv**

Table E-2: Royal Military College of Canada-effective dose statistics for nuclear energy workers

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of NEWs monitored	11	10	13	13	13	**n/a**
Average effective dose (mSv)	0.09	0	0	0.032	0.02	**n/a**
Maximum individual effective dose (mSv)	0.63	0	0	0.42	0.29	**50 mSv**

Table E-3: Royal Military College of Canada-effective dose statistics for non-nuclear energy workers (non-NEWs)

Dose statistics	2011	2012	2013	2014	2015	Regulatory limit
Number of non-NEWs monitored	10	16	14	10	13	**n/a**
Average effective dose (mSv)	0	0	0	0.01	0	**n/a**
Maximum individual effective dose (mSv)	0	0	0	0.11	0	**1 mSv**

Table E-4: University of Alberta-effective dose statistics for nuclear energy workers (NEWs)

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of NEWs monitored	2	3	3	2	2	n/a
Average effective dose (mSv)	0.24	0.04	0	0	0	n/a
Maximum individual effective dose (mSv)	0.48	0.13	0	0	0	50 mSv

Table E-5: École Polytechnique de Montréal-effective dose statistics for non-nuclear energy workers (non-NEWs)

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of non-NEWs monitored	5	5	5	5	5	n/a
Average effective dose (mSv)	0.08	0.03	0	0	0	n/a
Maximum individual effective dose (mSv)	0.24	0.14	0	0	0	1 mSv

Table E-6: École Polytechnique de Montréal Subcritical Assembly-effective dose for non-nuclear energy workers (non-NEWs)

Dose statistics	2011	2012	2013	2014	2015	Regulatory dose limit
Number of non-NEWs monitored	N/A*	1	N/A*	N/A*	N/A*	n/a
Average effective dose (mSv)	0	0	0	0	0	n/a
Maximum individual effective dose (mSv)	0*	0	0*	0*	0*	1 mSv/year

*Not in operation

Extremity doses

Uranium processing facilities

Table E-7: Blind River Refinery-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	10.2	11.4	14.1	5.4	1.5	n/a
Maximum individual extremity dose (mSv)	49.0	47.6	35.1	48.2	15.3	500 mSv/year

Table E-8: Cameco Fuel Manufacturing Inc.-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	23.4	16.5	14.3	15.5	15.5	n/a
Maximum individual extremity dose (mSv)	111.3	107.5	87.6	88.4	87.0	500 mSv/year

Table E-9: GEH-C Peterborough Facility-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	9.36	11.56	10.47	18.64	12.61	n/a
Maximum individual extremity dose (mSv)	56.12	58.82	76.03	98.98	39.34	500 mSv/year

Table E-10: GEH-C Toronto Facility-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	40.02	46.41	32.92	31.96	30.30	n/a
Maximum individual extremity dose (mSv)	160.64	357.29	143.59	102.44	109.62	500 mSv/year

Nuclear substance processing facilities

Table E-11: Nordion-equivalent (extremity) dose statistics for nuclear energy workers, 2011 -2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	0.71	0.54	0.54	0.73	0.46	**n/a**
Maximum individual extremity dose (mSv)	12.3	10.3	7.4	9.5	9.3	**500 mSv/year**

*Only NEWs routinely working in the active area are monitored for extremity dose at Nordion.

Table E-12: BTL-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average extremity dose (mSv)	0.19	0.23	0.36	0.37	0.17	**n/a**
Maximum individual extremity dose (mSv)	0.9	2.9	6.1	3.7	2.1	**500 mSv/year**

Small nuclear research reactor facilities

Table E-13: McMaster Nuclear Reactor-equivalent (extremity) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	14.6	8.1	5.9	5.9	6.2	**n/a**
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 2 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.

Class IB particle accelerator facilities

Table E-14: TRIUMF-equivalent (extremity) dose statistics for nuclear energy workers, 2011- 2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	6.52	6.6	6.03	4.42	5.00	**n/a**
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: Blind River Refinery-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	5.5	6.0	6.8	5.4	4.0	**n/a**
Maximum individual skin Dose (mSv)	48.8	39.2	41.4	41.2	28.1	**500 mSv/year**

Table E-16: Port Hope Conversion Facility-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	0.8	0.7	1.7	0.6	0.8	**n/a**
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: Cameco Fuel Manufacturing Inc.-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	6.9	6.5	7.3	8.1	6.3	**n/a**
Maximum individual skin dose (mSv)	95.4	93.2	88.4	108.4	95.6	**500 mSv/year**

Table E-18: GEH-C Peterborough Facility-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	RegulatorylLimit
Average skin dose (mSv)	4.54	5.04	3.8	4.75	4.1	**n/a**
Maximum individual skin dose (mSv)	22.62	36.99	31.20	29.91	22.47	**500 mSv/year**

Table E-19: GEH-C Toronto Facility-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	10.81	12.45	10.29	11.08	9.89	**n/a**
Maximum individual skin dose (mSv)	55.48	58.40	52.84	51.67	54.99	**500 mSv/year**

The reason for the consistently lower skin and extremity doses at the Peterborough facility is the low likelihood of direct pellet handling, as opposed to the Toronto facility, where this practice is considered routine. At the Peterborough facility, except in the end cap welding station, all pellets are shielded in zirconium tubes, bundles or boxes.

Nuclear substance processing facilities

Table E-20: Nordion-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average skin dose (mSv)	0.50	0.40	0.42	0.46	0.40	**n/a**
Maximum individual skin dose (mSv)	6.09	5.19	6.39	6.11	5.21	**500 mSv/year**

Small nuclear research reactor facilities

Table E-21: McMaster Nuclear Reactor-equivalent (skin) dose statistics for nuclear energy workers, 2011-2015

Dose Data	2011	2012	2013	2014	2015	Regulatory limit
Average equivalent dose (mSv)	1.25	1.00	0.61	0.46	0.45	**n/a**
Maximum individual equivalent dose (mSv)	13.11	6.80	4.26	4.18	4.70	**500 mSv/year**

F. ENVIRONMENTAL DATA

Blind River Refinery

Table F-1: Blind River Refinery-annual groundwater monitoring results

Parameter	2011	2012	2013	2014	2015	GCDWQ*
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

*Guidelines for Canadian Drinking Water Quality-Note that none of the groundwater wells monitored are used for drinking water

Table F-2: Blind River Refinery-Lake Huron annual average results at diffuser

Parameter	2011	2012	2013	2014	2015	CCME*
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: Blind River Refinery-soil monitoring results

Parameter	2011	2012	2013	2014	2015	CCME Guidelines (µg/g)*
Minimum uranium concentration (µg/g)	0.2	0.1	0.1	0.1	0.1	**23**
Average uranium concentration (µg/g) (within 1000 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: Port Hope Conversion Facility-mass (kg) of contaminants of concern (COC) removed by pumping wells, 2011- 2015

Mass of COC (kg)	Year				
	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: Port Hope Conversion Facility-harbour water quality

Parameter	Value	2011	2012	2013	2014	2015	CCME*
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: Port Hope Conversion Facility-average uranium concentrations from the south cooling water intake

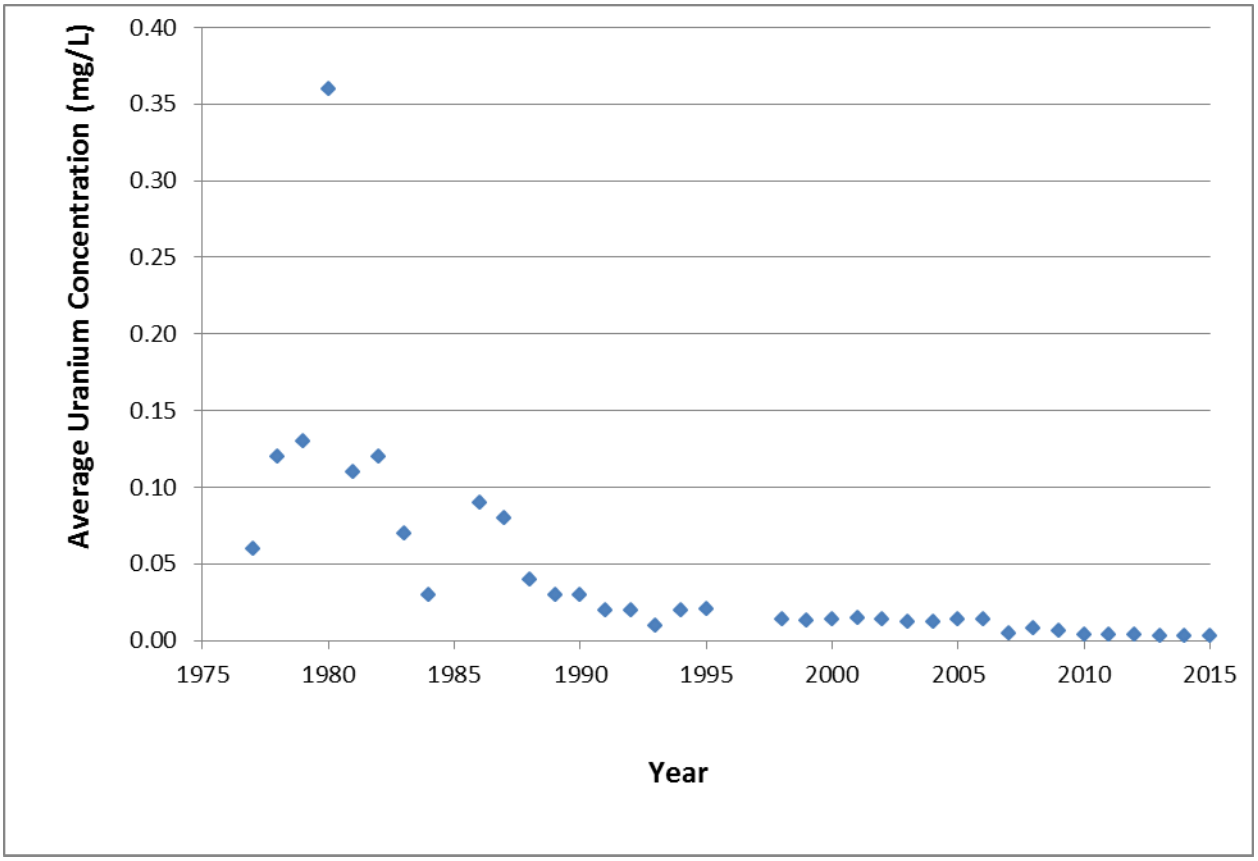


Table F-6: Port Hope Conversion Facility-uranium concentrations at Waterworks side yard remediated with clean soil (µg/g)

<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: Port Hope Conversion Facility-fluoride concentration in local vegetation

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's Upper Limit of Normal (ULN) guidelines

Cameco Fuel Manufacturing Inc.

Table F-8: Cameco Fuel Manufacturing Inc.-soil monitoring results*

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**

***** Note that CFM implements a three year soil monitoring program. CFM did not monitor soil in 2011, 2012, 2014 and 2015.
**Canadian Council of Ministers on the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (for residential and parkland land use).

GEH-C Toronto

Table F-9: GEH-C Toronto-air emission and liquid effluent monitoring results, 2011-2015

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 reflects 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 for 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 *Atmospheric Emissions*.

Table F-10: GEH-C Toronto-uranium in boundary air monitoring results, 2011-2015

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: Ontario Reg. 415/05 2016 standard for uranium in ambient air is 0.03 µg/m^3.

Table F-11: GEH-C Toronto-uranium in soil monitoring results, 2011-2012

Parameter	2011	2012
Average concentration (µg/g)	2.3	1.9
Maximum concentration (µg/g)	14.8	10.8

Table F-12: GEH-C Toronto-uranium in soil monitoring results, 2013-2015

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: GEH-C Peterborough-air emissions and liquid effluent monitoring results, 2011-2015

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

Table F-14: SRBT-atmospheric emissions monitoring results, 2011-2015

Parameter	2011	2012	2013	2014	2015	Licence limit (TBq/year)
Tritium as tritium oxide (HTO), TBq/year	12.50	8.36	17.82	10.71	11.55	**67**
Total tritium as HTO + tritium gas (HT), TBq/year	55.68	29.90	78.88	66.16	56.24	**448**

Table F-15: SRBT-liquid effluent monitoring results, 2011-2015

Parameter	2011	2012	2013	2014	2015	Licence limit (GBq/year)
Tritium-water soluble, GBq/year	8	12	9	13	7	**200**

Nordion Canada Inc.

Table F-16: Nordion (Canada) Inc.-air emissions monitoring results, 2011-2015

Parameter	2011	2012	2013	2014	2015	Derived Release Limit (GBq/year)[1]
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**

[1]Gigabecquerel per year

Table F-17: Nordion (Canada) Inc.-liquid effluent monitoring results, 2011-2015

Parameter	2011	2012	2013	2014	2015	Licence limit (GBq/year)[1]
β <1MeV	0.395	0.261	0.288	0.209	0.191	**7,780**
β>1MeV	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**

[1]Gigabecquerel per year

TRIUMF Accelerators Inc.

Table F-18: TRIUMF-air emission results, 2011-2015

Parameter	2011 (% DRL)[b]	2012 (% DRL)	2013 (% DRL)	2014 (% DRL)	2015 (% DRL)
Beta plus emitters and argon-41[a]	0.929	0.448	1.15	1.58	0.544
Tritium	0.000971	0.000220	0.000769	0.00112	0.00173
Noble gases	0.00712	0.00655	0.0126	0.00346	0.00486
Volatile and particulate	0.000037	0.0000760	0.0000584	0.0000543	0.000177
Total	0.94	0.45	1.16	1.58	0.55

a. Beta plus emitters are short-lived positron emitting radionuclides (carbon-11, nitrogen-13 and oxygen-15) as well as argon-41.
b. 100% of the Derived Release Limit equals a 1 mSv annual dose (regulatory limit for member of the public)

Table F-19: TRIUMF-liquid effluent results, 2011-2015

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. 100% of the Derived Release Limit equals a 1 mSv annual dose (regulatory limit for member of the public)

G. LOST-TIME INJURIES IN 2015

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

Facility	Lost-time injury	Action taken
Port Hope Conversion Facility	In June 2015, an employee was injured when taking a short cut 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 4ft. above the floor. The employee immediately experienced tingling and numbness throughout his left hand. This resulted in 3 days of lost time.	As a result of this event, Cameco has painted the screw conveyor and surrounding floor with a high visibility paint to identify caution when walking under the conveyor.
	In August 2015, a Cameco corporate employee working in the Science and Technology lab located at the PHCF site appeared in distress after dropping a bottle of potassium chloride. Cameco PHCF's emergency response team were immediately called for support. The potassium chloride spill was secured in a safe manner with barrier tape and cleaned up after the medical event was completed. The employee was attended to by the emergency response team and the individual was then transported by ambulance to the hospital in Coburg for further assessment. This resulted in 4 days of lost time.	As a result of this event, Cameco has reviewed the PHCF May 2015 "Monthly Safety Topic-Heat Stress" with the Science and Technology group at the 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: Cameco Fuel Manufacturing Inc.-Lost-time injuries

Facility	Lost-time injury	Action taken
Cameco Fuel Manufacturing	On January 8, 2015, a contractor was working in a tight space (not a normal working space). The individual 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 resulted in one day of lost time.	After the event, caution tape was hung around the area in question until the incident investigation was completed. A safety stand-down was held with all contractors which stressed the importance of maintaining awareness of their surroundings at all times, and the need to report any incidents immediately to both their supervisor as well as their CFM contact.

Table G-3: Best Theratronics-Lost-time injuries

Facility	Lost-time injury	Action taken
Best Theratronics	An employee twisted his knee when walking in the kitchen and supply area. This resulted in one day of lost time.	The incident was reviewed and no further action was taken.

Table G-4: TRIUMF-Lost-time injuries

Facility	Lost-time injury	Action taken
TRIUMF	An employee was splashed in the eyes with a small amount of isopropyl alcohol while draining equipment, causing redness to the eyes. This 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.
TRIUMF	An employee experienced back spasms and leg soreness as a result of lowering a heavy panel. This resulted in one day of lost time.	The incident was reviewed and no further action was taken.
TRIUMF	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 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.
TRIUMF	An employee sprained their ankle while stepping down the stairs. This resulted in six days of lost time.	The incident was reviewed and no further action was taken.

Table G-5: Canadian Light Source-Lost-time injuries

Facility	Lost-time injury	Action taken
Canadian Light Source	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, the employee only contacted the front edge of the seat. The chair then rocked forward slightly causing the employee to fall on the floor. This resulted in 2.5 days of time lost from work.	The incident was reviewed and no further action was taken.

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.	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/en
École Polytechnique de Montréal	polymtl.ca/nucleaire/en/LTN/SLP.php
TRIUMF Accelerators Inc.	triumf.ca
Canadian Light Source Inc.	lightsource.ca

I. CHANGES TO LICENCE AND LICENCE CONDITIONS HANDBOOK(S)

Table I-1: Changes to the Licence (Amendments)-by the Commission

Facility	Date	Facility Licence	Description of Change
Best Theratronics	January 2015	NSPFOL-14.01/2019	The licence was amended to direct Best Theratronics to provide an acceptable financial guarantee for the future decommissioning of its Ottawa 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 licensing basis and to incorporate written notification requirements. Incorporated licensee commitments with respect to CSA N288.3, N288.4 and N288.6. Made general formatting and edit 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 licensing basis and to incorporate improved written notification requirements. Updated to incorporate licensee commitments with respect to CSA N288.4, N288.5 and N288.6. Also, included general formatting and edit changes.

Facility	Date	Revision Number	Description of Change
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 LCH Change Request Form.
Cameco Fuel Manufacturing Inc.	August 2015	Revision 1	Updated to provide greater clarity on licensing basis and to incorporate improved written notification requirements. Updated to incorporate licensee commitments with respect to CSA N288.4, N288.5 and N288.6. CFM anticipates that it will be in full compliance with the aforementioned standards by December 31, 2017. Also, included general formatting and edit changes.
SRB Technologies	December 2015	Revision 1	Incorporated licensee commitments and target dates for compliance with respect to CSA N393 and REGDOC 2.10.1. Made general formatting and edit changes to correct errors.
Best Theratronics	January 2015	Revision 1	Updated to reflect a new date for the implementation of Best Theratronics' financial guarantee.
Best Theratronics	March 2015	Revision 2	Revised to include a funding schedule for the financial guarantee.

ACRONYMS AND ABBREVIATIONS

ALARA	As low as reasonably achievable
Ar-41	Argon-41
B^+	Beta Plus
Bq/L	Becquerel per litre
BRR	Blind River Refinery
BTL	Best Theratronics Limited
BWXT	BWXT Nuclear Energy Canada Inc.
CAMD	Center for Advanced Microstructures and Devices
CCME	Canadian Council of Ministers of the Environment
CFI	Canadian Foundation for Innovation
CFM	Cameco’s Fuel Manufacturing Inc.
CIRS	Cameco Incident Reporting System
CLS	Canadian Light Source Inc.
CMD	Commission member document
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
Co-60	Cobalt-60
COC	Contaminants of concern
Cs-137	Cesium-137
CSA	Canadian Standards Association
CSSC	Conversion Safety Steering Committee
DRL	Derived release limit
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
EHS	Environment, Health and Safety
EIR	Event Initial Report
EMS	Environmental Management System
E/OH&S	Environmental and Occupational Health and Safety
EPD	Electronic Personnel Dosimeter
ÉPM	École Polytechnique de Montréal

ESDC	Employment and Social Development Canada (formerly Human Resources and Skills Development Canada HRSDC)
ERA	Environmental Risk Assessment
EU	European Union
FHSC	Facility Health and Safety Committee
FSD	Fuel Services Division
GBq	Gigabecquerel
GCDWQ	Guidelines for Canadian Drinking Water Quality
GEH-C	General Electric-Hitachi Canada
GeV	Giga-electronvolt
GTLS	Gaseous tritium light sources
HEU	Highly enriched uranium
HSC	Health and Safety Committee
I-125	Iodine-125
IAEA	International Atomic Energy Agency
IEMP	Independent Environmental Monitoring Program
ISO	International Organization for Standardization
JH&SC	Joint Health and Safety Committee
KOH	Potassium hydroxide
KPI	Key performance indicator
Kg	Kilogram
kW	Kilowatt
LCH	Licence Conditions Handbook
LEU	Low-enriched uranium
LTI	Lost-time injury
MeV	Mega-electronvolt
mg/L	Milligram per litre
MFN	Mississauga First Nation
MNR	McMaster Nuclear Reactor
mSv	Millisievert
MOECC	Ontario's 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.
NRU	National Research Universal
NSCA	*Nuclear Safety and Control Act*
OHS	Occupational Health and Safety
OHSAS	Occupational Health and Safety Assessment Series
OHSC	Occupational Health and Safety Committee
OPG	Ontario Power Generation
ORL	Operating Release Level
PHCF	Port Hope Conversion Facility
PPE	Personal Protective Equipment
ppm	Parts per million
RMCC	Royal Military College of Canada
RP	Radiation Protection
SANS	Small Angle Neutron Scattering
SAT	Systematic Approach to Training
SCA	Safety and control area
SLOWPOKE	Safe Low Power Kritical Experiment
SRBT	SRB Technologies (Canada) Incorporated
SRC	Saskatchewan Research Council
SSC	Systems, structures and components
TBq	Terabequerel
TLD	Thermoluminescent dosimeters
TRIUMF	TRIUMF Accelerators Inc.
TSP	Total suspended particulate
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
WHSC	Workplace Health and Safety Committee
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 (Bq)

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 established by section 8 of the 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, associated with that development, production, possession or use
   - prevent unreasonable risk to national security associated with that development, production, possession or use
   - 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, on the environment and on the health and safety of persons, of the development, production, possession and use referred to in paragraph a)

Commission member document (CMD)

A document prepared for Commission hearings and meetings by CNSC staff, proponents and interveners. Each 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 (DRL)

As defined in the CSA Group publication CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*:

- the release rate that would cause an individual of the most highly exposed group to receive and be committed to a dose equal to the regulatory annual dose limit due to release of a given radionuclide to air or surface water during normal operation of a nuclear facility over the period of a calendar year

effective dose

The sum of the products, in Sievert, 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 Sievert, 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 injury or illness resulting in lost days beyond the date of injury as a direct result of an occupational injury or illness incident.

nuclear energy worker (NEW)

A person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.

reporting limit

The smallest concentration or amount of analyte that can be reported by a laboratory.

root-cause analysis

An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event, which 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.

unsealed source

A radioactive nuclear substance that is not contained in a sealed capsule of in a cover to which the substance is bonded.

ATTACHMENT

École Polytechnique

Le réacteur SLOWPOKE-2 de l'École Polytechnique de Montréal (EPM) se trouve sur le campus de l'Université de Montréal, à Montréal (Québec). Il se situe plus précisément au rez-de-chaussée de l'édifice principal de l'EPM, comme l'illustre la figure 13-8. Le réacteur, qui est en exploitation depuis 1976, est utilisé pour la recherche, l'enseignement, l'analyse neutronique et la production d'isotopes. Le cœur du réacteur est composé d'uranium faiblement enrichi (UFE).

Figure 13-8 : Vue aérienne de l'École Polytechnique de Montréal, à Montréal (Québec)

Rendement

Pour 2015, le personnel de la CCSN a continué de maintenir la cote de rendement de l'EPM à « Satisfaisant » pour tous les DSR. Les cotes de rendement de l'EPM de 2011 à 2015 figurent dans le tableau C-12 de l'annexe C.

Au cours de la période d'examen, l'EPM était conforme à la LSRN, aux règlements d'application et à son permis d'exploitation d'un réacteur nucléaire de faible puissance (PERFP-9A.00/2023). Pendant la même période, l'installation a été exploitée de manière sûre et fiable, et aucun problème opérationnel n'a été signalé. Les activités opérationnelles et l'utilisation des installations sont demeurées les mêmes que pour les périodes d'examen précédentes.

En septembre 2015, le personnel de la CCSN a effectué une inspection sur place à l'installation SLOWPOKE-2 de l'EPM pour vérifier la conformité à la LSRN et à ses règlements d'applications, au permis d'exploitation de l'EPM et aux programmes dont elle se sert pour respecter ses exigences réglementaires.

L’inspection était axée sur le système de gestion, la formation, la radioprotection, la santé et sécurité classiques et la protection de l’environnement. Aucune des constatations découlant de cette inspection n’a posé un risque immédiat ou déraisonnable pour la santé, la sûreté et la sécurité des travailleurs canadiens et pour l’environnement.

L’EPM a présenté un plan de déclassement préliminaire mis à jour et des garanties financières. Le personnel de la CCSN procède à l’évaluation des documents soumis et présentera une mise à jour à la Commission à l’occasion de la présentation du rapport de surveillance réglementaire.

École Polytechnique-Assemblage sous-critique

L’assemblage sous-critique de l’École Polytechnique se trouve sur le campus de l’Université de Montréal, à Montréal (Québec), et il est entouré d’un corridor, d’un laboratoire d’analyse par activation neutronique, d’un laboratoire de radiochimie, d’une salle de classe et des fondations de l’édifice. L’assemblage est constitué de barres d’uranium naturel insérées dans des blocs de graphite. L’assemblage sous-critique sert uniquement à des fins d’enseignement et de recherche. Pendant les périodes d’inactivité de l’assemblage, les barres d’uranium sont remises dans une boîte de stockage blindée et verrouillée, et les sources neutroniques sont enfermées et verrouillées dans des contenants blindés. L’assemblage sous-critique pose un très faible risque et son utilisation est très limitée (environ une fois tous les cinq ans).

Le 2 juillet 2015, l’EPM a demandé la révocation de son permis d’exploitation d’un assemblage sous-critique de faible puissance, PERFP-9.00/2016, et la modification du permis d’exploitation du réacteur SLOWPOKE-2, PERFP-9A.00/2023, afin d’y inclure l’exploitation de l’assemblage sous-critique de faible puissance. Cette demande a été traitée et acceptée dans le cadre d’un processus d’audience abrégé de la Commission composé d’un seul membre et ayant eu lieu le 30 juin 2016 (CMD 16-H107). L’autorisation d’exploitation de cet assemblage à faible risque est désormais intégrée au permis d’exploitation du réacteur SLOWPOKE-2 (PERFP-9A.01/2023).

Rendement

Pour 2015, le personnel de la CCSN a continué de maintenir la cote de rendement de l’assemblage sous-critique de l’EPM à « Satisfaisant » pour tous les DSR. Les cotes de rendement de 2011 à 2015 figurent dans le tableau C-13 de l’annexe C.

Pour ce type d’installation à faible risque, une inspection de vérification de la conformité sur place est réalisée habituellement tous les cinq ans lorsque l’installation est en exploitation. La dernière fois que l’installation a été exploitée était en mars 2012, et le personnel de la CCSN a réalisé une inspection de la conformité à ce moment-là.

Le titulaire du permis a l'obligation d'aviser la CCSN de son intention d'utiliser l'installation avec suffisamment de préavis afin de permettre au personnel de la CCSN de coordonner une inspection. Il n'y a eu aucun changement dans le rendement de l'installation depuis le renouvellement de son permis.