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Safety Commission

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de sûreté nucléaire

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Annual Report

Rapport annuel

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

**Rapport de surveillance
réglementaire des
installations de
traitement de l'uranium et
des substances
nucléaires au Canada :
2016**

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Summary

This Commission Member Document (CMD) is on the *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016* and is presented to the Commission.

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

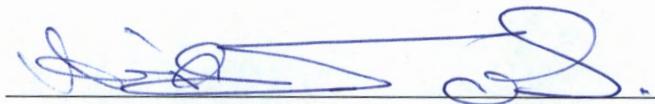
Résumé

Ce document à l'intention des commissaires (CMD) porte sur le *Rapport de surveillance réglementaire des installations de traitement de l'uranium et des substances nucléaires au Canada : 2016* et est présenté à la Commission.

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

Signed/signé le

13 October 2017



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Executive Summary

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

The report focuses on three safety and control areas (SCAs): radiation protection, environmental protection, and conventional health and safety. These three SCAs reflect the overall effectiveness of the implementation of licensee programs, and represent a good indication of the safety performance of 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 2016 calendar year, the performance of all uranium and nuclear substance processing facilities in all 14 SCAs was rated as “satisfactory” or better. Through regulatory oversight activities, CNSC staff confirmed that uranium and nuclear substance processing facilities in Canada continued to operate safely during 2016. 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 licensees.

CNSC staff's compliance activities confirmed that:

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

CNSC staff conclude that in 2016, 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, and Canada's international obligations.

The full report and the documents referenced in it are available to the public upon request.

1 OVERVIEW

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

Each year, CNSC staff assess the overall safety performance of the Canadian uranium and nuclear substance processing facilities, looking at each industry as a whole and at the performance of each facility. For 2016, this assessment is summarized in this *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016*. The assessment aligns with the legal requirements of the *Nuclear Safety and Control Act* [1] (NSCA) and the regulations made under the NSCA, a facility's licence conditions, and applicable standards and regulatory documents.

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

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

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

1.1 Canada's uranium and nuclear substance processing facilities

The *Regulatory Oversight Report for Uranium and Nuclear Substance Processing Facilities in Canada: 2016* summarizes the CNSC staff assessment of the safety performance of the following licensees, which are all located in Ontario:

- uranium processing facilities

- Cameco Corporation Blind River Refinery in Blind River, ON (FFOL-3632.00/2022)
- Cameco Corporation Port Hope Conversion Facility in Port Hope, ON (FFOL-3631.00/2027)
- Cameco Fuel Manufacturing Inc. in Port Hope, ON (FFOL-3641.00/2022)
- BWXT Nuclear Energy Canada (formerly GE Hitachi Nuclear Energy Canada Inc.) in Peterborough, ON (FFOL-3620.01/2020)
- BWXT Nuclear Energy Canada (formerly GE Hitachi Nuclear Energy Canada Inc.) in Toronto, ON (FFOL-3620.01/2020)
- nuclear substance processing facilities
 - SRB Technologies (Canada) Inc. in Pembroke, ON (NSPFOL-13.00/2022)
 - Nordion (Canada) Inc. in Ottawa, ON (NSPFOL-11A.00/2025)
 - Best Theratronics Ltd. in Ottawa, ON (NSPFOL-14.01/2019)

1.2 Regulatory oversight

The CNSC regulates the nuclear sector in Canada, including Canada's uranium and nuclear substance processing facilities, to:

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

The CNSC regulates these facilities through licensing, reporting, verification and enforcement activities. For each facility, CNSC staff conduct onsite inspections, assessments, reviews, and evaluations of licensee programs, processes and safety performance reports. The CNSC uses a risk-informed approach when conducting regulatory oversight activities 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 risks associated with the activities at the facility.

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

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

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

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

CNSC staff also verify compliance through desktop reviews of reports and licensee programs, which are supplemented with meetings with licensees, presentations and facility visits.

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

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

1.3 Safety and control area framework

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

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

- fully satisfactory (FS)

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

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

A licensee's performance is measured by its ability to minimize all risks posed by the licensed activity and to comply with all regulatory requirements. Performance in each SCA is continually assessed by CNSC staff. It is important to understand that each SCA is evaluated individually and every facility has different inputs into the annual rating for a specific SCA. For example, a rating may not have an input from onsite inspections if no onsite inspections were conducted in the area during the year. In these cases, the rating input is based on CNSC staff review of the information provided by the licensees in their annual compliance reports, and through desktop reviews of other performance reports submitted by licensees to the CNSC.

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

1.4 CNSC Independent Environmental Monitoring Program

Under the NSCA [1], the CNSC requires each nuclear facility licensee to develop, implement and maintain an environmental monitoring program to demonstrate that the public and the environment are protected from emissions related to the facility's nuclear activities. The results of these monitoring programs are submitted to the CNSC to ensure compliance with applicable guidelines and limits, as set out in regulations that oversee Canada's nuclear industry.

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

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

In 2016, CNSC staff conducted independent environmental monitoring at BWXT Nuclear Energy Canada (BWXT) in Toronto, Ontario and at Nordion (Canada) Inc. (Nordion) in Ottawa, Ontario. The 2016 IEMP results, which can be found on the CNSC's [IEMP Web page¹](#), indicate that the public and the environment in the vicinity of these facilities are protected and safe.

1.5 Overall conclusions

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

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

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

CNSC staff's compliance activities confirmed that:

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

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

¹ <http://nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/iemp/index-iemp.cfm>

PART I: URANIUM PROCESSING FACILITIES

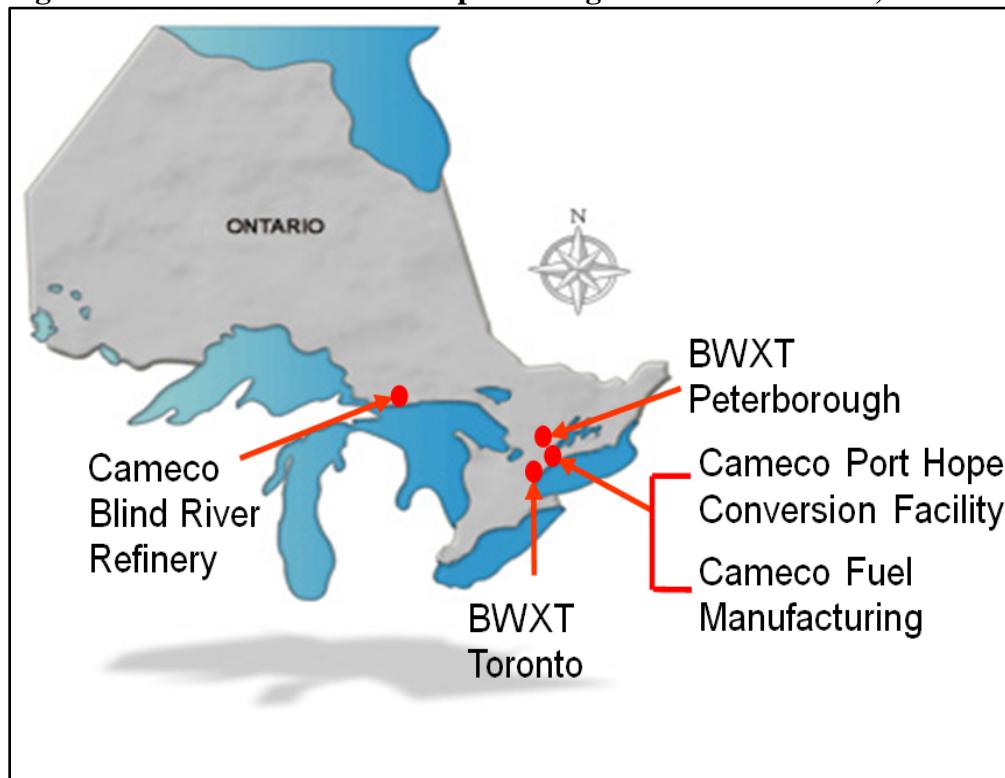
2 OVERVIEW

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

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

All five facilities are located in the Province of Ontario, as shown in figure 2-1. In November 2016, a public Commission proceeding was held in the community of Port Hope, ON regarding the renewal of Cameco's PHCF operating licence. The Commission renewed the licence for PHCF in March 2017; the licence will expire in February 2027. The licences for the BRR and CFM facilities were issued in March 2012 and will expire in February 2022. The two BWXT facilities operate under a combined licence that was issued in January 2011 and expires in December 2020.

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



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

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

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

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

The CNSC requires that each uranium processing facility licensee submit an annual compliance report by March 31 every year, as per its operating licence. These reports contain facility performance information such as annual production volumes, improvements to programs in all SCAs, and details related to environmental, radiological and safety performance, including any events and associated corrective actions. CNSC staff review these reports as part of normal regulatory compliance oversight to verify that licensees are complying with regulatory requirements and are operating safely. The full versions of these reports are available on the licensees' websites, as provided in appendix H.

The SCA performance ratings of uranium processing facilities are presented in table 2-2. For 2016, CNSC staff ratings for all individual SCAs were "satisfactory" for the uranium processing facilities, except for the Blind River Refinery, which was given a "fully satisfactory" rating in the conventional health and safety SCA. Additional information about this SCA rating is in the facility-specific section on the Blind River Refinery. Appendix C contains the SCA ratings from 2012 to 2016 for each facility.

Table 2-2: SCA performance ratings, uranium processing facilities, 2016

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

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

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

2.1 Radiation protection

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

This SCA encompasses the following specific areas:

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

Based on regulatory oversight activities, CNSC staff rated the performance of the uranium processing facilities for the radiation protection SCA as “satisfactory” in 2016, unchanged from the previous year.

Ratings for radiation protection SCA, uranium processing facilities, 2016

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

Application of ALARA

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

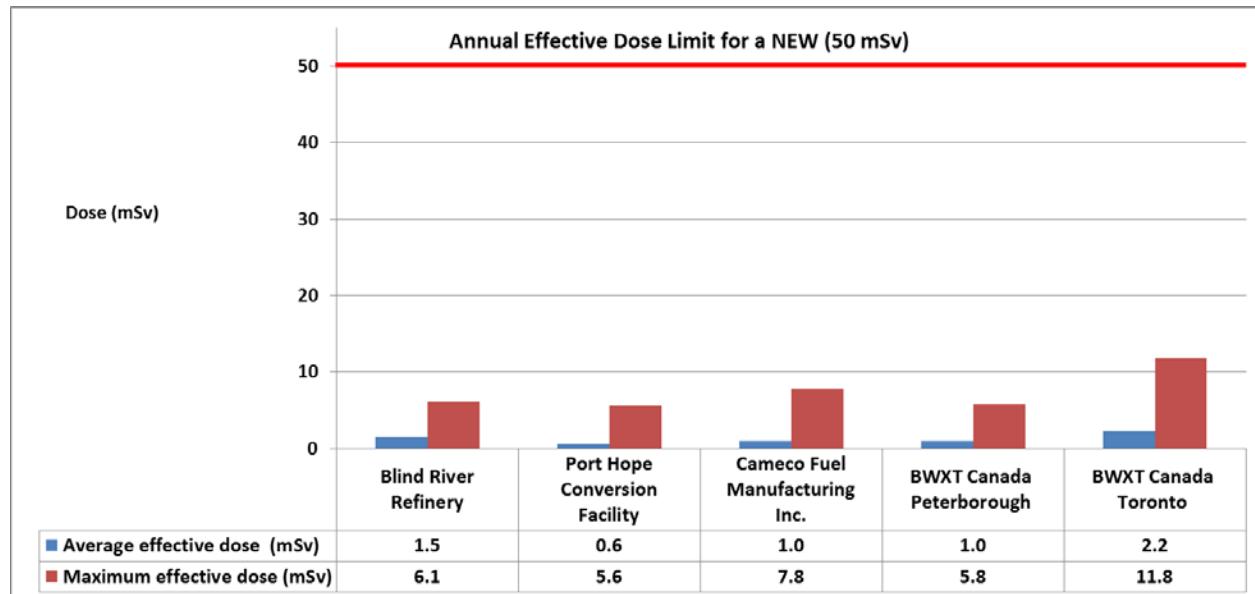
Worker dose control

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

During 2016, all uranium processing facility licensees monitored and controlled the radiation exposures and doses received by all persons present at their licensed facilities, including workers, contractors and visitors. Taking into consideration the inherent differences in the design of radiation protection programs 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 2016, the maximum individual effective dose received by a NEW at all facilities ranged from 5.6 millisieverts (mSv) to 11.8 mSv, which is well below the regulatory dose limit of 50 mSv/year for a NEW. These results are further discussed in the respective sections for each facility.

Figure 2-2: Average and maximum effective doses to NEWs, uranium processing facilities, 2016



Radiation protection program performance

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

Action levels

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time, depending on operational and radiological conditions.

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

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

Radiological hazard control

CNSC staff verified that 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 2016, levels of radioactive contamination were controlled within their facilities.

Estimated dose to the public

The maximum dose to the public from licensed activities at each uranium processing facility is calculated using monitoring results from air emissions, liquid effluent releases and fence-line gamma monitoring. The CNSC's requirements to apply ALARA principles ensure that licensees monitor their facilities and keep doses to the public below the annual public dose limit of 1 mSv/year.

Table 2-3 provides a comparison of estimated public doses from 2012 to 2016 for the uranium processing facility licensees. Estimated doses to the public from all uranium processing facility licensees continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Table 2-3: Public dose comparison table (mSv), uranium processing facilities, 2012-2016

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

**Beginning in 2014, GEH-C (now BWXT) Toronto implemented environmental gamma-exposure monitoring using licensed dosimeters and began to include this result in its estimated annual public dose.

Conclusion on Radiation Protection

CNSC staff conclude that the uranium processing facility licensees effectively implemented and maintained their radiation protection programs during 2016 to ensure the health and safety of persons working in their facilities.

2.2 Environmental protection

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

It encompasses the following specific areas:

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

Based on regulatory oversight activities, CNSC staff rated the performance of the uranium processing facilities for the environmental protection SCA as "satisfactory" in 2016, unchanged from the previous year.

Ratings for environmental protection SCA, uranium processing facilities, 2016

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

Effluent and Emissions Control (Releases)

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

In 2016, there was one environmental action level exceedance across all uranium processing facility licensees. The exceedance was at the Cameco Fuel Manufacturing Facility, and is further discussed in section 5.3. Cameco reported the action level exceedance to the CNSC, investigated the exceedance, and established corrective actions to the satisfaction of CNSC staff.

Environmental Management System

The CNSC requires that licensees develop and maintain environmental management systems that provide a framework for integrated activities related to environmental protection. The environmental management systems are described in approved environmental management programs, and include activities such as establishing annual environmental objectives and targets. Licensees conduct internal audits of their programs at least once every year. CNSC staff, as part of their compliance verification activities, review and assess these objectives, goals and targets. CNSC staff have determined that, the uranium processing facility licensees established and implemented environmental management systems in compliance with CNSC regulatory requirements in 2016.

Assessment and Monitoring

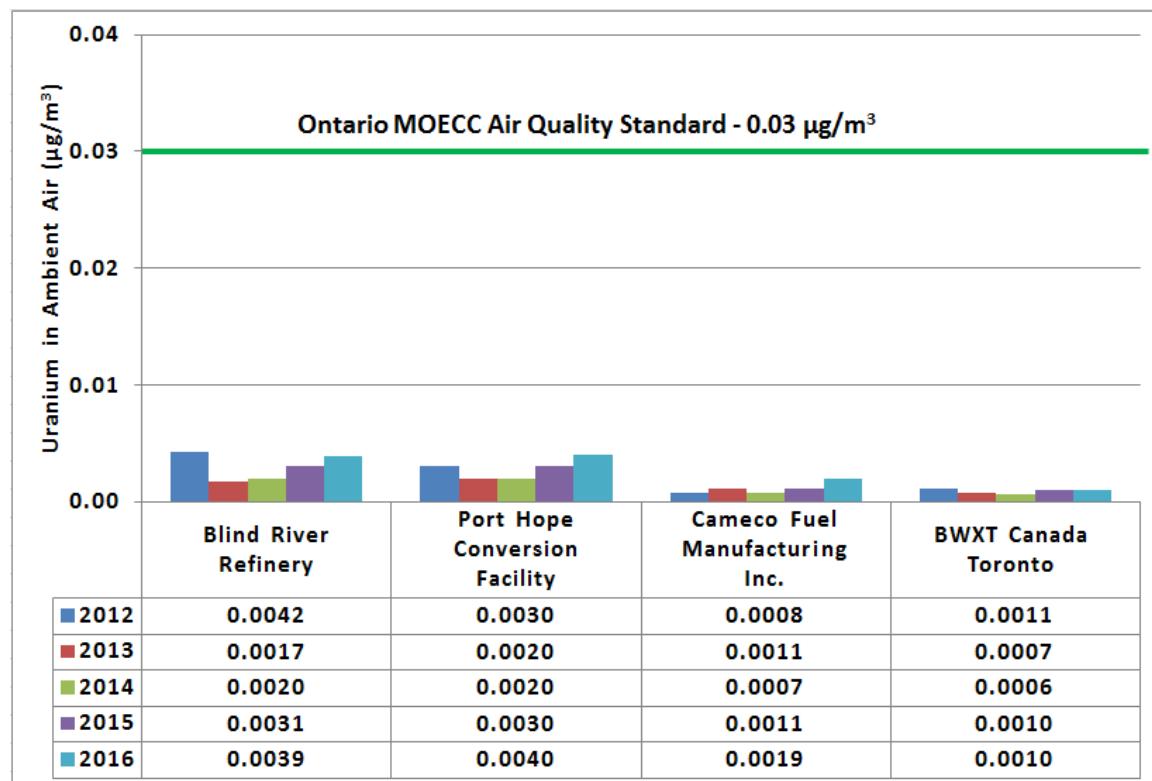
Each uranium processing facility licensee has environmental monitoring programs to monitor releases of nuclear and hazardous substances, and to characterize the quality of the environment associated with the licensed facility. These programs include the monitoring of uranium in ambient air and uranium in soil, described below.

Uranium in ambient air

Licensees measure uranium in ambient air to confirm the effectiveness of emission abatement systems and to monitor the impact of uranium emissions on the environment. The three Cameco facilities and BWXT Toronto operate high-volume air samplers at the perimeter of their facilities. BWXT Peterborough does not use fence-line air samplers, as stack emissions at the point of release already meet the Ontario Ministry of the Environment and Climate Change (MOECC) air standard for uranium ($0.03 \mu\text{g}/\text{m}^3$).

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

Figure 2-3: Uranium concentration in ambient air (maximum annual average), uranium processing facilities, 2012–2016



Uranium in soil

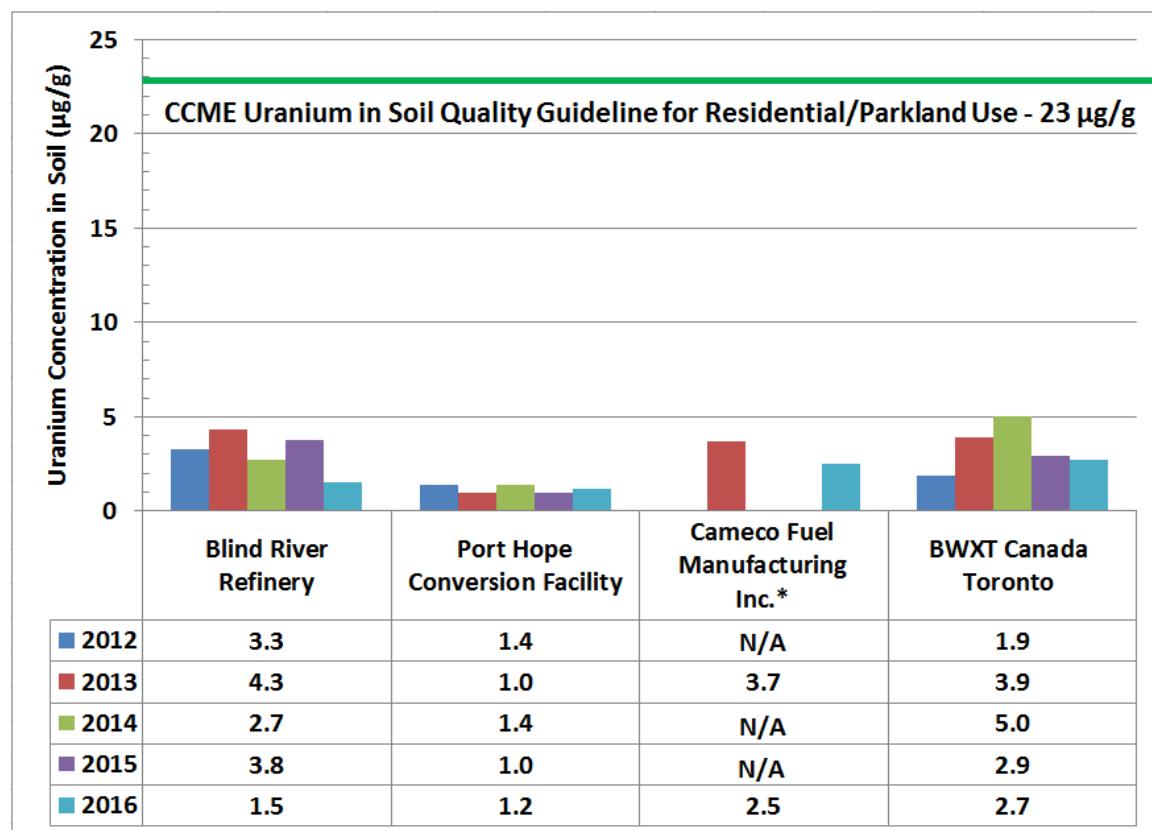
The three Cameco facilities and BWXT Toronto have soil monitoring programs to monitor the long-term effects of air emissions and to determine whether there is accumulation of uranium in soil in the vicinity of the facility. The sampling frequency at CFM is every three years, and annual at the other facilities.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

BWXT Peterborough does not conduct uranium-in-soil monitoring, as uranium releases from the BWXT Peterborough facility are negligible; the fuel pellets received from the Toronto facility are in solid form and uranium releases to air are very low. As described in the previous section, BWXT monitors the stack to confirm that releases to air remain low.

CNSC staff evaluated the results of licensees' soil sampling programs for 2016 and compared them to previous years. The results continue to indicate that there is no accumulation of uranium in surrounding soil due to current uranium emissions from the uranium processing facilities.

Figure 2-4 provides the annual average uranium concentrations in soil results for 2012 through 2016. In Ontario, natural background concentrations of uranium in soil are generally below 2.5 µg/g. The annual average concentrations of uranium in soil at uranium processing facilities are similar to natural background levels and well below the applicable guideline value for the land-use type, as described by the Canadian Council of Ministers of the Environment (CCME) soil quality guideline for residential and parkland use, which is 23 µg/g.

Figure 2-4: Uranium concentration in soil (annual average), uranium processing facilities, 2012-2016



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

Protection of the Public

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

Environmental Risk Assessment

Environmental risk assessments (ERA) are used to analyze the risks associated with contaminants in the environment as a result of licensed activities.

Environmental risk assessments provide the basis for the scope and complexity of environmental monitoring programs at the uranium processing facilities. The uranium processing facility licensees currently have acceptable environmental programs in place to ensure the protection of the public and the environment.

In 2014, CNSC staff requested that the uranium processing facilities implement CSA N288.6-12 *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3] in order to align with the design, implementation, and management of an environmental risk assessment program that incorporates best practices used in Canada and internationally. Work is underway to transition the uranium processing facilities to CSA N288.6-12. CNSC staff expect that all uranium processing facility licensees will fully implement CSA N288.6-12 by the end of 2017. CNSC staff will continue to review the licensees' respective documentation in order to address the compliance requirements of the standard.

Conclusion on Environmental Protection

CNSC staff conclude that the uranium processing facility licensees implemented their environmental protection programs satisfactorily during 2016. The licensees' programs are effective in protecting the health and safety of the public and the environment.

2.3 Conventional health and safety

This SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

It encompasses the following specific areas:

- performance
- practices
- awareness

Based on regulatory oversight activities, CNSC staff rated the performance of the uranium processing facilities for the conventional health and safety SCA as "satisfactory" in 2016, with the exception of the Blind River facility, which was given a "fully satisfactory" rating. These ratings are unchanged from the previous year.

Ratings for conventional health and safety SCA, uranium processing facilities, 2016

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

Performance

The regulation of conventional health and safety at uranium processing facilities involves both the Employment and Social Development Canada (ESDC) and the CNSC. Licensees submit hazardous occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements. Licensees are required to report unsafe occurrences to the CNSC as directed by section 29 of the *General Nuclear Safety and Control Regulations* [4]. These reports include serious illnesses or injuries incurred or possibly incurred as a result of licensed activity. The number of recordable lost-time injuries (LTIs) reported by all facilities has remained low over the past five years, as summarized in table 2-4. Further information is provided in facility-specific sections as well as appendix G.

Table 2-4: LTIs uranium processing facilities, 2012–16

| Facility | 2012 | 2013 | 2014 | 2015 | 2016 |
|---------------------------------------|------|------|------|------|------|
| Blind River Refinery | 0 | 0 | 0 | 0 | 0 |
| Port Hope Conversion Facility | 1 | 0 | 1 | 2 | 3 |
| Cameco Fuel Manufacturing Inc. | 0 | 0 | 0 | 1 | 0 |
| BWXT Toronto and Peterborough | 1 | 0 | 1 | 0 | 0 |

Practices

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

CNSC staff conducted desktop reviews and onsite inspections at all uranium processing facilities during 2016 to verify compliance of the licensees' conventional health and safety programs with regulatory requirements. Through these regulatory oversight activities, CNSC staff determined that the uranium processing facility licensees met all regulatory requirements for this specific area.

Awareness

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

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

Conclusion on Conventional Health and Safety

CNSC staff conclude that the uranium processing facility licensees implemented their conventional health and safety programs satisfactorily during 2016. Their programs are effective in protecting the health and safety of persons working in the facilities.

2.4 Public information and disclosure programs

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

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

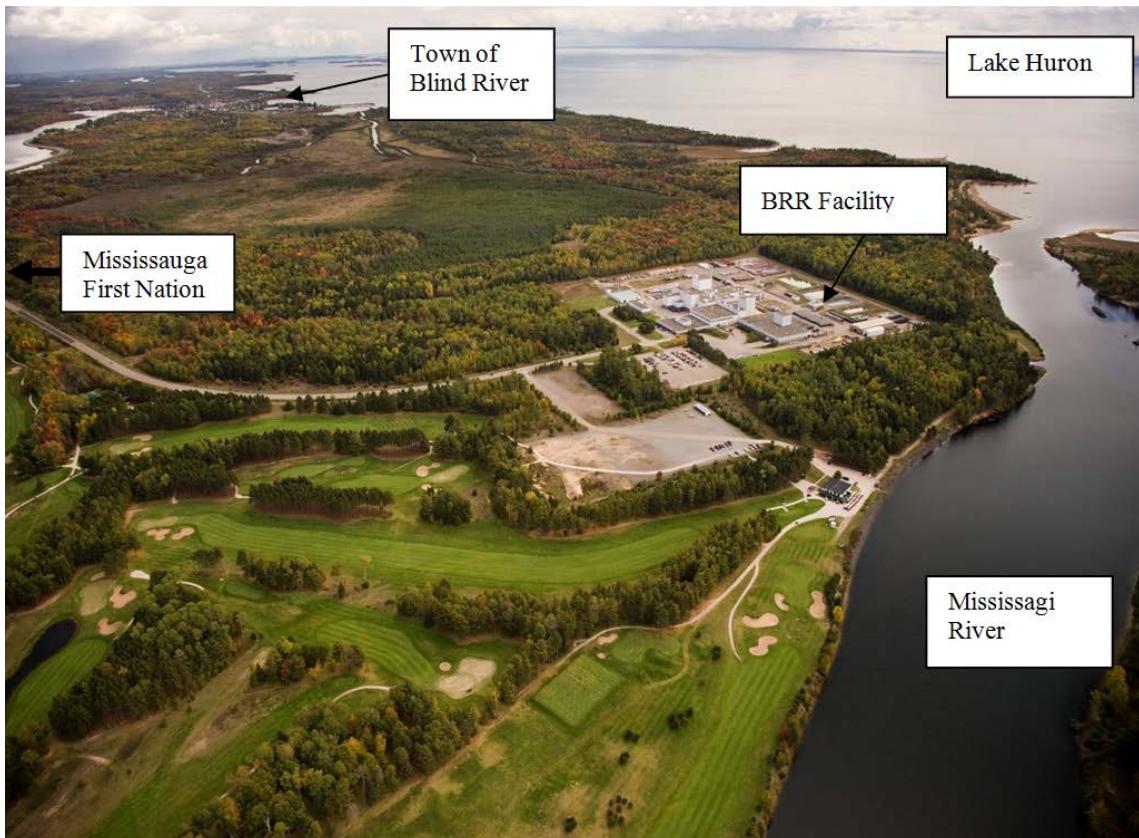
Licensees also issued information in accordance with their public disclosure protocols. Licensees' follow their public disclosure protocols to disclose information and reports of interest to the public, including routine and non-routine situations, events and activities. In 2016, Cameco posted event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

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

3 CAMECO BLIND RIVER REFINERY

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

Figure 3-1: Aerial view of the 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.

Figure 3-2: Shipping totes used to transfer UO₃ from Blind River Refinery to the Port Hope Conversion Facility



3.1 Performance

For 2016, 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 2012 to 2016 are provided in table C-1, appendix C.

Cameco continued to operate BRR in a safe manner throughout 2016. The facility underwent two planned shutdowns during the course of the year to conduct routine maintenance activities and implement facility upgrades. Cameco ensured that the BRR site was maintained according to the BRR's licensing basis.

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

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

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

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

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

3.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Blind River Refinery, 2012-2016:

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

Application of ALARA

Cameco established radiation protection objectives and targets for BRR in 2016, focused on reducing worker doses and airborne uranium concentrations.

Cameco's objectives included improvements to the respiratory protection program and implementation of additional continuous air monitors in work areas.

Cameco's site management team reviewed the status of the objectives and targets and allocated resources as required to achieve the targets. Cameco also utilizes an ALARA committee which makes recommendations for improving radiation protection at BRR.

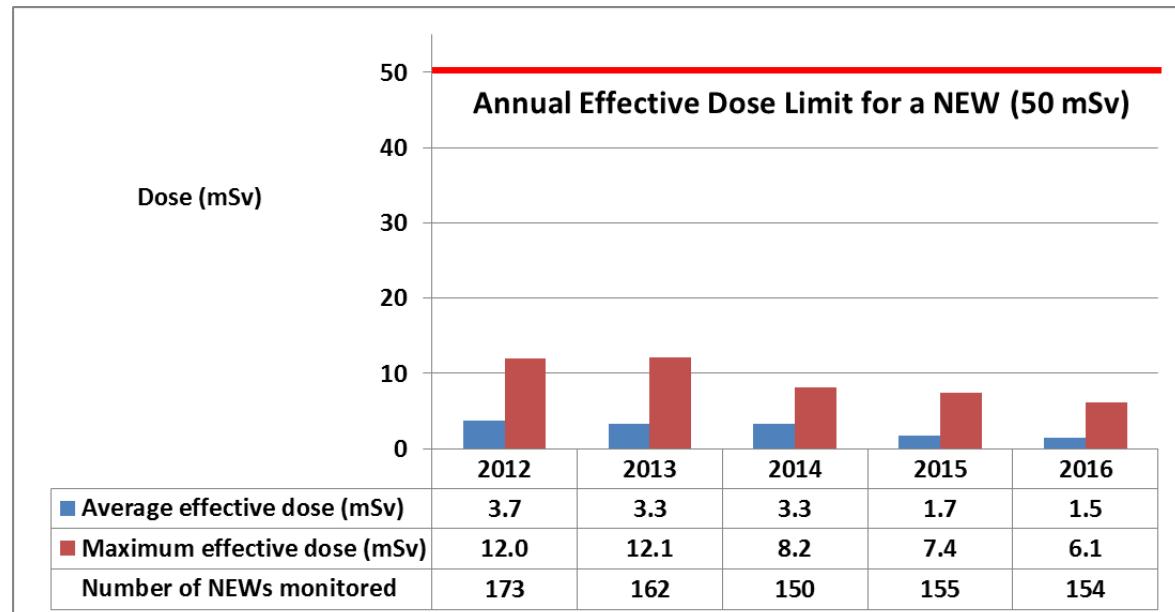
Worker dose control

Cameco ascertains external doses using whole body and extremity dosimetry. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at BRR. Internal dose is assessed and assigned at BRR through two programs: 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/year. In 2016, total effective dose was assessed for 154 NEWs at BRR, consisting of 138 Cameco employees and 16 contractors. The maximum effective dose received by a NEW in 2016 was 6.1 mSv, which is approximately 12 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

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

Figure 3-3: Average and maximum effective doses to NEWs, Blind River Refinery, 2012-2016



Average and maximum effective doses at BRR show a decreasing trend, likely due to the decrease in UO₃ production over these years.

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-7 and E-1 in appendix E. In 2016, the maximum skin dose received by a NEW at BRR was 26 mSv, which is approximately 5 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 10.6 mSv, which is approximately 2 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The average and maximum equivalent doses at BRR are relatively stable between 2012 and 2014, and thereafter show a decreasing trend, again likely due to the decrease in UO₃ production over these years.

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

Radiation protection program performance

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

Action levels for radiological exposures are established as part of the radiation protection program. If an action level is reached, it triggers Cameco staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2016, there were no instances at BRR where an action level was reached.

Radiological hazard control

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

Estimated dose to the public

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

Table 3-1: Maximum effective dose to a member of the public, Blind River Refinery, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory Dose Limit |
|------------------------------|-------|-------|-------|-------|-------|-----------------------|
| Maximum effective dose (mSv) | 0.012 | 0.012 | 0.005 | 0.005 | 0.005 | 1 mSv/year |

3.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Blind River Refinery, 2012-2016:

| 2012 | 2013 | 2014 | 2015 | 2016 |
|--|------|------|------|------|
| SA | SA | SA | SA | SA |
| For 2016, CNSC staff 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 Ministry of Environment and Climate Change (MOECC)'s applicable regulations and the certificates of approval. The measured releases to the environment were well below regulatory limits during 2016. Groundwater monitoring, surface water monitoring, soil sampling and ambient air data indicate that the public and the environment continue to be protected from facility releases. | | | | |

Effluent and Emissions Control (Releases)

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

Atmospheric Emissions

Cameco monitors uranium, nitrogen oxides + nitric acid, and particulates released from the facility stacks. The monitoring data in table 3-2 demonstrate that atmospheric emissions from the facility continued to be effectively controlled as they were consistently well below their respective licence limits in 2012-2016.

Table 3-2: Blind River Refinery – air emissions monitoring results (annual averages), 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limit |
|---|-------------|-------------|-------------|-------------|-------------|----------------------|
| Dust collection and exhaust ventilation stack – uranium (kg/h) | 0.00006 | 0.00004 | 0.00005 | 0.00005 | 0.00005 | 0.1 |
| Absorber stack – uranium (kg/h) | 0.00001 | <0.00001 | <0.00001 | 0.00001 | 0.00001 | 0.1 |
| Incinerator stack – uranium (kg/h) | <0.00001 | <0.00001 | <0.00001 | <0.00001 | <0.00001 | 0.01 |
| Nitrogen oxides (NO_x) + nitric acid (HNO₃) (kg NO₂/h) | 3.3 | 3.4 | 2.0 | 2.5 | 1.6 | 56.0 |
| Particulate (kg/h) | 0.024 | 0.014 | 0.009 | 0.006 | 0.006 | 11.0 |

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

In addition to licence limits, BRR has action levels that are used to provide assurance that the licence release limits will not be exceeded. Action levels provide early indication of a potential loss of control of part of the environmental protection program and triggers a requirement for specific action to be taken. No action levels for atmospheric emissions were exceeded at any time in 2016.

Liquid Effluent

There are three sources of allowable liquid effluent from the BRR facility: plant effluent, storm water runoff and sewage treatment plant effluent. These effluents are collected in lagoons and treated, as required, prior to 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 2012 to 2016 are summarized in table 3-3. For 2016, the liquid discharges from the facility continued to be below their respective licensed limits.

Table 3-3: Blind River Refinery – liquid effluent monitoring results (annual averages), 2012-2016

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

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

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

Environmental Management System

Cameco has developed and maintains an Environmental Management System (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 completed five out of six of its environmental objectives set for 2016. These completed objectives are related to liquid effluent discharge volume reduction, shredded drum disposal, an update of site EMS documentation, floor sump evaluation, and an absorbent materials assessment. The sixth objective was carried over to 2017 and is related to the identification and implementation of a suitable shredded drum shielding replacement.

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

Assessment and Monitoring

Cameco's environmental monitoring programs serve to demonstrate that the BRR site emissions of nuclear and hazardous substances are properly controlled. The program also provides data for estimates of annual radiological dose to the public to ensure that the public exposure 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 BRR site.

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

Uranium in Ambient Air

The concentrations of uranium in the ambient air as monitored by Cameco's sampling network around the facility continue to be consistently low. In 2016, the highest annual average concentration (amongst the sampling stations) of uranium in ambient air measured was 0.0039 µg/m³, which is well below the MOECC's standard for uranium in ambient air of 0.03 µg/m³.

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 BRR operations are not causing any adverse impact to groundwater quality. The average uranium concentration in groundwater decreased in 2016 compared to 2015. The maximum sampled uranium concentration in the groundwater was 14.0 µg/L in 2016, which is below the maximum acceptable concentration of 20 µg/L in the Guidelines for Canadian Drinking Water Quality (GCQWQ). Although the groundwater in the area is not used for drinking water, CNSC staff encourage the licensee apply the as low as reasonably achievable principle, where technology is available, to eliminate off-site impacts as much as possible. Groundwater monitoring results are provided in table F-1, appendix F.

Surface Water Monitoring

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

Soil Monitoring

Cameco collects 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 on soil quality due to deposition of airborne uranium on soil in the vicinity of the BRR facility. The 2016 soil monitoring results remained consistent with the respective concentrations detected in previous years (table F-3, appendix F). The maximum uranium soil concentrations measured near the facility continue to be slightly above the Ontario background of 2.5 µg/g near the facility, in the range of natural background at both the Mississauga First Nation and the Blind River communities, and well below 23 µg/g, which is the most restrictive CCME soil quality guideline for uranium (i.e., residential and parkland land use). Uranium soil concentrations do not appear to increase in the area surrounding the facility. These data demonstrate that current BRR operations do not contribute to accumulation of uranium in surrounding soil, and that no adverse consequences to relevant human and environmental receptors are expected.

Gamma Monitoring

A significant portion of radiological public dose in Blind River attributable to 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 potential gamma radiation exposure are safe and maintained ALARA. The land immediately outside the perimeter fence continues to be owned and controlled by Cameco. Therefore, Cameco sets an action level for gamma dose rates of 1.0 µSv/h at the north fence only since the critical receptor location for the gamma component of dose to the public is the neighboring golf course north of the BRR. The gamma radiation effective dose rates are measured using environmental dosimeters. The monthly average of fenceline gamma measurements at the BRR were 0.49 µSv/h (east), 0.30 µSv/h (north), 0.55 µSv/h (south) and 1.69 µSv/h (west) in 2016. All north fence results in 2016 were below the action level. These measurements indicate that gamma dose rates are controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Blind River area in 2013 and 2014. The results are available on the CNSC's [IEMP Web page](#). The IEMP results indicate that the public and the environment in the vicinity of the BRR are protected and safe.

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

On July 5, 2016, CNSC staff met with MFN staff to develop an IEMP sampling plan on MFN lands. A sampling plan that is representative of both parties' needs was subsequently developed. The CNSC's Participant Funding Program provided financial support to the MFN for all of these meetings.

The next independent environmental monitoring campaign at BRR is scheduled for October 2017, and will include the sampling plan developed with the MFN. A subsequent campaign is scheduled for 2019.

Protection of the Public

According to the regulatory requirements, 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.

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the BRR licence and LCH. 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 review of the programs at the BRR, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental Risk Assessment

Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment. Cameco indicated that it would implement the three environmental protection standards – CSA N288.4-10 *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8], CSA N288.5-11 *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9] and CSA N288.6-12 *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3] – by the end of 2017. Cameco submitted the BRR ERA to the CNSC at the end of 2016. CNSC staff have reviewed the document and concluded that the ERA for BRR is consistent with the overall methodology described in CSA N288.6-12. Cameco remains on track to complete the implementation of the CSA requirements by the end of 2017.

3.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Blind River Refinery, 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | FS | FS | FS | FS |

For 2016, CNSC staff continued to rate the conventional health and safety SCA at BRR as “fully satisfactory.” Overall, the compliance verification activities conducted by CNSC staff at BRR confirmed that Cameco continues to view conventional health and safety as an important consideration. Cameco has implemented an effective occupational health and safety management program, which has helped to keep its workers safe from occupational injuries; no LTIs have occurred for more than ten years.

Performance

CNSC staff monitor Cameco’s performance related to conventional health and safety at the BRR during onsite inspections and through event reviews. Cameco continues to develop and maintain a comprehensive conventional health and safety management program for BRR. Cameco’s conventional health and safety program at BRR incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for this SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. Per table 3-4, the number of LTIs remained at zero in 2016. Cameco has not had an LTI at BRR in the past ten years.

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

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

Cameco also met its internal targets and objectives related to conventional health and safety at BRR in 2016. In recognition of Cameco's effective implementation of its conventional health and safety program at BRR, CNSC staff continue to rate Cameco's overall performance for the conventional health and safety SCA at BRR as "fully satisfactory."

Practices

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

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

Awareness

Workers are made aware of the conventional health and safety program as well as workplace hazards through training and ongoing internal communications with Cameco. Cameco holds monthly safety meetings for all employees at BRR on various safety topics such as radiation protection, environmental protection and fire protection. Attendance is tracked at the safety meetings as an indicator for safety performance. Cameco workers at BRR also attend daily toolbox meetings where they are notified of any concerns or ongoing maintenance in their area. Cameco also undertook the safety initiative of holding a "safety stand-down" for the workers upon return to work after the summer and Christmas shutdown periods.

4 PORT HOPE CONVERSION FACILITY

Cameco Corporation (Cameco) owns and operates the Port Hope Conversion Facility (PHCF). PHCF is located in the Municipality of Port Hope, ON, situated on the north shore of Lake Ontario, approximately 100 kilometres east of Toronto. Aerial photographs of the PHCF sites are shown in figure 4-1 and figure 4-2.

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



Figure 4-2: Aerial view of Port Hope Conversion Facility site 2 on Dorset Street in Port Hope



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

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

4.1 Performance

For 2016, CNSC staff continued to rate PHCF's performance as "satisfactory" in all SCAs. The PHCF performance ratings for 2012 through 2016 are provided in table C-2, appendix C.

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

Vision in Motion (VIM) is Cameco's project to clean up and renew the PHCF. The project is being carried out under Cameco's operating licence for the facility. In 2016, Cameco carried out clean-up and remediation work to further progress the planning and design development for VIM. Cameco also completed the demolition of building 42 on the Center Pier, which was no longer in use.

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

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

In 2016, CNSC staff conducted four onsite inspections at PHCF to verify compliance with the NSCA [1] and its regulations, Cameco's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in Table J-2 in appendix J. These planned onsite inspections focused on the radiation protection, environmental protection, fire protection and security SCAs. Nineteen enforcement actions were raised as result of the inspections. The findings were of low safety significance and did not affect the health and safety of workers, the public, or the environment, or the safe operation of the facility. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

At the time of writing this CMD, the Commission had issued an administrative monetary penalty to Cameco for events at PHCF that occurred in 2017. This does not change CNSC staff's findings for 2016.

4.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Port Hope Conversion Facility, 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Application of ALARA

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

Worker dose control

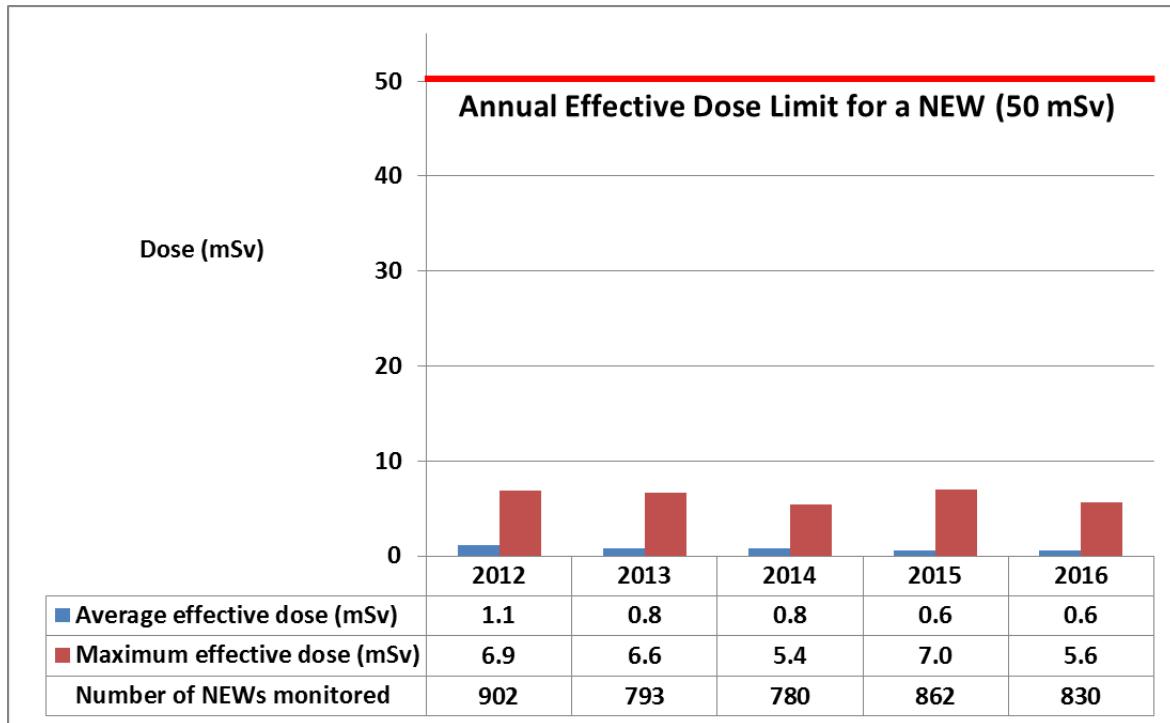
Radiation exposures at PHCF are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at PHCF, as reported by Cameco, were well below the CNSC's regulatory dose limits.

Cameco ascertains external doses using whole body dosimetry. Cameco did not use extremity dosimetry, which is used on a case-by-case basis dependent on the work activities being carried out, in 2016. For internal radiological exposures, Cameco's Fuel Services Division holds a CNSC dosimetry service licence, which authorizes Cameco to provide in-house internal dosimetry services at PHCF. Internal dose is assessed and assigned at PHCF through two programs: urine analysis and lung counting.

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

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

Figure 4-3: Average and maximum effective doses to NEWs, Port Hope Conversion Facility, 2012-2016



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

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

Radiation protection program performance

In 2016, CNSC staff assessed the performance of Cameco's radiation protection program at the PHCF through various compliance activities, including a focused inspection on radiation protection. Overall, Cameco's compliance with the Radiation Protection Regulations [2] and CNSC licence requirements at PHCF was found to be acceptable. Corrective actions were established by Cameco to address areas requiring improvement, which included administrative aspects of the management of external dosimetry, the maintenance of fume hoods and dust collection systems, and the use of contamination monitoring equipment and instrumentation.

Action levels for radiological exposures are established as part of the radiation protection program. If an action level is reached, it triggers Cameco staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2016, there were no instances at PHCF where an action level was reached.

Radiological hazard control

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

Estimated dose to the public

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

Table 4-1: Maximum effective dose to a member of the public, Port Hope Conversion Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory Dose Limit |
|-------------------------------------|-------|-------|-------|-------|-------|-----------------------|
| Maximum effective dose (mSv) | 0.029 | 0.021 | 0.012 | 0.006 | 0.020 | 1 mSv/year |

4.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Port Hope Conversion Facility, 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

For 2016, CNSC staff rate the environmental protection SCA at Cameco's Port 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 MOECC's applicable requirements. During 2016, the measured releases to the environment were well below regulatory limits. Fenceline gamma measurements, groundwater monitoring, soil sampling, vegetation and ambient air data indicate that the public and the environment continue to be protected from facility releases.

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

Atmospheric emissions

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

Table 4-2: Air emissions monitoring results (annual averages), Port Hope Conversion Facility, 2012-2016

| Location | Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limit |
|-----------------------------|------------------|--------|--------|--------|--------|--------|---------------|
| UF₆ plant | Uranium (kg/h) | 0.0042 | 0.0051 | 0.0012 | 0.0017 | 0.0012 | 0.290 |
| | Fluorides (kg/h) | 0.0160 | 0.0190 | 0.0130 | 0.0170 | 0.0100 | 0.650 |
| UO₂ plant | Uranium (kg/h) | 0.0012 | 0.0013 | 0.0012 | 0.0012 | 0.0010 | 0.150 |
| | Ammonia (kg/h) | 1.9 | 2.0 | 2.2 | 2.4 | 1.7 | 58 |

In addition to the licence limits, Cameco has action levels at the PHCF that are used to provide assurance that the licence release limits will not be exceeded. Action levels provide early indication of a potential loss of control of part of the environmental protection program and triggers a requirement for specific action to be taken. No action levels for air emissions were exceeded at any time in 2016.

Liquid effluent

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

Cameco does discharge non-process liquid effluent, such as cooling water and sanitary sewer discharges, from the PHCF. Cameco monitors these releases in compliance with the requirements of other regulators that have jurisdiction.

CNSC staff reviewed these monitoring results and found them to be acceptable.

Cameco met its licence requirement not to discharge process waste water effluent.

Environmental management system

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 including annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco met its objectives related to reviewing its environmental protection program against CSA standards N288.4-10 *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [8], and N288.5-11 *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [9]; and the deployment of waste management projects to dispose of contaminated materials at licensed hazardous facilities.

The EMS is verified through the annual licensee's management review where minutes and follow-up to outstanding issues are documented. CNSC staff, as part of their compliance verification activities, review these documents and follow-up on any outstanding issues with Cameco staff as appropriate. The results of these compliance verification activities demonstrate that, in 2016, Cameco conducted an annual management review in accordance with CNSC requirements, and that identified issues are being addressed properly.

Assessment and monitoring

Cameco's environmental monitoring program serves to demonstrate that the PHCF site emissions of nuclear and hazardous substances are properly controlled. The program also provides data for estimates of the annual radiological dose to the public to ensure that the public exposure attributable to 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 PHCF site.

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

Uranium in ambient air

Cameco measures uranium in the ambient air at several locations around the facility, to confirm the effectiveness of emission abatement systems and to monitor the impact of the facility on the environment. For 2016, the measurements show that the highest annual average uranium concentration in ambient air (as suspended particulate) amongst the sampling stations was $0.004 \mu\text{g}/\text{m}^3$, well below the MOECC's standard for uranium in ambient air of $0.03 \mu\text{g}/\text{m}^3$.

Groundwater monitoring

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

- 12 active pumping wells on a monthly basis
- 66 monitoring wells in the overburden on a quarterly basis
- 15 monitoring wells in the bedrock on an annual basis

CNSC staff found that the groundwater monitoring program, including the pump-and-treat wells, has been performing as expected. The pump-and-treat wells have been significantly reducing the mass of contaminants of concern reaching the harbour, as shown in table F-4, appendix F.

Surface water monitoring

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

Surface water is sampled at two depths (just below the water surface and just above the harbour sediment layer) at each of the 13 locations in the harbour. Annual average and maximum concentrations of uranium, fluoride, nitrate, and ammonia monitored in the harbour water in 2012-2016 are provided in table F-5, appendix F. Surface water concentrations continue to be stable, protective of human health, and generally below the respective CCME guidelines for protection of aquatic life.

Soil monitoring

Cameco's soil monitoring program consists 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 2016 attributable to current PHCF operations have not increased, and have 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. The results have been well below the most restrictive CCME soil quality guideline for residential and parkland land use of 23 µg/g and within the range of natural background for Ontario.

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

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 2016 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 fenceline of the PHCF and the Dorset Street site to ensure that levels of potential gamma radiation exposure are safe and maintained ALARA. The gamma radiation effective dose rates for both sites are measured using environmental dosimeters supplied by a licensed dosimeter service. The annual average of fenceline gamma measurements at the PHCF was 0.005 µSv/h in 2016. For the PHCF, Cameco has a licensed limit for fenceline gamma dose rates of 0.14 µSv/h at the critical receptor located at station 14, opposite 125 Mill Street. The annual average of fenceline gamma measurements at the Dorset Street site was 0.054 µSv/h in 2016. The Dorset street site has a licensed limit of 0.40 µSv/h at the fenceline. Details are provided in table F-8, appendix F. These measurements indicate that gamma dose rates are controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Port Hope area in 2014 and 2015. The results are available on the CNSC's [IEMP Web page](#). The IEMP results indicate that the public and the environment in the vicinity of the PHCF are protected and safe. The next independent environmental monitoring campaigns at PHCF are scheduled for May 2017 and in 2020.

Protection of the public

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the PHCF licence and LCH. The CNSC staff review of hazardous (non-radiological) discharges to the environment for PHCF in 2016 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 ERA on January 8, 2016 for CNSC staff review and concurrence. CNSC staff have reviewed the ERA and concluded that the document complies in general with CSA standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. ERA conclusions and recommendations, as well as guidance outlined in CSA standard N288.4-10 *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [8] and CSA standard N288.5-11 *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills* [9], will be incorporated into the PHCF Environmental Monitoring Plan and the PHCF Environmental Inspection and Test Plan by December 31, 2017. Cameco currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

4.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Port Hope Conversion Facility, 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Performance

CNSC staff monitor Cameco's performance related to conventional health and safety at the PHCF during onsite inspections and through event reviews. Cameco continues to develop and maintain a comprehensive occupational health and safety management program for PHCF. Cameco's conventional health and safety program at the PHCF incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

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

Table 4-3: Lost-time injuries, Port Hope Conversion Facility, 2012-2016

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

Practices

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

Conventional health and safety efforts at PHCF are supported by the Conversion Safety Steering Committee, a joint committee that was created in 2013. The Conversion Safety Steering Committee inspects the workplace and meets monthly to improve the safety performance of the site and promote continuous improvement.

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

Awareness

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

5 CAMECO FUEL MANUFACTURING INC.

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

Figure 5-1: Aerial view of the Cameco Fuel Manufacturing facility



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

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

5.1 Performance

For 2016, CNSC staff rated Cameco's performance at CFM as "satisfactory" in all 14 SCAs. The CFM performance ratings for 2012 to 2016 are found in table C-3, appendix C.

Cameco continued to operate CFM in a safe manner throughout 2016. The facility underwent two planned shutdowns during the course of the year to conduct routine maintenance activities and implement facility upgrades. Cameco ensured that the CFM site was maintained according to CFM's licensing basis.

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

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

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

5.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Cameco Fuel Manufacturing Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Application of ALARA

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

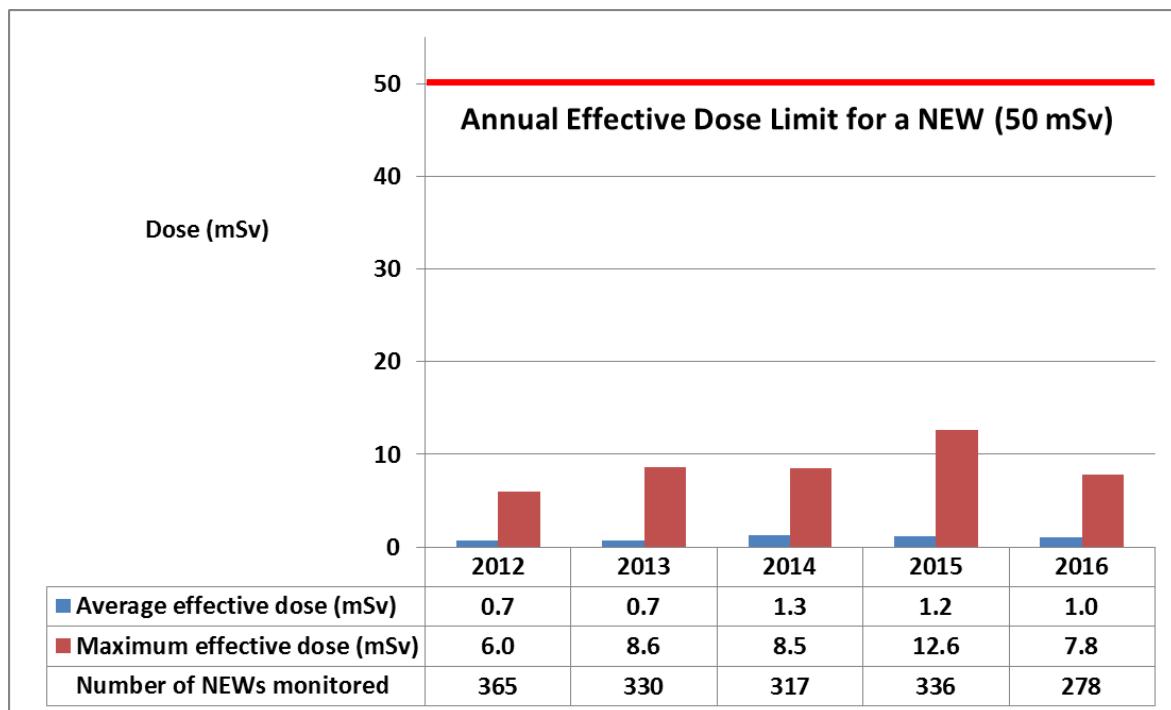
Worker dose control

Radiation exposures at CFM are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at CFM, as reported by Cameco, were well below 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. In 2016, the total effective dose was assessed for 278 NEWs at CFM, consisting of 227 Cameco employees and 51 contractors. The maximum effective dose received by a NEW in 2016 was 7.8 mSv, or approximately 16 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period. Figure 5-2 provides the average and maximum effective doses to NEWs at CFM between 2012 and 2016.

Figure 5-2: Average and maximum effective doses to NEWs, Cameco Fuel Manufacturing Inc., 2012-2016



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

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

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

Radiation protection program performance

In 2016, CNSC staff assessed the performance of Cameco's radiation protection program at CFM through various compliance activities, including an onsite inspection in January 2016. Based on the findings of the inspection, CNSC staff concluded that Cameco is in overall compliance with CNSC regulatory requirements. However, the inspection identified areas requiring improvement, including the need 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 compromise 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 Cameco workers at CFM. Cameco continues to work towards implementing corrective actions to adequately address all of CNSC staff's findings. CNSC staff will continue to track and evaluate Cameco's corrective actions to ensure that they are satisfactory.

Action levels for radiological exposures are established as part of the radiation protection program. If an action level is reached, it triggers Cameco staff to establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. In 2016 there were no action level exceedances associated with the radiation protection program.

Radiological hazard control

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

Estimated dose to the public

The maximum dose to the public from licensed activities at CFM is calculated using monitoring results. The maximum effective doses to a member of the public for the years 2012 to 2016 are shown in table 5-1. The doses are well below the CNSC regulatory dose limit for a member of the public of 1 mSv/year.

Table 5-1: Maximum effective dose to a member of the public, Cameco Fuel Manufacturing Inc., 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory Dose Limit |
|-------------------------------------|-------|-------|-------|-------|-------|-----------------------|
| Maximum effective dose (mSv) | 0.031 | 0.013 | 0.018 | 0.025 | 0.023 | 1 mSv/year |

5.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Cameco Fuel Manufacturing Inc., 2012–2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

For 2016, CNSC staff 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 satisfactory compliance with the conditions of the operating licence and regulatory requirements. Groundwater monitoring, soil sampling and high-volume air sampler data indicate that the public and the environment continue to be protected from facility releases.

Effluent and emissions control (releases)

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

Atmospheric emissions

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

Table 5-2: Air emissions monitoring results, Cameco Fuel Manufacturing Inc., 2012-2016

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

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

In addition to the licence limits, Cameco has action levels at CFM that are used to provide assurance that the licence release limits will not be exceeded. Action levels provide early indication of a potential loss of control of part of the environmental protection program and triggers a requirement for specific action to be taken.

There was one action level exceedance with respect to stack emissions in 2016. The action level exceedance occurred during the third quarter of 2016 in the stack servicing the new automated grinder. The measured value was $9.52 \mu\text{gU}/\text{m}^3$ compared to the action level of $2.0 \mu\text{gU}/\text{m}^3$. Cameco completed an investigation of the event and implemented corrective actions accordingly. Cameco's ambient air monitoring conducted around the facility at the time of this event confirmed that uranium concentrations remained far below levels associated with potential risk to the public. CNSC staff are satisfied that the corrective actions implemented by Cameco will be effective in preventing recurrence of this event.

Liquid effluent

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

Table 5-3: Liquid effluent monitoring results, Cameco Fuel Manufacturing Inc., 2012-2016

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

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

Environmental management system

Cameco has developed and maintains an EMS which provides a framework for integrated activities with respect to the protection of the environment at CFM. The EMS is described in Cameco's Radiation & Environmental Protection Manual and includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities. Cameco met its objectives related to improved environmental sampling and monitoring, as well as the implementation of its multi-year waste reduction initiative.

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

Assessment and monitoring

Cameco's environmental monitoring program serves to demonstrate that the CFM site emissions of nuclear and hazardous substances are properly controlled. The program also provides data for estimates of the annual radiological dose to the public to ensure that the public exposure attributable to the Cameco's 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, soil, and gamma radiation around the CFM site.

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

Uranium in ambient air

Cameco operates high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The samplers are located on the east, north, southwest and northwest sides of the facility. In 2016, the results from these samplers show that the highest annual average concentration (amongst the sampling stations) of uranium in ambient air was $0.0019 \text{ }\mu\text{g}/\text{m}^3$, well below the MOECC's standard for uranium in ambient air of $0.03 \text{ }\mu\text{g}/\text{m}^3$.

Groundwater monitoring

As of the end of 2016, CFM has a network of 75 groundwater monitoring wells located onsite (59) and offsite (16) of the facility. These wells are screened within the overburden (soil) and some are within the underlying bedrock. The groundwater monitoring results confirm that current operations are not contributing to the concentrations of uranium in groundwater on the licensed property.

Surface water monitoring

In 2016, Cameco collected surface water samples at six locations in June, eight locations in August and eight locations in October. The sample locations were on and adjacent to the facility, and were analyzed for uranium.

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

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

Soil monitoring

Cameco collects soil samples from 23 locations surrounding the facility, on a three-year sampling frequency. Soil samples were last collected in 2016 and analyzed for uranium content. The average uranium levels in soil near CFM are just slightly above the Ontario background of 2.5 µg/g (table F-9, appendix F). The maximum concentrations detected are attributable to historic contamination in Port Hope, which has long been recognized and continues to be the focus of environmental studies and clean-up activities. These concentrations are not representative of soil quality as opposed to the statistically significant average values. Nevertheless, the results for all samples were below 23 µg/g, which is the most restrictive CCME soil quality guideline for uranium for residential and parkland use and, therefore, are not expected to result in any adverse consequences to human and environmental receptors. A comparison of 2016 results with previous years indicates that uranium emissions from the facility are not resulting in an accumulation of uranium in soil.

Gamma monitoring

A significant portion of radiological public dose in Port Hope attributable to the CFM operations is due to gamma radiation sources. Therefore, it is essential to monitor gamma radiation effective dose rates at the fenceline of the CFM site to ensure that levels of potential gamma radiation exposure are safe and maintained ALARA. The gamma radiation effective dose rates for the site are measured using environmental dosimeters supplied by a licensed dosimeter service. The annual average of fenceline gamma measurements at the CFM site was 0.010 µSv/h in 2016. CFM has a licensed limit for fenceline gamma dose rates of 0.2 µSv/h at the monitoring station corresponding to the critical receptor. These measurements indicate that gamma dose rates are effectively controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring in the Port Hope area in 2014 and 2015. The results are available on the CNSC's [IEMP Web page](#). The IEMP results indicate that the public and the environment in the vicinity of CFM are protected and safe. The next independent environmental monitoring campaigns at CFM are scheduled for May 2017 and in 2020.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made for protecting the health and safety of the public from exposures to hazardous 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 LCH. CNSC staff's review of hazardous (non-radiological) discharges from CFM to the environment in 2016 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* [8], CSA N288.5-11 *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9] and CSA N288.6-12 *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3], by the end of 2017. Recently, CNSC staff have reviewed the ERA for CFM and concluded that the Cameco's ERA is in compliance with CSA standard 288.6-12 and the CFM conclusions regarding potential risk to human health and the environment are valid. Cameco currently has acceptable environmental programs in place to ensure protection of the public and the environment.

5.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Cameco Fuel Manufacturing Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Performance

CNSC staff monitor Cameco's performance related to conventional health and safety at CFM during onsite inspections and through event reviews. Cameco continues to develop and maintain a comprehensive occupational health and safety management program for CFM. Cameco's conventional health and safety program at CFM incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for the conventional health and safety SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work to carry out their duties for a period of time. As indicated in table 5-4, there were no LTIs at CFM in 2016.

Table 5-4: Lost-time injuries, Cameco Fuel Manufacturing Inc., 2012-2016

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

Practices

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

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

Awareness

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

6 BWXT NUCLEAR ENERGY CANADA INC.

BWXT Nuclear Energy Canada Inc. (BWXT), formerly known as GE-Hitachi Nuclear Energy Canada Inc. (GEH-C), produces nuclear fuel bundles used by Ontario Power Generation's (OPG) Pickering and Darlington nuclear generating stations. BWXT operates in three plant locations: Arnprior, Toronto and Peterborough, Ontario. The Arnprior facility is not licensed by the CNSC and is not discussed further in this report. The Toronto and Peterborough facilities are Class IB nuclear facility operations operating under a licence issued by the CNSC. BWXT's licence authorizes it to operate and modify its nuclear fuel facility to produce natural and UO₂ pellets in Toronto, and produce and test fuel bundles in Peterborough. The Peterborough facility is also authorized to receive, repair, modify and return contaminated equipment from offsite nuclear facilities. BWXT's licence expires in December 2020.

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

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



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



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

The changes to BWXT's licence and LCH are described in tables I-1 and I-2, appendix I.

6.1 Performance

For 2016, CNSC staff rated all safety ratings as "satisfactory" for BWXT. The SCA ratings for BWXT facilities over the period 2012 to 2016 are provided in table C-4, appendix C.

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

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

BWXT experienced four events that were reported to CNSC staff in 2016. BWXT reported these events in accordance with its regulatory reporting requirements. In April, a suspicious package was received at the BWXT Toronto facility, which was later deemed benign following response by licensee staff and first responders. Also in April, a dedicated shipment from the Peterborough facility to the Toronto facility containing a single stack of uranium pellets and a zircaloy tube was incorrectly labelled as empty. In May, BWXT reported a radiation protection action level exceedance, which is further discussed in section 6.2. In September, BWXT reported a worker injury that did not result in a lost-time injury. For each event, BWXT completed an investigation and implemented corrective actions to the satisfaction of CNSC staff.

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

6.2 Radiation protection

Overall compliance ratings for radiation protection SCA, BWXT Nuclear Energy Canada, 2012–16:

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Application of ALARA

BWXT established radiation protection goals and initiatives for the Toronto and Peterborough facilities in 2016. BWXT has an ALARA Committee which met quarterly and set annual ALARA goals focused on reducing worker dose and surface contamination throughout the facilities. BWXT met all ALARA goals for 2016 in both the Peterborough and Toronto sites.

Worker Dose Control

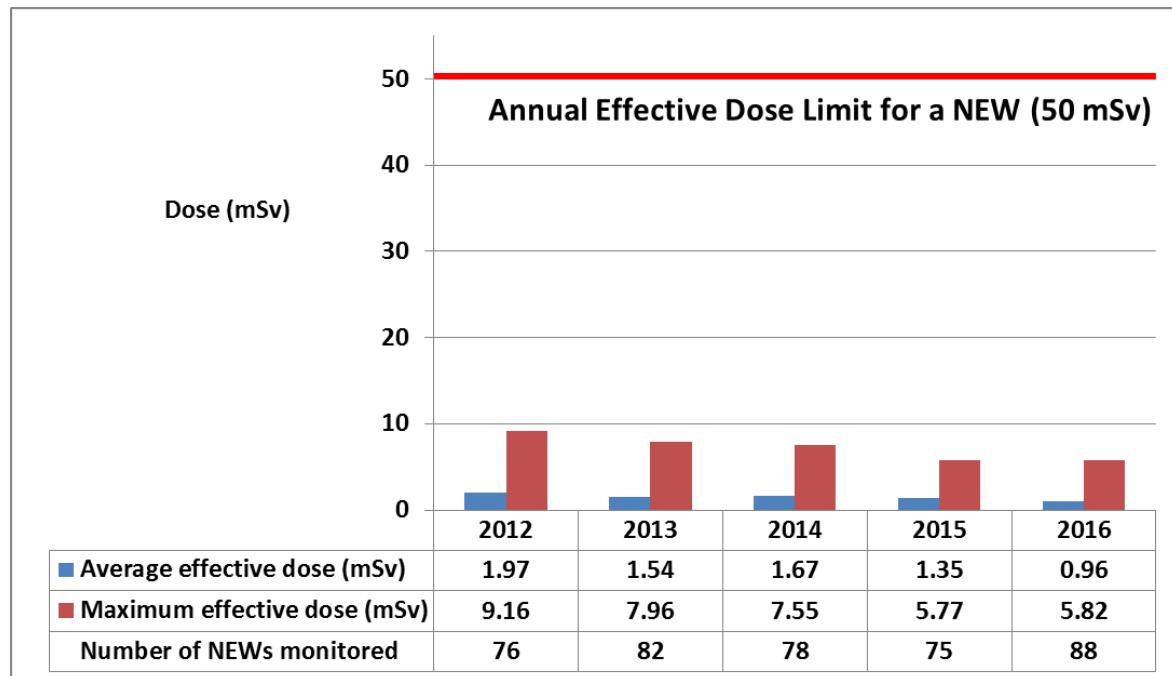
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and to maintain radiation doses ALARA. In 2016, no worker's radiation exposure, reported by BWXT, exceeded the CNSC's regulatory dose limits.

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

The maximum effective dose received by a NEW in 2016 at the Peterborough facility was 5.82 mSv, or approximately 12 per cent of the regulatory limit for effective dose of 50 mSv in a one-year dosimetry period.

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

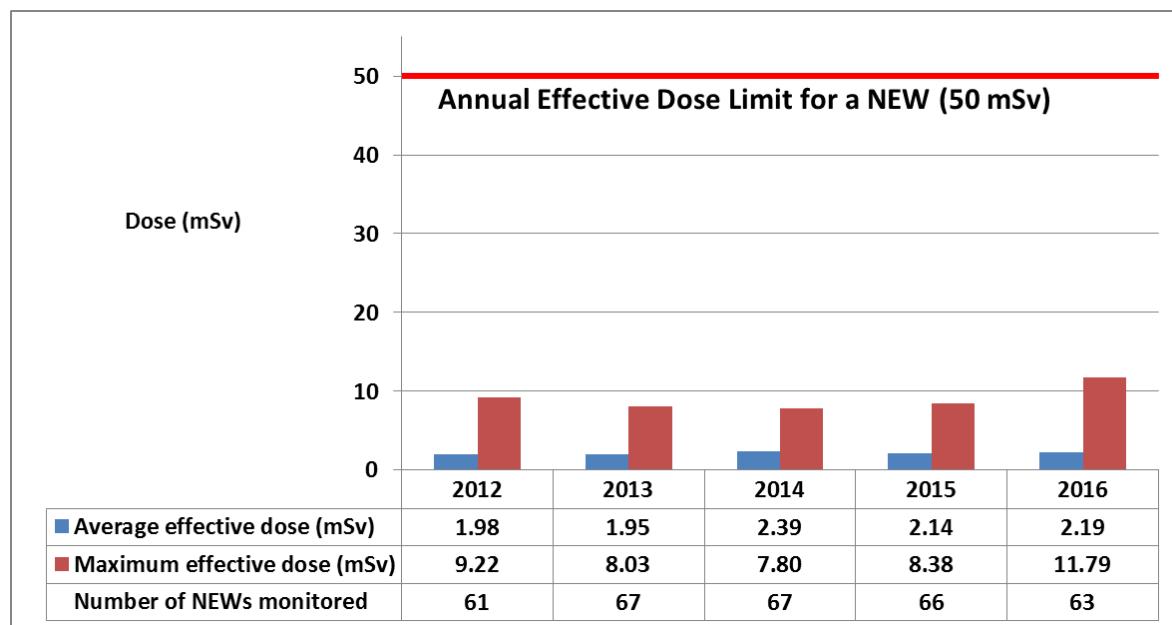
Figure 6-3: Average and maximum effective doses to NEWs, BWXT Nuclear Energy Canada Peterborough Facility, 2012-2016



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

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

Figure 6-4: Average and maximum effective doses to NEWS, BWXT Nuclear Energy Canada Toronto Facility, 2012-2016



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

Annual average and maximum equivalent (skin) and equivalent (extremity) dose results from 2012 to 2016 are provided in tables E-10 and E-11, and tables E-3 and E-4, in appendix E. In 2016, the maximum equivalent skin dose for both facilities was 74.26 mSv (Toronto), which is approximately 15 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. The maximum equivalent extremity dose was 119.47 mSv (Toronto), or approximately 24 percent of the regulatory equivalent dose limit of 500 mSv in a one-year dosimetry period. Over the past five years, average equivalent extremity and skin doses have been relatively stable at both facilities. The reason for the consistently lower skin and extremity doses at the Peterborough facility is the low likelihood of direct pellet handling, as opposed to the Toronto facility, where direct pellet handling is considered routine. At the Peterborough facility, except in the end cap welding station, all pellets are shielded in zirconium tubes, bundles or boxes.

Radiation Protection Program Performance

Action levels for radiological exposures, urinalysis results and contamination control are established as part of the BWXT radiation protection program. If reached, it triggers BWXT staff to establish the cause for reaching the action level and, if applicable, restore the effectiveness of the radiation protection program. In 2016, there was one action level exceedance at BWXT Toronto, pertaining to a urinalysis result of 13 µg/L, which exceeded the 10 µg/L action level. BWXT provided the CNSC with an investigation report and identified six corrective actions, which were reviewed and accepted by CNSC staff. BWXT determined that the potential cause for the elevated urinalysis result was most likely a contaminated sample, with exposure due to ingestion not completely ruled out. The committed effective dose to the affected worker was calculated by CNSC staff to be approximately 0.2 mSv as a result of this event.

Radiological Hazard Control

BWXT established radiation contamination controls at its facilities to control and minimize the spread of radioactive contamination. Methods of contamination control include the use of a radiation zone control program and monitoring using surface contamination swipes to confirm the effectiveness of the program. In 2016, the number of swipe locations remained relatively constant. No adverse trends were identified in monitoring results in 2016. CNSC staff are satisfied with BWXT's radiological hazard control.

Estimated Dose to the Public

The maximum dose to the public from licensed activities at BWXT is calculated using monitoring results. The 2012 to 2016 annual effective doses to members of the public are shown in table 6-1 for BWXT's Toronto facility. BWXT's Peterborough facility has consistently reported doses to members of the public of 0 mSv over 2013 to 2016. Effective doses to members of the public are well below the CNSC regulatory dose limit of 1 mSv/year.

Table 6-1: Maximum effective dose to a member of the public, BWXT Nuclear Energy Canada Toronto Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory Limit |
|------------------------------|--------|--------|---------|--------|--------|------------------|
| Maximum Effective Dose (mSv) | 0.0011 | 0.0006 | *0.0055 | 0.0101 | 0.0007 | 1 mSv/year |

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

6.3 Environmental protection

Overall compliance ratings for environmental protection SCA, BWXT Nuclear Energy Canada, 2012-2016

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

Effluent and Emissions Control (Releases)

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

Atmospheric Emissions

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

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

Liquid Effluent

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

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

Environmental Management System

BWXT has developed and is maintaining an EMS that provides a framework for integrated activities with respect to the protection of the environment at the BWXT facility. BWXT's EMS is described in its Environmental Management Program Manual. BWXT's EMS includes activities such as establishing annual environmental objectives and targets which are reviewed and assessed by CNSC staff through compliance verification activities. BWXT met its objectives related to improved environmental sampling and monitoring, emissions reduction, and the completion of a noise abatement project.

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

Assessment and Monitoring

BWXT's environmental monitoring programs serve to demonstrate that the site emissions of nuclear and hazardous substances are properly controlled. The programs also provide data for estimates of annual radiological dose to the public to ensure that the public exposure attributable to BWXT's Toronto and Peterborough operations 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 BWXT Toronto and gamma radiation around both facilities.

Uranium in Ambient Air

BWXT Toronto operates five high-volume air samplers to measure the airborne concentrations of uranium at points of impingement of stack plumes. The results from these samplers show that the annual average concentration (amongst the sampling stations) of uranium in ambient air measured around the facility in 2016 was $0.001 \mu\text{g}/\text{m}^3$, well below the MOECC's standard for uranium in ambient air of $0.03 \mu\text{g}/\text{m}^3$. Air monitoring results for BWXT Toronto are provided in table F-11, appendix F.

BWXT Peterborough does not monitor uranium in ambient air because the atmospheric emissions discharged from the facility already meet the MOECC standard of $0.03 \mu\text{g}/\text{m}^3$ at the point of release. Therefore additional ambient monitoring is not necessary.

Soil Monitoring

BWXT conducts soil sampling at its Toronto facility as part of its environmental program. In 2016, samples were taken from 49 locations and analyzed for uranium content. The samples were collected on the BWXT site, on commercial property located along the south border of the site, and in the nearby residential neighborhood. In 2016, the average soil concentration of uranium for residential locations was 0.5 µg/g while the maximum concentration of uranium in soil for these locations was 0.7 µg/g. These values are in the range of natural background 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). These data demonstrate that current BWXT operations do not contribute to accumulation of uranium in surrounding soil and no adverse consequences to relevant human and environmental receptors are expected. Soil sampling results are provided in tables F-12 and F-13, appendix F.

Gamma Monitoring

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

Starting in 2014, the gamma radiation effective dose rate for the BWXT Toronto site has been measured using environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2016 was 0.0 mSv, for a total estimated critical receptor dose of 0.0007 mSv when combined with the contribution from the air emissions. This is well below the regulatory dose limit of 1 mSv per year to a member of the public.

Starting in 2016, the gamma radiation effective dose rate for the BWXT Peterborough plant has been measured using environmental dosimeters. The estimated effective dose as a result of gamma radiation during 2016 was 0.0 mSv, for a total estimated critical receptor dose of 0.0 mSv when combined with the contribution from the air emissions.

These estimates indicate that gamma dose rates from both BWXT facilities are controlled and that the public is protected.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring around both facilities in 2014, and outside the Toronto facility in 2016. The results are available on the CNSC's [IEMP Web page](#). The IEPM results indicate that the public and the environment in the vicinity of BWXT Toronto and BWXT Peterborough are protected and safe. The next independent environmental monitoring campaigns at the BWXT facilities are scheduled for 2018 (Peterborough) and 2019 (both facilities).

Protection of the Public

The licensee is required to demonstrate that adequate provisions are made 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 BWXT licence and LCH. Review of hazardous (non-radiological) discharges to the environment for BWXT in 2016 indicates that these discharges would not pose significant risks to the public or the environment during this period. Based on CNSC staff's review of the programs at the BWXT Toronto and Peterborough facilities, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental Risk Assessment

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

6.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, BWXT Nuclear Energy Canada, 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|--|------|------|------|------|
| FS | SA | SA | SA | SA |
| For 2016, CNSC staff continue to rate the “Conventional health and safety” SCA at GEH-C as “satisfactory”. Overall, the compliance verification activities conducted by CNSC staff confirmed that BWXT continues to view conventional health and safety as an important consideration. BWXT has demonstrated a satisfactory ability to keep its workers safe from occupational injuries. | | | | |

Performance

CNSC staff monitor BWXT's performance related to conventional health and safety during onsite inspections and through event reviews. BWXT continues to develop and maintain a comprehensive occupational health and safety management program for its facilities. BWXT's conventional health and safety program incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

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

Table 6-2: Lost-Time Injuries (LTIs) for BWXT – Toronto, 2012-2016

| | 2012 | 2013 | 2014 | 2015 | 2016 |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| Lost-Time Injuries | 1 | 0 | 1 | 0 | 0 |

Table 6-3: Lost-Time Injuries (LTIs) for BWXT – Peterborough, 2012-2016

| | 2012 | 2013 | 2014 | 2015 | 2016 |
|---------------------------|-------------|-------------|-------------|-------------|-------------|
| Lost-Time Injuries | 0 | 0 | 0 | 0 | 0 |

Practices

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

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

Awareness

BWXT's management regularly reviews performance metrics. In 2016, BWXT at its Peterborough facility conducted investigations and inspections, including WSC inspections, manager inspections, and near miss and incident investigations. Finding categories included housekeeping, equipment safety, emergency response procedures, walking/working surfaces and chemical management compatibility/segregation. At its Toronto facility, BWXT conducted investigations and inspections, including WSC inspections, and near miss and incident investigations. Finding categories included housekeeping, chemicals, unsafe conditions, and electrical. BWXT logs and tracks actions arising from investigations and inspections to closure.

PART II: NUCLEAR SUBSTANCE PROCESSING FACILITIES

7 OVERVIEW

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

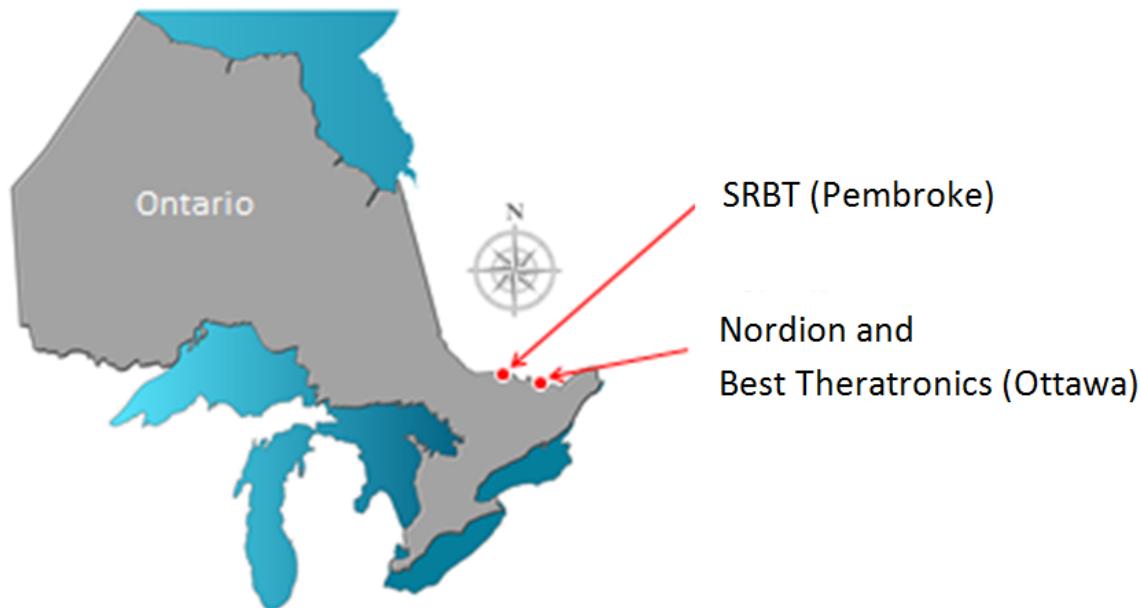
- SRB Technologies (Canada) Inc. (SRBT) in Pembroke, ON
- Nordion (Canada) Inc. (Nordion) in Ottawa, ON
- Best Theratronics Ltd. (BTL) in Ottawa, ON

All three facilities are located in the province of Ontario, as shown in figure 7-1. The licence for SRBT was issued in July 2015 and expires in June 2022.

Nordion's licence was issued in November 2015 and expires in October 2025.

BTL's licence was issued in July 2014 and expires in June 2019.

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



CNSC staff conducted consistent risk-informed regulatory oversight activities at each nuclear substance processing facility in 2016. Table 7-1 presents the licensing and compliance effort from CNSC staff for these facilities during 2016.

Table 7-1: CNSC regulatory oversight licensing and compliance activities, nuclear substance processing facilities, 2016

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

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

Each nuclear substance processing facility licensee is required to submit annual reports on the operations of their facilities by March 31 of each year. These reports must contain all environmental, radiological and safety-related information, including events and associated corrective actions taken. CNSC staff review these reports as part of normal regulatory compliance oversight to verify that licensees are complying with regulatory requirements and are operating safely. The full versions of these reports are available on the licensees' websites, as provided in appendix H of this CMD.

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

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

Appendix C contains the SCA ratings from 2012 to 2016 for each facility.

Table 7-2: SCA performance ratings, nuclear substance processing facilities, 2016

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

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

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

7.1 Radiation protection

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

This SCA encompasses the following specific areas:

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

Based on regulatory oversight activities, CNSC staff rated the performance of the nuclear processing facilities for the radiation protection SCA as “satisfactory” in 2016, unchanged from the previous year.

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

| SRBT | Nordion | BTL |
|------|---------|-----|
| SA | SA | SA |

Application of ALARA

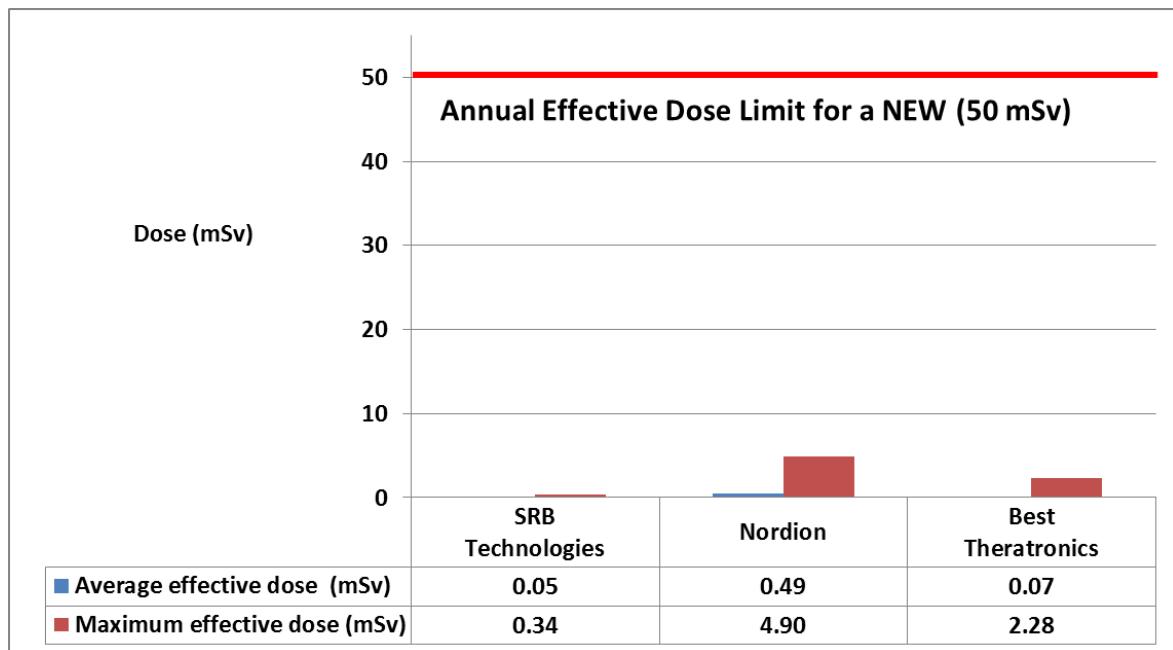
During 2016, all nuclear substance processing facility licensees continued to implement radiation protection measures to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. The CNSC requirement to apply the ALARA principle has consistently resulted in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

Worker dose control

The design of radiation protection programs, including the dosimetry methods and the determination of workers who are identified as NEWs, varies depending on the radiological hazards present and the expected magnitude of doses received by workers. Taking into consideration the inherent differences in the design of radiation protection programs between licensees, the dose statistics provided in this report are primarily for NEWs. Additional information is provided in the facility specific write-ups on the total number of monitored persons, including workers, contractors and visitors.

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

Figure 7-2: Average and maximum effective doses to NEWS, nuclear substance processing facility licensees, 2016



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

Radiation protection program performance

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

Action Levels

Action levels for radiological exposures are established as part of the licensees' radiation protection programs. Licensees are responsible for identifying the parameters of their program that represent timely indicators of potential losses of control of the program. For this reason, action levels are licensee-specific and may change over time depending on operational and radiological conditions.

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

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 2016, levels of radioactive contamination were controlled within their facilities.

Estimated dose to the public

The maximum dose to the public from licensed activities at SRBT is calculated using monitoring results; the maximum dose to the public from licensed activities at Nordion is calculated from derived release limits. Public dose estimates are not provided for BTL because its licensed activities involve sealed sources and there are no discharges to the environment. The CNSC's requirements to apply ALARA principles ensure that licensees monitor their facilities and take corrective actions whenever action levels are exceeded.

Table 7-3 provides a comparison of estimated public doses from 2012 to 2016 for the nuclear substance processing facility licensees. Estimated doses to the public from all nuclear substance processing facility licensees continued to be well below the regulatory annual public dose limit of 1 mSv/year.

Table 7-3: Public dose comparison table (mSv), nuclear substance processing facilities, 2012-2016

| Facility | Year | | | | | Regulatory limit |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------------------|
| | 2012 | 2013 | 2014 | 2015 | 2016 | |
| SRBT | 0.0049 | 0.0068 | 0.0067 | 0.0068 | 0.0046 | 1 mSv/year |
| Nordion | 0.020 | 0.022 | 0.010 | 0.0056 | 0.0021 | |
| BTL | N/A | N/A | N/A | N/A | N/A | |

Conclusion on Radiation Protection

CNSC staff conclude that the nuclear substance processing facility licensees effectively implemented and maintained their radiation protection programs during 2016 to ensure the health and safety of persons working in their facilities.

7.2 Environmental protection

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

It encompasses the following specific areas:

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

Based on regulatory oversight activities, CNSC staff rated the performance of the nuclear processing facilities for the environmental protection SCA as “satisfactory” in 2016, with the exception of Nordion, which was given a “fully satisfactory” rating. These ratings are unchanged from the previous year.

Ratings for environmental protection SCA, nuclear substance processing facilities, 2016

| SRBT | Nordion | BTL |
|------|---------|-----|
| SA | FS | SA |

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

CNSC staff conclude that the nuclear substance processing facility licensees implemented their environmental programs satisfactorily during 2016. Their programs are effective in protecting the health and safety of the public and the environment. There were no exceedances of licence limits for any nuclear substance processing facilities in 2016. Further information is provided in the facility-specific sections.

7.3 Conventional health and safety

This SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

It encompasses the following specific areas:

- performance
- practices
- awareness

Based on regulatory oversight activities, CNSC staff rated the performance of the nuclear processing facilities for the conventional health and safety SCA as “satisfactory” in 2016, with the exception of SRBT, which was given a “fully satisfactory” rating. This is unchanged from the previous year.

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

| SRBT | Nordion | BTL |
|------|---------|-----|
| FS | SA | SA |

Performance

The regulation of conventional health and safety at nuclear substance processing facilities involves both ESDC and the CNSC. CNSC staff monitor compliance with regulatory reporting requirements. When a concern is identified, CNSC staff consult with ESDC staff. Licensees submit hazardous occurrence investigation reports to both ESDC and the CNSC, in accordance with their respective reporting requirements.

Licensees are required to report unsafe occurrences to the CNSC as directed by section 29 of the *General Nuclear Safety and Control Regulations* [4]. These reports include serious illnesses or injuries incurred or possibly incurred as a result of a licensed activity. Table 7-4 summarizes the number of recordable LTIs reported by nuclear substance processing facilities from 2012 to 2016. Further information is provided in facility-specific sections as well as appendix G.

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

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

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

Conclusion on Conventional Health and Safety

CNSC staff conclude that the nuclear substance processing facility licensees implemented their conventional health and safety programs satisfactorily during 2016. Their programs are effective in protecting the health and safety of persons working in their facilities.

7.4 Public information and disclosure programs

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

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

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

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

8 SRB TECHNOLOGIES (CANADA) INCORPORATED

SRB Technologies (Canada) Inc. (SRBT) is a gaseous tritium light source (GTLS) manufacturing facility located on the outskirts of Pembroke, ON, approximately 150 km northwest of Ottawa. Figure 8-1 shows an aerial view of the SRBT facility.

Figure 8-1: Aerial view of the SRBT facility in Pembroke



SRBT processes tritium gas to produce GTLS and manufactures radiation devices such as signs, markers and tactical devices, which are distributed in Canada and internationally. The Class IB nuclear facility has been in operation since 1990. Figure 8-2 shows examples of GTLS exit signs and other markers produced at SRBT. In 2015, the Commission renewed SRBT's operating licence, NSPFOL-13.00/2022, which expires in June 2022.

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



8.1 Performance

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

SRBT implemented highly effective measures for both SCAs rated as "fully satisfactory," and SRBT's overall compliance in these SCAs remained stable. Regarding fitness for service, SRBT performed preventative maintenance activities according to its maintenance plan, tracked corrective maintenance, and identified trends. No safety-significant equipment failures occurred at the facility, indicating the effectiveness of the implemented maintenance program. Conventional health and safety is further discussed in the SCA section below.

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

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

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

In 2016, CNSC staff conducted one inspection at SRBT to ensure compliance with the NSCA [1] and its regulations, SRBT's operating licence and the programs used to meet regulatory requirements. This inspection is listed in Table J-5 in appendix J. The inspection focused on the environmental protection and conventional health and safety SCAs. One enforcement action was raised as a result of the inspection. CNSC staff concluded that the findings from this inspection posed a low risk to the achievement of regulatory objectives and CNSC expectations.

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

In 2016, there were no licence amendments for SRBT and no significant changes were made to SRBT's Licence Condition Handbook (LCH).

8.2 Radiation protection

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

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Application of ALARA

As required by the *Radiation Protection Regulations* [2], SRBT continued to implement radiation protection measures at its facility in 2016 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. SRBT continues to make annual improvements to its radiation protection program. In 2016, SRBT added remote display units, improved the tritium trap valve design, commissioned an upgraded power supply on the liquid scintillation counting equipment, and implemented revised radiation protection program procedures. SRBT's Health Physics Committee meets regularly to discuss various aspects of the program, including worker doses, radiological hazard monitoring results and internal audit results. The Health Physics Committee also tracks progress against ALARA targets for maximum effective dose to a worker and for collective dose, continuously working toward reducing the already very low doses to workers.

Worker dose control

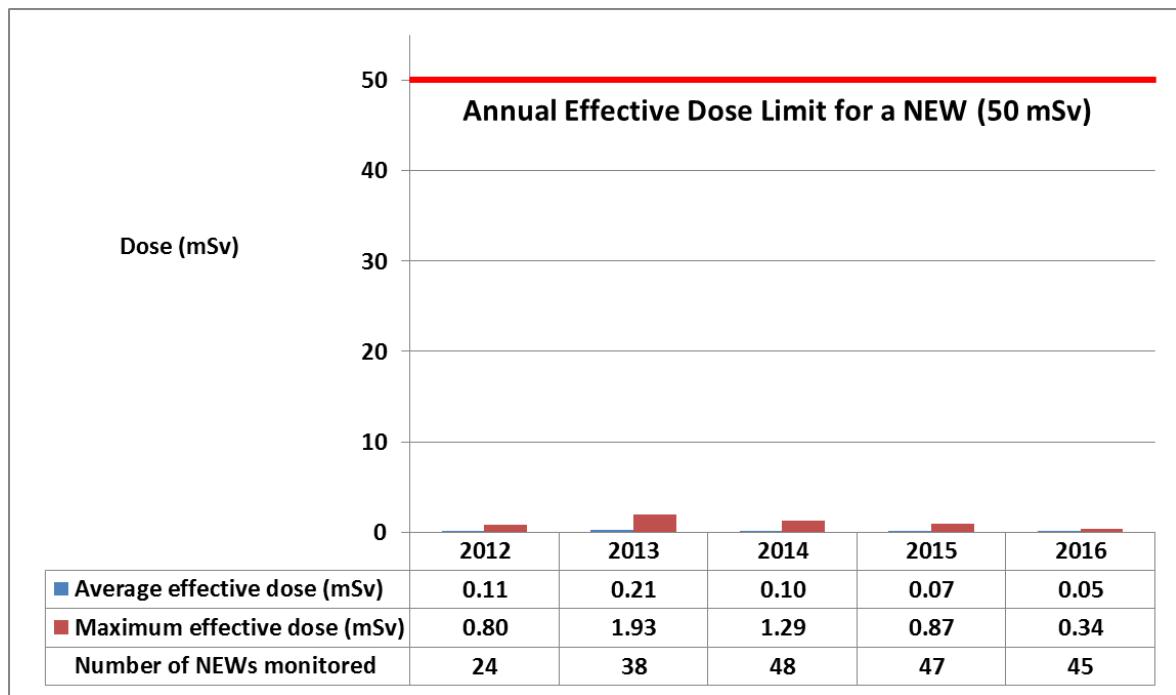
Inhalation, ingestion and absorption of tritium are the main radiological hazards faced by SRBT workers. SRBT ascertains internal tritium exposures through a urine analysis program that is part of its CNSC-licensed internal dosimetry service.

All workers employed at SRBT are identified as NEWs. In general, contractors are not identified as NEWs as they do not perform radiological work; however, they are monitored per regulatory requirements and provided with training as necessary to ensure doses remain ALARA and below the dose limit of 1 mSv/year. In 2016, no contractors were classified as NEWs, and none received a recordable dose due to work activities performed at the SRBT facility.

In 2016, none of the radiation exposures reported by SRBT for NEWs exceeded the CNSC's regulatory dose limits. The maximum effective dose received by a NEW in 2016 was 0.34 mSv, or approximately 0.7 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 8-3 provides the average and maximum effective doses to NEWs at SRBT between 2012 and 2016. Since 2013, there has been a downward trend in the average effective dose and maximum effective dose at SRBT, which demonstrates SRBT's continued improvements to its radiation protection program.

Figure 8-3: Average and maximum effective doses to NEWS, SRB Technologies (Canada) Inc., 2012–2016



Due to the uniform distribution of tritium in the body tissues, equivalent skin doses are essentially the same as the effective whole body dose and are therefore not reported separately. For this same reason, extremity doses are not separately monitored for workers at SRBT.

Radiation protection program performance

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

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

Improvements in the performance of SRBT's radiation protection program led to a 31 percent decrease in collective dose in 2016 in spite of the fact that the total amount of tritium processed by SRBT was relatively stable in 2016 compared with 2015. SRBT attributes the improved performance to a number of items, including: increased use of portable tritium-in-air monitors, implementation of a new valve design on SRBT tritium traps, continuous oversight by the Health Physics team, and expanding and improving radiation protection training for staff.

Radiological hazard control

SRBT established radiation and contamination control programs to control and minimize radiological hazards and the spread of radioactive contamination. These controls include the use of a radiation zone control program and the monitoring of surface and airborne tritium concentrations to confirm the effectiveness of that program. CNSC staff did not identify any adverse trends in the monitoring results in 2016. CNSC staff are satisfied with SRBT's radiological hazard control.

Estimated dose to the public

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

Table 8-1: Maximum effective dose to a member of the public, SRB Technologies (Canada) Inc., 2012-2016

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

8.3 Environmental protection

Overall compliance ratings for environmental protection SCA, SRB Technologies (Canada) Inc., 2012-2016:

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| SA | SA | SA | SA | SA |

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

Effluent and Emissions Control (Releases)

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

Atmospheric Emissions

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

In addition to licence limits, SRBT has action levels in place that are used to provide assurance that the licence release limits will not be exceeded. Action level exceedances provide early indication of a potential loss of control of part of the environmental protection program and trigger a requirement for specific action to be taken. No action levels were exceeded at any time in 2016.

The fluctuations in total tritium released to air in 2012-2016 are in general due to respective changes in tritium processing at SRBT during the same period and in part due to effective emission reduction initiatives, such as the improved tritium trap valves.

Liquid Effluent

SRBT continues to monitor and control tritium released as liquid effluent from the facility. The monitoring data for 2012 through 2016, provided in table F-16, appendix F, demonstrate that liquid effluent from the facility continued to be effectively controlled as tritium releases were consistently well below the licence limit.

In addition to licence limits, SRBT has action levels that are used to provide assurance that the licence release limits will not be exceeded. Action level exceedances provide early indication of a potential loss of control of part of the environmental protection program and trigger a requirement for specific action to be taken. No action levels were exceeded at any time in 2016.

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

Environmental Management System

SRBT has developed and is maintaining an EMS which provides a framework for integrated activities with respect to the protection of the environment at the SRBT facility. SRBT's EMS includes activities such as establishing annual environmental objectives and targets, which are reviewed and assessed by CNSC staff through compliance verification activities. The EMS is verified through the licensee's safety meeting during which environmental protection issues are discussed and documented. CNSC staff, as part of their compliance verification activities, review these documents and follow-up on any outstanding issues with SRBT staff as appropriate. The results of these compliance verification activities demonstrate that in 2016, SRBT was conducting an annual management review in accordance with CNSC requirements and that identified issues are being addressed properly.

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

Assessment and Monitoring

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

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

Tritium in Ambient Air

SRBT has a total of 40 passive air samplers located within a two-kilometre radius of the facility. The 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. The 2016 air monitoring results from these samplers demonstrate that tritium levels in ambient air near SRBT remain low, and have decreased to 33.44 Bq/m³ compared to 54.74 Bq/m³ in 2015.

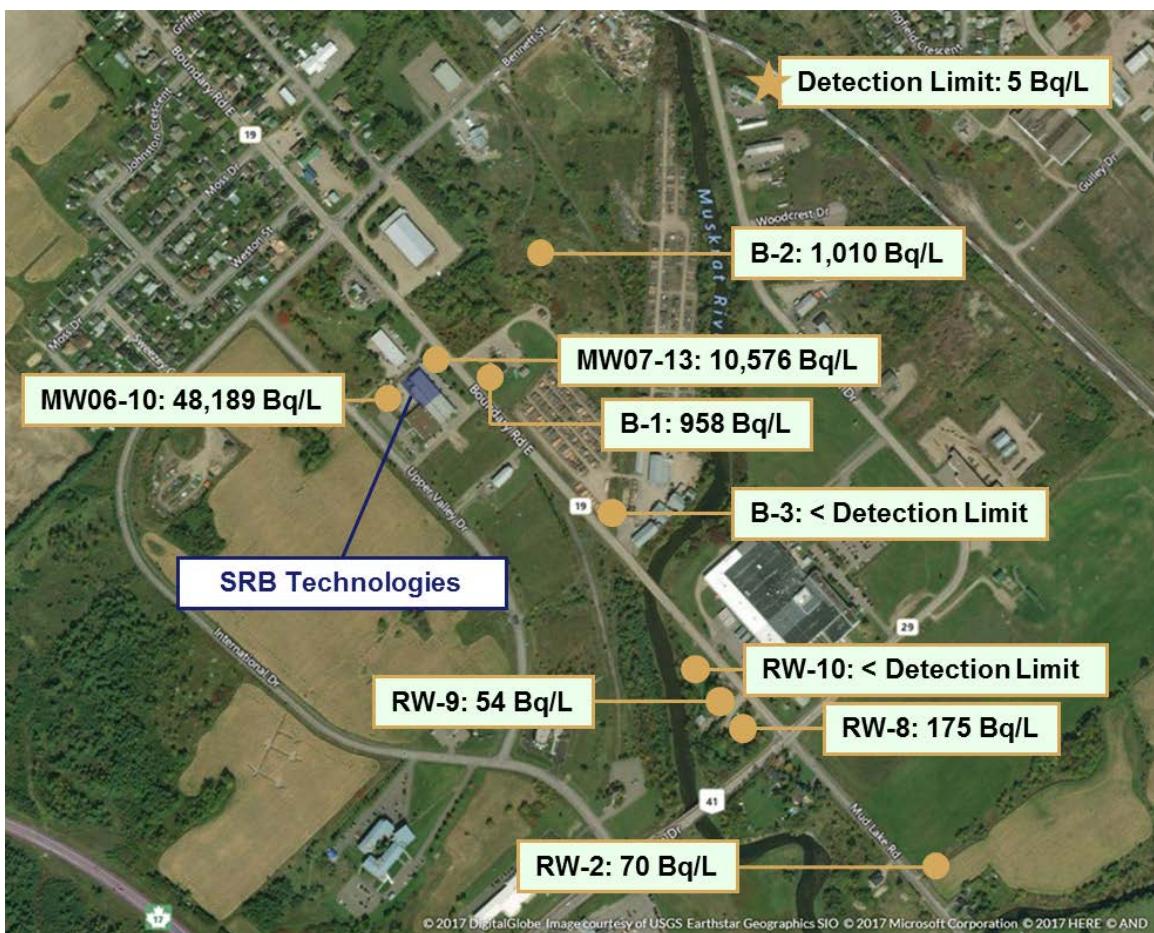
Groundwater Monitoring

Groundwater is currently sampled from 34 monitoring wells around the facility, and an additional 15 residential and business wells. Out of all of the groundwater monitoring wells, two showed tritium concentrations exceeding 7,000 Bq/L at the conclusion of 2016. The highest tritium concentration was found in well MW06-10, which is located near the SRBT stacks, averaging 48,189 Bq/L in 2016. The wells exceeding 7,000 Bq/L are restricted to a small area adjacent to the SRBT building and are not used for drinking water.

Tritium concentrations decrease significantly at locations further away from SRBT. In 2016, the highest tritium concentration in a potential drinking water well was found in residential well RW-08, averaging 175 Bq/L and remaining far below Ontario's drinking quality standard of 7,000 Bq/L. Overall, CNSC staff conclude that the tritium inventory in the groundwater system around the facility has been trending downwards since 2006. This trend is due to SRBT's initiative to reduce emissions, including the commissioning of improved tritium trap valves and remote display units, the real-time monitoring of gaseous effluent, and a reduction in the amount of failed leak tests of manufactured light sources. In addition to the reduced emissions, the concentration of tritium in the groundwater is decreasing due to the natural decay of tritium and the flushing of historical tritium emissions through the groundwater system.

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

Figure 8-4: Annual Average Tritium Concentrations in Groundwater, SRB Technologies (Canada) Inc., 2016



Other Monitoring

SRBT samples and analyzes runoff water from its site, and engages a qualified third party to perform monitoring and analysis of precipitation, surface water, produce, milk, and wine. The 2016 monitoring data for these items are very low, and consistent with previous years, with an average tritium concentration ranging between 3 Bq/L and 120 Bq/L for water runoff, surface water, milk and wine; and an average free-water tritium concentration of 72 Bq/kg for produce. This monitoring complements the principal monitoring activities, which focus on air and groundwater.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring at SRBT in 2013, 2014 and 2015. The results are available on the CNSC's [IEMP Web page](#) and indicate that the public and the environment in the vicinity of SRBT are protected and safe. The next independent environmental monitoring campaigns at SRBT are scheduled for 2018 and 2020.

Protection of the Public

The licensee is required to demonstrate that adequate provisions are made for protecting the health and safety of the public from exposures to hazardous substances released from the facility. There were no releases of hazardous substances (non-radiological) to the environment in 2016 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, CNSC staff informed SRBT that several environmental management standards would need to be included as part of the future licensing basis for the facility. CNSC staff requested that SRBT provide implementation dates along with a gap analysis documenting the areas where SRBT's existing programs did not address the requirements of the standards.

On January 15, 2016, SRBT submitted its gap analysis and action plan for several environmental protection standards, including CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [3]. SRBT has indicated that it would conduct an ERA in advance of its next licence renewal application, expected in 2020. In general, CNSC staff found the gap analysis conducted by SRBT for CSA N288.6-12 to be acceptable. SRBT provided an action plan and a time frame for full implementation by 2020. CNSC staff are satisfied with SRBT's progress towards implementing the CSA requirements. SRBT currently has acceptable environmental programs in place to ensure the protection of the public and the environment.

8.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, SRB Technologies (Canada) Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| FS | FS | FS | FS | FS |

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

Performance

CNSC staff monitor SRBT's performance related to conventional health and safety during onsite inspections and through event reviews. SRBT continues to develop and maintain a comprehensive occupational health and safety management program for its facility. SRBT's conventional health and safety program incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for this SCA is the number of LTIs that occur in a given year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. As per table 8-2, no LTIs occurred at SRBT in 2016.

Table 8-2: Lost-time injuries, SRB Technologies (Canada) Inc., 2012-2016

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

Practices

SRBT's activities and operations must comply with not only the NSCA [1] and its associated regulations but also with Part II of the *Canada Labour Code* [5]. As such, SRBT is required to report incidents resulting in an injury to ESDC. The SRBT Workplace Health and Safety Committee inspects the workplace and meets frequently to resolve and track any issues related to health and safety. In 2016, this committee met nine times. CNSC staff review the meeting minutes and associated corrective actions through onsite inspections to ensure that 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.

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. Nordion's licence expires in October 2025. Figure 9-1 shows an aerial view of the Nordion facility.

Figure 9-1: Aerial view of the Nordion facility



At this facility, Nordion processes unsealed radioisotopes (such as iodine-131) for health and life sciences applications, and manufactures sealed radiation sources for industrial applications. The facility is comprised of two major production operations, one involving the processing of radioisotopes used in nuclear medicine (Medical Isotopes) and the other involving sealed sources used in cancer therapy and irradiation technologies (Gamma Technologies). Effective October 31, 2016, Nordion made the business decision to cease production and sale of Iodine-125, Iodine-131, and Xenon-133. There was no impact to Nordion's environment, health and safety programs as a result of this change.

In its licence renewal application in 2015, Nordion indicated that it had historical neutron sources for which it could not find a disposal pathway. The Commission requested that Nordion provide updates on the disposal of these sources when a path forward had been determined. As reported in the 2015 Regulatory Oversight Report, Nordion was working with Energy Solutions, which was able to receive and dispose of these neutron sources. Nordion completed the shipment of the neutron sources to Canadian Nuclear Laboratories (CNL) in July 2017. This Commission request is now closed.

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



9.1 Performance

CNSC staff rated all of Nordion's SCAs as "satisfactory" for 2015 with the exception of environmental protection and security, both of which were rated as "fully satisfactory." The Nordion facility ratings for 2012 to 2016 are provided in table C-6, appendix C.

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

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

As required by the NSCA [1], its associated regulations and Nordion's licence, Nordion submitted a total of 10 reports to the CNSC on events or incidents that occurred in 2016. CNSC staff reviewed these reports and concluded that none of the events or incidents compromised the health and safety of persons or the environment. Of the 10 reports, seven were related to packaging and transport (largely due to the fact that Nordion transports approximately 10,000 packages containing nuclear substances per year). The packaging and transport reports were related to low-risk items such as incorrect shipping documents, errors in labelling, visible damage to Type A packages sustained in transit, and incorrect activity listed on labels or documents. The remaining event reports were also low risk, related to maintenance and shipping. CNSC staff have reviewed and are satisfied with the corrective actions taken by Nordion for all of the reports submitted in 2016.

In 2016, CNSC staff conducted three inspections at Nordion's facility to ensure compliance with the NSCA [1] and its regulations, Nordion's operating licence and the programs used to meet regulatory requirements. A list of these inspections can be found in Table J-6 in appendix J. The inspections focused on the operating performance, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management, packaging and transport, and emergency management and fire protection SCAs. Seven enforcement actions were raised as a result of the inspections. CNSC staff concluded that the findings from these inspections posed a low risk to the achievement of regulatory objectives and CNSC expectations.

9.2 Radiation protection

Overall compliance ratings for radiation protection SCA, Nordion (Canada) Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| 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* [2].

Application of ALARA

As required by the *Radiation Protection Regulations* [2], Nordion continued to implement radiation protection measures at its facility in 2016 to keep radiation exposures and doses to persons ALARA, taking into account social and economic factors. Nordion's Environmental Health and Safety Committee meets regularly to discuss various aspects of the program, including worker doses, radiological hazard monitoring results and internal audit results.

Worker dose control

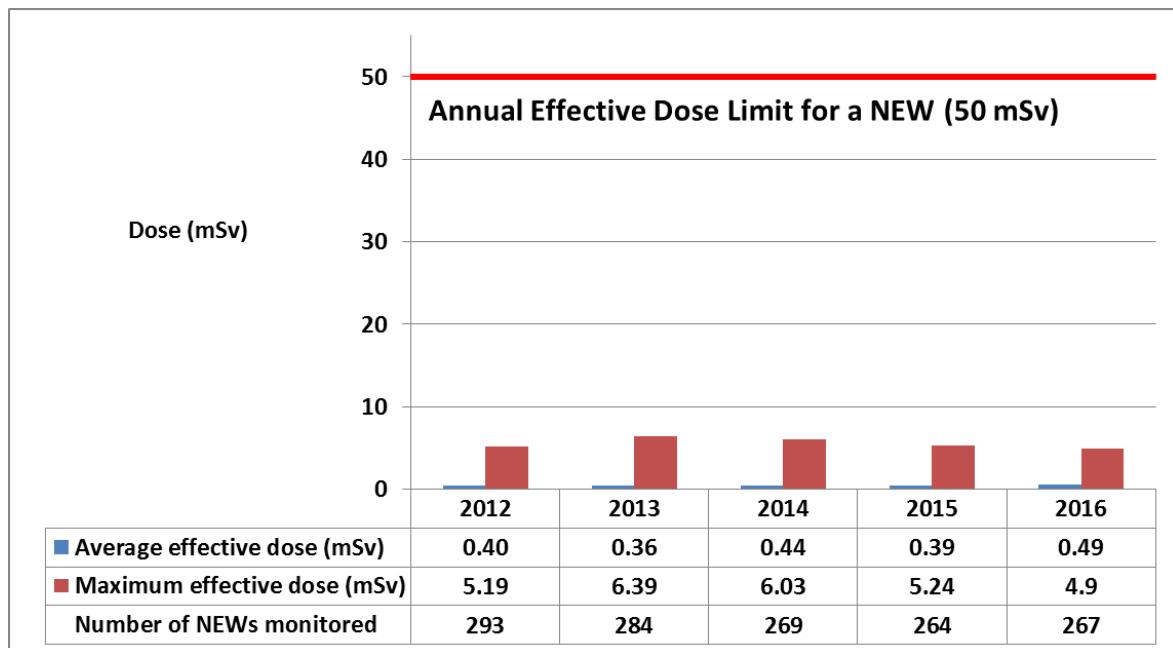
Radiation exposures are monitored to ensure compliance with the CNSC's regulatory dose limits and with keeping radiation doses ALARA. In 2016, radiation exposures at Nordion were well below CNSC regulatory dose limits. The main radiological hazards faced by workers include exposure to alpha, beta and gamma radiation emitted from the radioisotopes processed for medical purposes, and from the production of sealed sources for industrial applications and medical therapy. External whole body and equivalent doses are ascertained using dosimeters. For internal radiological exposures, Nordion has a screening program for routine thyroid monitoring of workers working with iodine-125 and iodine-131. There are also provisions for whole body counting and urine analysis in the event of elevated air and/or contamination monitoring results. There were no internal doses recorded in 2016.

All employees who work in or enter an area where radiological work is performed (i.e., the active area) have a reasonable probability of receiving an occupational dose greater than 1 mSv/year and are 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 doses remain less than the regulatory dose limit of 1 mSv/year and ALARA.

In 2016, the total effective dose was assessed for 267 NEWs at Nordion, consisting of 140 workers working in the active area and 127 workers who work primarily in the non-active area but may perform some work duties in the active area. All of the NEWs are Nordion employees. The maximum effective dose received by a NEW in 2016 was 4.9 mSv, or approximately 10 percent of the regulatory effective dose limit of 50 mSv in a one-year dosimetry period.

Figure 9-3 provides the average and maximum effective doses to NEWs at Nordion between 2012 and 2016. Average and maximum effective doses were relatively stable between 2012 and 2016.

Figure 9-3: Average and maximum effective doses to NEWS, Nordion (Canada) Inc., 2012-2016



Nordion also ascertained the total effective dose for contractors (non-NEWS) in 2016. Fifty-three (53) contractors were monitored, and the maximum effective dose received by a contractor in 2016 was 0.36 mSv, or 36 percent of the regulatory effective dose limit of 1 mSv in a one-year dosimetry period. The average effective dose for contractors in 2016 was 0.07 mSv.

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

Radiation protection program performance

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

Action levels (annual and by dosimetry period) are established as part of Nordion's radiation protection program for effective and equivalent doses to workers. If reached, Nordion must establish the cause, notify the CNSC and, if applicable, restore the effectiveness of the program. No worker received a dose of radiation exceeding an action level in 2016.

Radiological hazard control

Nordion established radiation and contamination control programs to control and minimize radiological hazards and the spread of radioactive contamination.

Methods of control include radiation zone controls, surface contamination monitoring, in-plant air-monitoring systems and radiological surveys. CNSC staff did not identify any adverse trends in the monitoring results in 2016. CNSC staff are satisfied with Nordion's radiological hazard control.

Estimated dose to the public

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

Table 9-1: Maximum effective dose to a member of the public, Nordion (Canada) Inc., 2012-2016

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

9.3 Environmental protection

Overall compliance ratings for environmental protection SCA, Nordion (Canada) Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| FS | FS | FS | FS | FS |

For 2016, CNSC staff continued to rate the environmental protection SCA at Nordion as "fully satisfactory."

Nordion continues to implement and maintain a highly effective environmental protection program per regulatory requirements to control and monitor gaseous and liquid releases of radioactive substances from its facility into the environment. For the last five years, the gaseous emissions and liquid effluents have remained stable and well below the DRLs. No action levels were exceeded in 2016. Groundwater monitoring, soil sampling and gamma exposure measurements indicate that the public and the environment continue to be protected from facility releases.

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

Atmospheric emissions

Nordion continues to monitor and control the releases of radioactive materials from the facility to prevent unnecessary releases of radioisotopes to the atmosphere. Table F-17, appendix F, shows Nordion's radiological air emissions monitoring results from 2012 to 2016. The monitoring data in table F-17 demonstrate that the radiological air emissions from the facility in 2016 continued to be effectively controlled as they were consistently well below the DRLs prescribed in its operating licence.

In addition to licence limits, Nordion has action levels that are used to provide assurance that the licence release limits will not be exceeded. Action level exceedances provide early indication of a potential loss of control of part of the environmental protection program and trigger a requirement for specific action to be taken. No action levels were exceeded at any time in 2016.

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

Liquid effluent

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

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

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. 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. Nordion's objectives included reducing non-hazardous waste to landfill, reducing energy use, and reducing particulate matter air emissions. By the end of 2016, Nordion had met or was in the process of meeting its targets for these objectives.

The EMS is verified through Nordion's annual management review which involves the evaluation of actions from the previous 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 their compliance verification activities, review the results of the annual review and follow-up with Nordion staff on any outstanding issues.

Assessment and monitoring

Nordion's environmental monitoring program serves to demonstrate that the site emissions of 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 off site to demonstrate that emissions from the facility do not pose risks to public health or to the environment. The monitoring results since 2012 are further described below.

Nordion committed to complete a gap analysis of its environmental program against CSA N288.4-10 *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8] and CSA N288.5-11 *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [9] by May 31, 2016. Nordion completed its gap analysis and submitted it for CNSC review. CNSC staff's review of the gap analysis is ongoing and pending completion of the review of the environmental risk assessment, described below.

Groundwater monitoring

There are nine groundwater monitoring wells around the Nordion site. 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 2005 results were all near background levels or the detection limit. Nordion's monitoring is conducted at least once per year to ensure that there have been no significant changes since 2005. The monitoring results over the period of 2012 to 2016 demonstrate that there were no significant changes for concentrations of hazardous substances in the groundwater relative to 2005.

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 were detected. These results, which are either below detection limits or at natural background levels, indicate that releases of radioactive and hazardous substances from the Nordion's facility have had no measurable impact on groundwater quality.

Soil sampling

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

Environmental 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 located near the facility. The annual monitoring results for 2016 showed that the levels of gamma radiation at off-site monitoring locations are in the range of natural background. These results indicate that Nordion is not contributing to the public's exposure to gamma radiation at and beyond the perimeter of the facility.

CNSC Independent Environmental Monitoring Program

CNSC staff conducted independent environmental monitoring at Nordion in 2016. The results are available on the CNSC's [IEMP Web page](#). The IEMP results indicate that the public and the environment in the vicinity of Nordion are protected and safe. The next independent environmental monitoring campaigns at Nordion are scheduled for 2018 and 2020.

Protection of the public

The licensee is required to demonstrate that adequate provisions are made for protecting the health and safety of the public from exposures to hazardous 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's review of the programs at Nordion, CNSC staff conclude that the public continues to be protected from facility emissions.

Environmental risk assessment

Nordion currently has acceptable environmental programs in place to ensure the protection of the public and the environment. Nordion committed to formalize and document its risk assessment in accordance with CSA N288.6-12, *Environmental Risk Assessment at Class I Nuclear Facilities and Uranium Mines and Mills* [3] by May 31, 2016. CNSC staff reviewed the ERA submitted by Nordion and found it to be generally consistent with CSA N288.6-12, although several technical comments remain to be addressed by the licensee before the ERA is accepted.

9.4 Conventional health and safety

Overall compliance ratings for conventional health and safety SCA, Nordion (Canada) Inc., 2012-2016

| 2012 | 2013 | 2014 | 2015 | 2016 |
|------|------|------|------|------|
| FS | FS | SA | SA | SA |

For 2016, CNSC staff continued to rate the conventional health and safety SCA at Nordion as “satisfactory.” Compliance verification activities confirmed that Nordion continues to view conventional health and safety as an important consideration for all activities.

Performance

CNSC staff monitor Nordion’s performance related to conventional health and safety during onsite inspections and through event reviews. Nordion continues to develop and maintain a comprehensive occupational health and safety management program for its facility. Nordion’s conventional health and safety program incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response. Nordion made several improvements to its conventional health and safety program in 2016, including improvements to incident, near miss and hazard identification reporting; the development of a formal occupational health and safety manual; and quarterly safety focus talks.

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

Table 9-4: Lost-time injuries, Nordion (Canada) Inc., 2012-2016

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

Practices

Nordion's activities and operations must comply with not only the NSCA [1] and its regulations but also Part II of the *Canada Labour Code* [5]. Nordion's conventional health and safety program is under the oversight of Nordion's joint Workplace Health and Safety Committee, which met ten times in 2016. CNSC staff review the meeting minutes and associated corrective actions during onsite inspections to ensure that issues are promptly resolved.

Awareness

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

10 BEST THERATRONICS

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

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



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



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

On August 24, 2015, a CNSC Designated Officer issued an order to BTL. The order was issued following BTL's failure to comply with a condition of the Commission-issued licence NSPFOL-14.01/2019 that imposed requirements on BTL to provide an acceptable financial guarantee by July 31, 2015. The intent of the order was to ensure that sufficient funds are available for the future decommissioning of the BTL facility. BTL was granted an opportunity to be heard, and the Commission subsequently amended the order twice, on September 28, 2015 [17] and on February 29, 2016 [18].

The order required BTL to dispose of or transfer all depleted uranium, sealed sources and prescribed equipment in its possession; cease all imports and increases to its current inventory of sealed sources and prescribed equipment containing radioactive sources or depleted uranium; and limit the operation of particle accelerators. As a result of the order issued to BTL, BTL reduced its inventory of nuclear substances. BTL submitted a revised preliminary decommissioning plan to reflect the significant decrease in the number of sealed sources, prescribed equipment and depleted uranium at its facility, including a revised decommissioning cost estimate of \$1.8 million. On July 14, 2017, the Commission accepted the financial guarantee [19], and BTL has submitted the financial guarantee to the full amount. At the time of writing this report, BTL is in compliance with its financial guarantee licence condition and the order has since been closed by the Commission.

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

10.1 Performance

For 2016, CNSC staff rated BTL's performance as "satisfactory" in all SCAs. The BTL performance ratings from 2015 to 2016 are provided in table C-7, appendix C.

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

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

10.2 Radiation protection

Overall compliance ratings for radiation protection SCA, BEST Theratronics Limited, 2012–16:

| 2012 | 2013 | 2014 | 2015 | 2016 |
|---|------|------|------|------|
| SA | SA | SA | SA | SA |
| For 2016, CNSC staff continued to rate the radiation protection SCA at BTL as “satisfactory”. BTL has implemented and maintained a radiation protection program as required by the <i>Radiation Protection Regulations</i> [2]. | | | | |

Application of ALARA

In 2016, BTL continued to implement radiation protection measures 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 provisions for dose trend analysis.

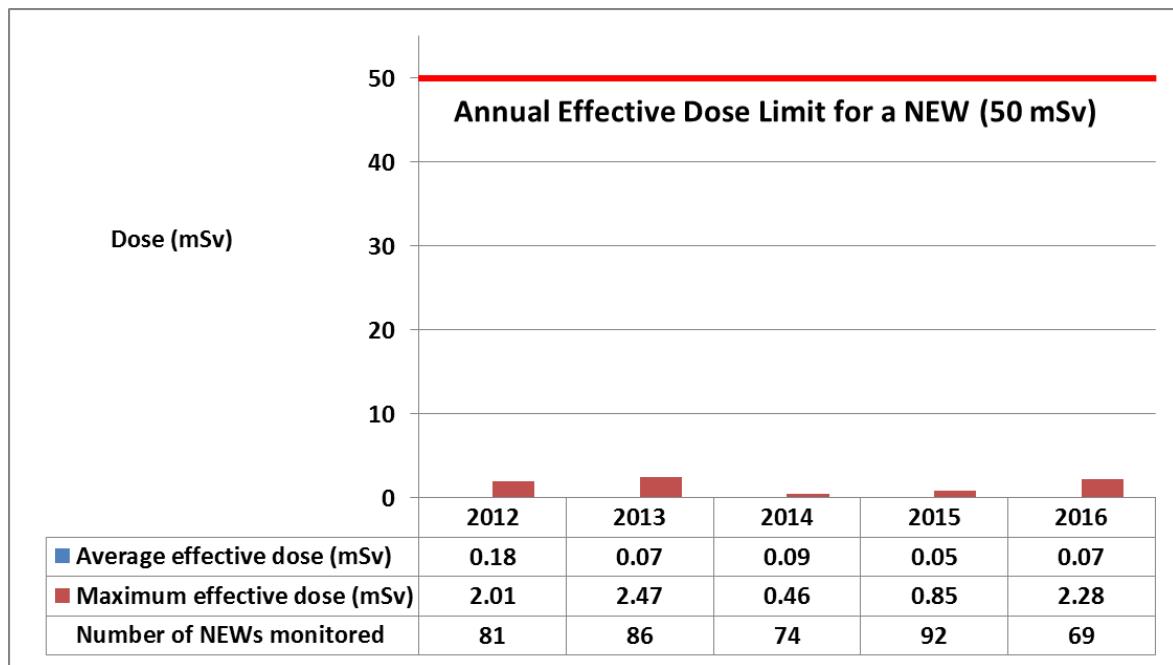
Worker Dose Control

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

BTL workers are exposed externally to sealed sources of radiation. At BTL, employees are classified as NEWs if they are expected to have a reasonable probability of receiving an occupational dose greater than 1 mSv. Such workers include service technician and source handlers. External whole body and equivalent doses are ascertained using dosimetry. In 2016, the maximum effective dose received by a NEW at BTL was 2.28 mSv, or approximately 4.6 per cent of the regulatory limit for effective dose of 50 mSv in a one-year dosimetry period.

Figure 10-3 provides the average and maximum effective doses for NEWs at BTL between 2012 and 2016. Over the past five years, annual effective doses at BTL have remained stable and very low.

Figure 10-3: Average and maximum effective doses to NEWs, BEST Theratronics Limited, 2012-2016



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

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

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

Radiation Protection Program Performance

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

Action levels for effective 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 and, if applicable, restore the effectiveness of the radiation protection program. In 2016, there were no action level exceedances at BTL.

Radiological Hazard Control

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

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, and following work where the potential for contamination exists. There has been no indication of the presence of contamination from routine contamination swipes at the BTL facility.

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

Estimated Dose to the Public

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

10.3 Environmental protection

Overall compliance ratings for environmental protection SCA, BEST Theratronics Limited (BTL), 2014-2016:

| 2014 | 2015 | 2016 |
|------|------|------|
| SA | SA | SA |

For 2016, CNSC staff continue 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. During 2016, 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 an Environmental Management System in order to conform to REGDOC 2.9.1, *Environmental Protection Policies, Programs and Procedures* [14].

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 shield for the sealed sources.

There are no hazardous liquid releases that require controls. Hazardous liquid effluents from routine operations are collected, temporarily stored on-site 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, such as filters and ventilation, are in place to reduce or eliminate emissions generated during operations.

Environmental Management System

In 2015, BTL implemented a new EMS to conform to REGDOC 2.9.1, *Environmental Protection Policies, Programs and Procedures* [14], a requirement of its Class I licence. CNSC staff have verified that BTL continues to meet the requirements outlined in the regulatory document.

Assessment and Monitoring

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

Protection of the Public

The licensee is required to demonstrate that adequate provisions are made for protecting the health and safety of the public from exposures to hazardous 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

BTL included an ERA in its application for a Class IB licence in 2014. The ERA included mitigation measures for the identified risks, such as filtration and ventilation for airborne hazardous emissions. CNSC staff reviewed BTL's ERA 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. The results indicated 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

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

| 2014 | 2015 | 2016 |
|------|------|------|
| SA | SA | SA |

For 2016, CNSC staff continued to rate the conventional health and safety SCA at BTL as "satisfactory." The compliance verification activities conducted by CNSC staff confirmed that BTL views conventional health and safety as an important consideration. BTL has demonstrated 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

CNSC staff monitor BTL's performance related to conventional health and safety during onsite inspections and through event reviews. BTL continues to develop and maintain a comprehensive occupational health and safety management program for its facility. BTL's conventional health and safety program incorporates various elements, including accident reporting and investigation, hazard prevention, preventive maintenance, health and safety committees, training, personal protective equipment, and emergency preparedness and response.

A key performance measure for this SCA is the number of LTIs that occur per year. An LTI is an injury that takes place at work and results in the worker being unable to return to work and carry out their duties for a period of time. As indicated in table 10-1, there were three LTIs reported at the BTL facility in 2016. The LTIs included injured fingers and a broken wrist, and resulted in three days of lost time. For each LTI that occurred, BTL conducted an investigation and implemented corrective actions which are summarized in table G-3, appendix G. CNSC staff reviewed the corrective actions and are satisfied with the actions taken by BTL to prevent recurrence.

Table 10-1: Lost-time injuries, Best Theratronics Ltd., 2014-2016

| | 2014 | 2015 | 2016 |
|-------------------------------|-------------|-------------|-------------|
| Lost-time injuries | 1 | 1 | 3 |

Practices

BTL's activities and operations must comply with not only the NSCA [1] and its regulations but also Part II of the *Canada Labour Code* [5]. BTL has a Health and Safety Committee that inspects the workplace and meets monthly to resolve and track any safety issues. CNSC staff review the monthly meeting minutes of this committee and associated corrective actions to ensure issues are promptly resolved. CNSC staff have confirmed that when issues have been raised through BTL's workplace health and safety inspections, BTL addresses the issues and takes corrective action.

Awareness

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

11 OVERALL CONCLUSIONS

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

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

- uranium processing facilities were rated as “satisfactory” or better.
- nuclear substance processing facilities were rated as “satisfactory” or better.

CNSC staff's compliance activities confirmed that:

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

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

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ACRONYMS

| | |
|---------------|---|
| ALARA | As low as reasonably achievable |
| BE | Below expectations |
| Bq | Becquerel |
| BRR | Blind River Refinery |
| BTL | Best Theratronics Ltd. |
| BWXT | BWXT Nuclear Energy Canada Inc. |
| Cameco | Cameco Corporation |
| CANDU | Canada Deuterium Uranium |
| CCME | Canadian Council of Ministers of the Environment |
| CFM | Cameco Fuel Manufacturing Inc. |
| Ci | Curie |
| Cm | centimeter |
| 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 (now CSA Group) |
| DRL | Derived release limit |
| EHS | Environmental Health & Safety |
| EMS | Environmental management system |
| ESDC | Employment and Social Development Canada (formerly Human Resources and Skills Development Canada) |
| ERA | Environmental risk assessment |
| FINAS | Fuel Incident Notification and Analysis System |
| g | gram |
| GBq | Gigabecquerel |
| GCQWQ | Guidelines for Canadian Drinking Water Quality |
| GEH-C | GE Hitachi Nuclear Energy Canada Inc. |
| GTLS | Gaseous tritium light source |

| | |
|------------------------|--|
| h | Hour |
| HNO₃ | Nitric Acid |
| IAEA | International Atomic Energy Agency |
| IEMP | Independent Environmental Monitoring Program |
| ISO | International Organization for Standardization |
| KPI | Key performance indicator |
| Kg | Kilogram |
| L | Liter |
| LCH | Licence Conditions Handbook |
| LTI | Lost-time injury |
| M³ | Cubic meters |
| Max. | Maximum |
| MeV | Megaelectronvolt |
| Min. | Minimum |
| mg/L | Milligram per litre |
| MFN | Mississauga First Nation |
| mSv | Millisievert |
| MOECC | Ontario Ministry of the Environment and Climate Change |
| NEW | Nuclear energy worker |
| NOx | Nitrogen oxides |
| NO₂ | Nitrogen Dioxide |
| Nordion | Nordion (Canada) Inc. |
| NSCA | Nuclear Safety and Control Act |
| OPG | Ontario Power Generation |
| PHCF | Port Hope Conversion Facility |
| ppm | Parts per million |
| SA | Satisfactory |
| SCA | Safety and control area |
| SI | System of Units |
| SRBT | SRB Technologies (Canada) Inc. |
| TBq | Terabecquerel |
| TLD | Thermoluminescent dosimeters |
| UA | Unacceptable |

| | |
|-----------------------|----------------------------|
| µg | Microgram |
| µSv | Microsievert |
| UF₆ | Uranium hexafluoride |
| UO₂ | Uranium dioxide |
| UO₃ | Uranium trioxide |
| VIM | Vision in Motion |
| WSC | Workplace Safety Committee |

GLOSSARY

| | |
|--|--|
| action levels | A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program or environmental protection program, and triggers a requirement for specific action to be taken. |
| becquerel | The International System of Units (SI) unit of radioactivity. One becquerel (Bq) is the activity of a quantity of radioactive material in which one nucleus decays per second. In Canada, the Bq is used instead of the non-SI unit curie (Ci). 1 Bq = 27 µCi (2.7×10^{-11} Ci) and 1 Ci = 3.7×10^{10} Bq. 1 megabecquerel (MBq) = 10^6 Bq 1 gigabecquerel (GBq) = 10^9 Bq 1 terabecquerel (TBq) = 10^{12} Bq |
| Canadian Nuclear Safety Commission (CNSC) | Canada's nuclear regulator, established under the <i>Nuclear Safety and Control Act</i> [1] to regulate the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public. |
| Commission | The Canadian Nuclear Safety Commission established by section 8 of the <i>Nuclear Safety and Control Act</i> [1]. The Commission consists of not more than seven members, appointed by the Governor in Council, to: <ul style="list-style-type: none">• make independent, fair and transparent decisions on the licensing of nuclear-related activities• establish legally binding regulations• set regulatory policy direction on health, safety, security and environmental issues affecting the Canadian nuclear sector This term is not used when the intention is to refer to both Commission members and CNSC staff. (See also Canadian Nuclear Safety Commission.) |
| Commission member document | A document prepared for Commission hearings and meetings by CNSC staff, proponents and interveners. |
| critical receptor | As defined in CSA Group standard N288.6, <i>Environmental risk assessments at Class I nuclear facilities and uranium mines and mills</i> , a critical receptor refers to the receptor receiving the greatest dose, which applies to both radiological and non- |

| | |
|------------------------------------|---|
| | radiological risk assessments. |
| cyclotron | A particle accelerator that speeds up particles in a circular motion until they hit a target at the perimeter of the cyclotron. Some cyclotrons are used to produce medical isotopes. |
| derived release limit (DRL) | As defined in the CSA Group publication CSA N288.1, <i>Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities</i> : the release rate that would cause an individual of the most highly exposed group to receive and be committed to a dose equal to the regulatory annual dose limit due to release of a given radionuclide to air or surface water during normal operation of a nuclear facility over the period of a calendar year. |
| effective dose | The sum of the products, in sieverts, obtained by multiplying the equivalent dose of radiation received by and committed to each organ or tissue set out in column 1 of an item of Schedule 1 of the <i>Radiation Protection Regulations</i> by the weighting factor set out in column 2 of that item. Effective dose is a measure of the total detriment, or risk, due to an exposure to ionizing radiation. If the exposure to different organs or tissues is not uniform (as is the case when radionuclides are deposited in the body), the concept of effective dose is used. The basic idea is to express the risk from the exposure to a single organ or tissue in terms of the equivalent risk from an exposure to the whole body. The unit of effective dose is the sievert. |
| enforcement action | The set of activities associated with re-establishing compliance with regulatory requirements. |
| equivalent dose | The product, in sieverts, obtained by multiplying the absorbed dose of radiation of the type set out in column 1 of an item of Schedule 2 of the <i>Radiation Protection Regulations</i> by the weighting factor set out in column 2 of that item. Equivalent dose and effective dose are protection quantities used to reflect how radiation exposure can affect overall health of the human body. They specify dose values, which are derived from the body's absorbed dose, for limiting the occurrence of stochastic health effects below acceptable levels and avoiding tissue reactions. The equivalent dose (multiplying the radiation type by its radiation weighting factor) is designed to reflect the amount of harm caused, regardless of the type of radiation. Values (expressed in sieverts) of equivalent dose to a specified tissue or organ from any type(s) of radiation can be compared |

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

Note: The CNSC published Regulatory Document REGDOC-3.6, *Glossary of CNSC Terminology*, in December 2016 [20].

A. SAFETY AND CONTROL AREA FRAMEWORK

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

| Functional area | Safety and control area | Definition | Specific areas |
|------------------------|--------------------------------|---|---|
| Management | Management system | Covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives and fosters a healthy safety culture. | <ul style="list-style-type: none"> ▪ management system ▪ organization ▪ performance assessment, improvement and management review ▪ operating experience ▪ change management ▪ safety culture ▪ configuration management ▪ records management ▪ management of contractors ▪ business continuity |
| | Human performance management | Covers activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties. | <ul style="list-style-type: none"> ▪ human performance program ▪ personnel training ▪ personnel certification ▪ initial certification examinations and requalification tests ▪ work organization and job design ▪ fitness for duty |
| | Operating performance | Includes an overall review of the conduct of licensed activities as well as other activities that enable effective performance. | <ul style="list-style-type: none"> ▪ conduct of licensed activity ▪ procedures ▪ reporting and trending ▪ outage management performance ▪ safe operating envelope ▪ severe accident management and recovery ▪ accident management and |

| Functional area | Safety and control area | Definition | Specific areas |
|------------------------|--------------------------------|--|---|
| | | | recovery |
| Facility and equipment | Safety analysis | Covers maintenance of the safety analysis that supports the overall safety case for a facility. Safety analysis involves a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility, and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards. | <ul style="list-style-type: none"> ▪ deterministic safety analysis ▪ hazard analysis ▪ probabilistic safety analysis ▪ criticality safety ▪ severe accident analysis ▪ management of safety issues (including R&D programs) |
| | Physical design | Relates to activities that affect the ability of structures, systems and components to meet and maintain their design basis, taking into account new information as it arises and changes in the external environment. | <ul style="list-style-type: none"> ▪ design governance ▪ site characterization ▪ facility design ▪ structure design ▪ system design ▪ component design |
| | Fitness for service | Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective. Includes programs that ensure all equipment is available to perform its intended design function when called upon to do so. | <ul style="list-style-type: none"> ▪ 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 <i>Radiation Protection Regulations</i> . This program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA). | <ul style="list-style-type: none"> ▪ 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. | <ul style="list-style-type: none"> ▪ performance ▪ practices ▪ awareness |

| Functional area | Safety and control area | Definition | Specific areas |
|------------------------|--|--|--|
| | Environmental protection | Covers programs that identify, control and monitor all releases of radioactive and hazardous substances, and the effects on the environment from facilities or as the result of licensed activities. | <ul style="list-style-type: none"> ▪ effluent and emissions control (releases) ▪ environmental management system ▪ assessment and monitoring ▪ protection of the public ▪ environmental risk assessment |
| | Emergency management and fire protection | Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions (including any results of participation in exercises). | <ul style="list-style-type: none"> ▪ conventional emergency preparedness and response ▪ nuclear emergency preparedness and response ▪ fire emergency preparedness and response |
| | Waste management | Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. Also covers the planning for decommissioning. | <ul style="list-style-type: none"> ▪ waste characterization ▪ waste minimization ▪ waste management practices ▪ decommissioning plans |
| | Security | Covers the programs required to implement and support the security requirements stipulated in the regulations, licence, orders or expectations for the facility or activity. | <ul style="list-style-type: none"> ▪ facilities and equipment ▪ response arrangements ▪ security practices ▪ drills and exercises |
| | Safeguards and non-proliferation | Covers the programs and activities required to successfully implement the obligations arising from the Canada's safeguards agreement with the International Atomic Energy Agency (IAEA) as well as all other measures arising from the <i>Treaty on the Non-Proliferation of Nuclear Weapons</i> . | <ul style="list-style-type: none"> ▪ nuclear material accountancy and control ▪ access and assistance to the IAEA ▪ operational and design information ▪ safeguards equipment, containment and surveillance ▪ import and export |
| | Packaging and transport | Covers the programs that relate to the safe packaging and transport of nuclear substances to and from the licensed facility. | <ul style="list-style-type: none"> ▪ package design and maintenance ▪ packaging and transport |

| Functional area | Safety and control area | Definition | Specific areas |
|--|-------------------------|------------|--|
| | | | <ul style="list-style-type: none">▪ registration for use |
| Other matters of regulatory interest | | | |
| <ul style="list-style-type: none">▪ environmental assessment▪ CNSC consultation (Aboriginal)▪ CNSC consultation (other)▪ cost recovery▪ financial guarantees▪ improvement plans and significant future activities▪ licensee public information program▪ nuclear liability insurance | | | |

B. RATING METHODOLOGY AND DEFINITIONS

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

Fully satisfactory (FS)

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

Satisfactory (SA)

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

Below expectations (BE)

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

Unacceptable (UA)

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

C. SAFETY AND CONTROL AREA RATINGS

Table C-1: Safety and control area ratings, Blind River Refinery, 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|-------------|-------------|-------------|-------------|-------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | SA | SA | SA |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | SA | FS | FS | FS | FS |
| Environmental protection | SA | SA | SA | SA | SA |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | SA | SA | SA | SA | SA |
| Safeguards and non-proliferation | SA | SA | SA | SA | SA |
| Packaging and transport | SA | SA | SA | SA | SA |

Table C-2: Safety and control area ratings, Port Hope Conversion Facility, 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | SA | SA | SA |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | SA | SA | SA | SA | SA |
| Environmental protection | SA | SA | SA | SA | SA |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | SA | SA | SA | SA | SA |
| Safeguards and non-proliferation | SA | SA | SA | SA | SA |
| Packaging and transport | SA | SA | SA | SA | SA |

Table C-3: Safety and control area ratings, Cameco Fuel Manufacturing Inc., 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | SA | SA | SA |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | SA | SA | SA | SA | SA |
| Environmental protection | SA | SA | SA | SA | SA |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | SA | SA | SA | SA | SA |
| Safeguards and non-proliferation | SA | SA | SA | SA | SA |
| Packaging and transport | SA | SA | SA | SA | SA |

Table C-4: Safety and control area ratings, BWXT Nuclear Energy Canada, 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | SA | SA | SA |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | SA | SA | SA | SA | SA |
| Environmental protection | FS | FS | FS | SA | SA |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | SA | SA | SA | SA | SA |
| Safeguards and non-proliferation | SA | SA | SA | SA | SA |
| Packaging and transport | SA | SA | SA | SA | SA |

Table C-5: Safety and control area ratings, SRB Technologies (Canada) Inc., 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | FS | FS | FS |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | FS | FS | FS | FS | FS |
| Environmental protection | SA | SA | SA | SA | SA |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | SA | SA | SA | SA | SA |
| Safeguards and non-proliferation | NA | NA | NA | NA | NA |
| Packaging and transport | SA | SA | SA | SA | SA |

NA: There are no safeguard verification activities associated with this facility.

Table C-6: Safety and control area ratings, Nordion (Canada) Inc., 2012-2016

| Safety and control areas | 2012 rating | 2013 rating | 2014 rating | 2015 rating | 2016 rating |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| Management system | SA | SA | SA | SA | SA |
| Human performance management | SA | SA | SA | SA | SA |
| Operating performance | SA | SA | SA | SA | SA |
| Safety analysis | SA | SA | SA | SA | SA |
| Physical design | SA | SA | SA | SA | SA |
| Fitness for service | SA | SA | SA | SA | SA |
| Radiation protection | SA | SA | SA | SA | SA |
| Conventional health and safety | FS | FS | SA | SA | SA |
| Environmental protection | FS | FS | FS | FS | FS |
| Emergency management and fire protection | SA | SA | SA | SA | SA |
| Waste management | SA | SA | SA | SA | SA |
| Security | FS | FS | FS | FS | FS |
| Safeguards and non-proliferation | SA | SA | SA | SA | SA |
| Packaging and transport | SA | SA | SA | SA | SA |

Table C-7 Safety and control area ratings, Best Theratronics Ltd., 2014-2016

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

D. FINANCIAL GUARANTEES

Table D-1: Financial guarantees, uranium processing facilities

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

Table D-2: Financial Guarantees, nuclear processing facilities

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

E. WORKER DOSE DATA

Extremity doses – uranium processing facilities

Table E-1: Equivalent (extremity) dose statistics for nuclear energy workers, Blind River Refinery, 2012-2016

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

Table E-2: Equivalent (extremity) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2012-2016

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

Table E-3: Equivalent (extremity) dose statistics for nuclear energy workers, BWXT Nuclear Energy Canada Peterborough Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory limit |
|--|-------|-------|-------|-------|-------|---------------------|
| Average Extremity Dose (mSv) | 11.56 | 10.47 | 18.64 | 12.61 | 9.78 | n/a |
| Maximum Individual Extremity Dose (mSv) | 58.82 | 76.03 | 98.98 | 39.34 | 32.84 | 500 mSv/year |

Table E-4: Equivalent (extremity) dose statistics for nuclear energy workers, BWXT Nuclear Energy Canada Toronto Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory limit |
|---|--------|--------|--------|--------|--------|------------------|
| Average Extremity Dose (mSv) | 46.41 | 32.92 | 31.96 | 30.30 | 27.71 | n/a |
| Maximum Individual Extremity Dose (mSv) | 357.29 | 143.59 | 102.44 | 109.62 | 119.47 | 500 mSv/year |

Extremity doses – nuclear substance processing facilities

Table E-5: Equivalent (extremity) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2012-2016

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

Note: Only the workers who routinely work in the active area are monitored for extremity dose at Nordion.

Table E-6: Equivalent (extremity) dose statistics for nuclear energy workers, BEST Theratronics Limited, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory limit |
|---|------|------|------|------|------|------------------|
| Average Extremity Dose (mSv) | 0.23 | 0.36 | 0.37 | 0.31 | 1.85 | n/a |
| Maximum Individual Extremity Dose (mSv) | 2.9 | 6.1 | 3.7 | 2.1 | 29.9 | 500 mSv/year |

Skin doses – uranium processing facilities

Table E-7: Equivalent (skin) dose statistics for nuclear energy workers, Blind River Refinery, 2012-2016

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

Table E-8: Equivalent (skin) dose statistics for nuclear energy workers, Port Hope Conversion Facility, 2012-2016

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

Table E-9: Equivalent (skin) dose statistics for nuclear energy workers, Cameco Fuel Manufacturing Inc., 2012-2016

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

Table E-10: Equivalent (skin) dose statistics for nuclear energy workers, BWXT Nuclear Energy Canada Peterborough Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory limit |
|------------------------------------|-------|-------|-------|-------|-------|------------------|
| Average Skin Dose (mSv) | 5.04 | 3.8 | 4.75 | 4.1 | 2.66 | n/a |
| Maximum Individual Skin Dose (mSv) | 36.99 | 31.20 | 29.91 | 22.47 | 21.15 | 500 mSv/year |

Table E-11: Equivalent (skin) dose statistics for nuclear energy workers, BWXT Nuclear Energy Canada Toronto Facility, 2012-2016

| Dose Data | 2012 | 2013 | 2014 | 2015 | 2016 | Regulatory limit |
|---|-------|-------|-------|-------|-------|---------------------|
| Average Skin Dose (mSv) | 12.45 | 10.29 | 11.08 | 9.89 | 10.23 | n/a |
| Maximum Individual Skin Dose (mSv) | 58.40 | 52.84 | 51.67 | 54.99 | 74.26 | 500 mSv/year |

Skin doses – nuclear substance processing facilities

Table E-12: Equivalent (skin) dose statistics for nuclear energy workers, Nordion (Canada) Inc., 2012-2016

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

F. ENVIRONMENTAL DATA

Blind River Refinery

Table F-1: Annual groundwater monitoring results, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | GCDWQ* |
|---|------|------|------|------|------|-----------|
| Average uranium concentration ($\mu\text{g/L}$) | 0.3 | 0.5 | 0.6 | 1.7 | 1.3 | 20 |
| Maximum uranium concentration ($\mu\text{g/L}$) | 2.0 | 3.7 | 8.9 | 18.5 | 14.0 | 20 |

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

Table F-2: Surface water annual average results at BRR outfall diffuser in Lake Huron, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | CCME Guidelines* |
|---|---------|---------|---------|--------|--------|------------------|
| Average uranium concentration ($\mu\text{g/L}$) | 0.2 | 0.4 | < 0.2 | 0.2 | <0.8** | 15 |
| Average nitrate concentration (mg/L as N) | 0.1 | 0.3 | 0.2 | 0.2 | 0.2 | 13 |
| Average radium-226 concentration (Bq/L) | < 0.005 | < 0.005 | < 0.005 | <0.005 | <0.005 | N/A |
| Average pH | 7.4 | 7.2 | 7.6 | 7.3 | 8.0 | 6.5 – 9.0 |

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

* Canadian Council of Ministers of the Environment (CCME), *Canadian Water Quality Guidelines for the Protection of Aquatic Life*

** The ambient water method detection limit was reassessed by BRR in 2016

Table F-3: Soil monitoring results, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | CCME Guidelines* |
|---|-------------|-------------|-------------|-------------|-------------|-------------------------|
| Minimum uranium concentration (µg/g) | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | |
| Average uranium concentration (µg/g) (within 1000 m, 0-5 cm depth) | 3.3 | 4.3 | 2.7 | 3.8 | 1.5 | 23 |
| Maximum uranium concentration (µg/g) | 12.1 | 16.4 | 7.2 | 9.7 | 2.9 | |

*Canadian Council of Ministers on the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (for residential/parkland land use).

Port Hope Conversion Facility

Table F-4: Mass (kg) of contaminants of concern (COC) removed by pumping wells, 2012-2016

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

Table F-5: Harbour water quality, 2012-2016

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

*Canadian Council of Ministers of the Environment (CCME), Canadian Water Quality Guidelines for the Protection of Aquatic Life

Table F-6: Uranium concentrations at Waterworks side yard remediated with clean soil ($\mu\text{g/g}$), 2012-2016

| Soil Depth (cm) | 2012 | 2013 | 2014 | Soil Depth (cm) | 2015 | 2016 | CCME Guidelines* | |
|------------------------|-------------|-------------|-------------|------------------------|-------------|-------------|-------------------------|--|
| 0-2 | 1.4 | 1.0 | 1.4 | 0-5 | 1.0 | 1.2 | 23 | |
| 2-6 | 1.1 | 0.9 | 1.2 | | | | | |
| 6-10 | 1.3 | 1.0 | 1.1 | | 1.0 | 1.1 | | |
| 10-15 | 1.5 | 1.0 | 1.1 | | 1.2 | 1.0 | | |
| 70 cm composite | 1.2 | 1.5 | 1.4 | | | | | |

*Canadian Council of Ministers on the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (for residential/parkland land use).

Table F-7: Fluoride concentration in local vegetation, 2012-2016

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

*Ontario Ministry of the Environment and Climate Change's Upper Limit of Normal (ULN) guidelines

Table F-8: Gamma monitoring results – annual average, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limit |
|---|-------|-------|-------|-------|-------|---------------|
| PHCF (Site 1) ($\mu\text{Sv/h}$) | 0.011 | 0.007 | 0.003 | 0.007 | 0.005 | 0.14 |
| Dorset Street (Site 2) ($\mu\text{Sv/h}$) | 0.056 | 0.058 | 0.054 | 0.044 | 0.054 | 0.40 |

Cameco Fuel Manufacturing

Table F-9: Cameco Fuel Manufacturing – soil monitoring results*

| Parameter | 2010 | 2013 | 2016 | CCME Guidelines** |
|---|------|------|------|-------------------|
| Average uranium concentration ($\mu\text{g/g}$) | 4.5 | 3.7 | 2.5 | 23 |
| Maximum uranium concentration ($\mu\text{g/g}$) | 21.1 | 17.4 | 11.2 | 23 |

* Note that CFM reverted to three year soil monitoring program and 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).

BWXT Nuclear Energy Canada Toronto

Table F-10: Air emission and liquid effluent monitoring results, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 | Licence Limit |
|--|--------|--------|--------|--------|--------|---------------|
| Uranium discharged to air (kg/year) | 0.0172 | 0.0104 | 0.0109 | 0.0108 | 0.0108 | 0.76 |
| Uranium discharged to sewer (kg/year) | 0.90 | 0.83 | 0.72 | 0.39 | 0.65 | 9,000 |

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

Table F-11: Uranium in boundary air monitoring results, 2012-2016

| Parameter | 2012 | 2013 | 2014 | 2015 | 2016 |
|--|-------|-------|-------|-------|-------|
| Average concentration ($\mu\text{g}/\text{m}^3$) | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |

Note: Ontario Reg. 415/05 2016 standard for uranium in ambient air is $0.03 \mu\text{g}/\text{m}^3$

Table F-12: Uranium in soil monitoring results, 2012-2014

| Parameter | BWXT Property | | | Industrial/Commercial Lands | | | Residential Locations | | |
|--|---------------|------|------|-----------------------------|------|------|-----------------------|------|------|
| | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 | 2012** | 2013 | 2014 |
| Number of samples | - | 1 | 1 | - | 24 | 34 | 49 | 24 | 14 |
| Average uranium concentration ($\mu\text{g}/\text{g}$) | - | 2.3 | 2.3 | - | 3.9 | 5.0 | 1.9 | 1.1 | 0.6 |
| Maximum uranium concentration ($\mu\text{g}/\text{g}$) | - | 2.3 | 2.3 | - | 24.9 | 22.1 | 10.8 | 3.1 | 2.1 |
| CCME Guidelines ($\mu\text{g}/\text{g}$)* | 300 | | | 33 | | | 23 | | |

*Canadian Council of Ministers on the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health.

**Note: In 2012 there was no distinction between the three CCME property uses. All results were compared to the most stringent use, residential which is $23 \mu\text{g}/\text{g}$.

Table F-13: Uranium in soil monitoring results, 2015-2016

| Parameter | BWXT Property | | Industrial/Commercial Lands | | Residential Locations | |
|---|---------------|------|-----------------------------|------|-----------------------|------|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Number of samples | 1 | 1 | 30 | 34 | 18 | 14 |
| Average uranium concentration ($\mu\text{g/g}$) | 1.4 | 1.2 | 2.9 | 2.7 | 0.7 | 0.5 |
| Maximum uranium concentration ($\mu\text{g/g}$) | 1.4 | 1.2 | 8.7 | 13.6 | 2.1 | 0.7 |
| CCME Guidelines ($\mu\text{g/g}$)* | 300 | | 33 | | 23 | |

*Canadian Council of Ministers on the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health.

BWXT Nuclear Energy Canada Peterborough

Table F-14: Air emissions and liquid effluent monitoring results, 2012-2016

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

SRB Technologies (Canada) Inc.**Table F-15: Atmospheric emissions monitoring results, 2012-2016**

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

Table F-16: Liquid effluent monitoring results, 2012-2016

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

Nordion (Canada) Inc.**Table F-17: Air emissions monitoring results, 2012-2016**

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

Table F-18: Liquid effluent monitoring results, 2012-2016

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

G. LOST-TIME INJURIES IN 2016

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

| Lost-time injury | Action taken |
|--|--|
| <p>An employee was cutting a piece of steel in the cutting booth. Their left hand was placed on the ground clip that was installed on the cutting table. A cut to the final piece of steel caused it to fall over, crushing the end of the employee's finger between the ground clip and the piece of steel leading to a lost time incident. This injury resulted in four days of lost time.</p> | <p>As a result of this event, Cameco implemented the following corrective actions:</p> <ul style="list-style-type: none"> • Developed a new procedure for safe use and operation of the plasma cutter. • Completed training needs analysis for the cutting procedure. • Conduct a lighting survey of the cutting booth. • Linked the plasma cutting activity to a Process Hazard Analysis. • Moved the plasma cutter grounding clamp to another location (leg of the work table) • Installed additional clamp to hold materials during cutting process, thus moving employees hands away from the object • Purchased new lens for welding/cutting helmets, which transition quicker to minimize the time of reduced visibility for employees when plasma cutting stops. |
| <p>An employee working in the UF₆ plant rolled their ankle and required medical attention. A medical assessment confirmed that the employee broke a bone in their leg. This injury resulted in four days of lost time.</p> | <p>Cameco reviewed this event and determined that there were no known causal factors, i.e. no slip or trip hazards present and all Personal Protective Equipment were in good condition. The employee did not move their feet while turning, resulting in the lost time incident.</p> |

| Lost-time injury | Action taken |
|--|---|
| | As a result of this event, Cameco issued a safety bulletin to Cameco staff to provide awareness. |
| An employee required medical treatment for a sprained left ankle. The employee was working in the cylinder filling area standing on the cylinder trolley. When the employee turned to complete a task, the employee rolled their ankle and fell. This injury resulted in one day of lost time. | <p>As a result of this event, Cameco implemented the following corrective actions:</p> <ul style="list-style-type: none"> • Installed an articulating arm with a light in the work area instead of manually placing the light in position. • Design and install an alternative platform in the affected area to provide more space for workers. • Review the incident for Process Hazard Analysis inclusion. |

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

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

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

| Lost-time injury | Action taken |
|--|--|
| An employee twisted and scraped their thumb trying to lift heavy equipment. This injury resulted in 0.5 days of lost time. The employee returned to work with adjusted duties. | Employee was reminded to work within limits and be aware of surroundings. |
| An employee was hurt when a steel part was dropped onto their finger. This injury resulted in 0.5 days of lost time. | Employee was reminded to use caution and work within limits. |
| An employee fell and broke their wrist. This injury resulted in 2 days of lost time. The employee returned to work with adjusted duties. | Employee was reminded to be aware of their surroundings and to act in safe manner. |

H. LINKS TO LICENSEE WEBSITES

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

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

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

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

Table I-2: Changes to the licence conditions handbook (revisions)

| Facility | Date | Revision number | Description of change |
|--|--------------|------------------------|--|
| BWXT Nuclear Energy Canada Inc. | June 2016 | Revision 2 | <p>In June 2016 GEH-C's LCH was updated to the latest format. The improvements included:</p> <ul style="list-style-type: none"> a. Additional clarity on licensing basis; b. Written notification requirements (prior & non-prior) for GEH-C's program documents that form part of licensing basis; c. Inclusion of several compliance verification criteria including all commitments by GEH-C to implement new Regulatory documents in 2014-2015; d. Additional clarity on reporting requirements and inclusion of program documents related to each Safety and Control Area (SCA); and e. Updated list of Action levels. |
| BWXT Nuclear Energy Canada Inc. | January 2017 | Revision 3 | <p>In January 2017, a revised LCH was issued to reflect changes due to the transfer of the licence to BWXT.</p> |

J. CNSC INSPECTIONS

CNSC Inspections - uranium processing facilities

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

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|---|---|-----------------------------|
| Security Inspection | Security | February 22, 2016 |
| BRR Type II Inspection NPFD-BRR-2016-03-08 | Radiation Protection, Public Information and Disclosure Program* | May 2, 2016 |
| BRR Type II Inspection NPFD-BRR-2016-05-02 | Fire Protection | July 7, 2016 |
| BRR Type II Inspection BRR-2016-04 | Management System, Radiation Protection, Conventional Health and Safety, Emergency Management and Fire Protection | January 26, 2017 |

*Not a safety and control area

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

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|---|----------------------------------|-----------------------------|
| PHCF Type II Inspection NPFD-PHCF-2016-02-24 | Fire Protection | May 20, 2016 |
| Security Inspection | Security | July 26, 2016 |
| PHCF Type II Inspection NPFD-PHCF-2016-06-09 | Radiation Protection | August 11, 2016 |
| PHCF Type II Inspection Cameco-PHCF-2016-04 | Environmental Protection | October 7, 2016 |

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

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|---|--|------------------------------------|
| CFM Type II Inspection NPFD-CFM-2016-01-18 | Radiation Protection | March 18, 2016 |
| CFM Type II Inspection NPFD-CFM-2016-06-14 | Environmental Protection | September 22, 2016 |
| CFM Type II Inspection Cameco-CFM-2016-03 | Emergency Management and Fire Protection | March 9, 2017 |

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

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|--|---|------------------------------------|
| BWXT – Type II Routine Inspection GEHC-2016-02-24 | Fire Protection, Waste management, Conventional Health & Safety, Fitness for Service, and Safety Analysis | May 20, 2016 |
| BWXT – Type II Reactive Inspection GEHC-2016-02 | Radiation Protection – Internal Dosimetry | November 3, 2016 |
| BWXT – Type II Emergency Response Inspection GEHC-2016-03 | Emergency Management and Fire Protection | March 27, 2017 |

CNSC Inspections - nuclear substance processing facilities**Table J-5: Inspections, SRB Technologies Inc., 2016**

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|---|---|------------------------------------|
| SRBT Type II Inspection SRBT-2016-01 | Environmental Protection | December 16, 2016 |

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

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|-------------------------|---|------------------------------------|
| EMPD-NORDION-2016-T01 | Emergency Management and Fire Protection | September 13, 2016 |
| NORDION-2016-02 | Operating Performance, Fitness for Service, Radiation Protection, Environmental Protection, Conventional Health and Safety, Waste Management, Packaging and Transport | December 07, 2016 |
| NORDION-2016-03 | Operating Performance (Import and Export) | December 28, 2016 |

Table J-7: Inspections, Best Thertronics, 2016

| Inspection Title | Safety and Control Areas Covered | Inspection report sent date |
|---|---|------------------------------------|
| Monthly Reporting Inspection | Operating Performance | April 29, 2016 |
| NPFD-BEST-2016-06-21 Radiation Protection Type II Inspection | Radiation Protection | September 7, 2016 |
| BT-2016-03 Export Inspection | Operating Performance (Export) | January 9, 2017 |
| BT-2016-04 Environmental Inspection | Environmental Protection | February 28, 2017 |

Notes:

The implementation of the revised DNCFR Conduct of Inspection process in July 2016 resulted in a change in inspection numbering.

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