Canada's Nuclear Regulator

Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2015

Canadian Nuclear Safety Commission
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Canada

Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada 2015

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Cover images

From left to right:

Cigar Lake Mine
McArthur River Mine
Rabbit Lake Mine and Mill
Key Lake Mill
McClean Lake Mill

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EXECUTIVE SUMMARY

This report, titled *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2015*, presents CNSC staff's assessment of the performance of operating, historic and decommissioned uranium mines and mills regulated by the Canadian Nuclear Safety Commission (CNSC). In accordance with the direction of the Commission, the scope of this report has been expanded from the previous edition to include historic and decommissioned sites, to better consolidate and to improve the context of updates provided by staff. The sites added to this report are all low-risk sites, most of which are in long-term monitoring states.

CNSC staff use the safety and control area (SCA) framework to evaluate the performance of each licensee. The report provides performance ratings for all 14 SCAs for operating mines and mills, and where applicable, historic and decommissioned sites. In accordance with previous uranium mines and mills annual reports, this report focuses on the three SCAs which provide the key performance indicators for these facilities: radiation protection, environmental protection, and conventional health and safety. The information provided covers the 2015 calendar year and, where possible, shows trends and compares information to previous years. The report also discusses relevant aspects of the CNSC's Independent Environmental Monitoring Program, public information and community engagement programs, as well as information on licensees' operations, major developments and significant events.

The SCA ratings provided in this report were derived from results of regulatory oversight activities conducted by CNSC staff. These activities included onsite inspections, technical assessments, reviews of reports submitted by licensees, event and incident reviews, and ongoing exchanges of information with licensees. For this reporting year, CNSC staff rated all SCAs as satisfactory for all but one regulated site. Only the Deloro mine site was rated below expectations in one SCA. This resulted in CNSC staff issuing an order to the licensee. CNSC staff confirmed that all uranium mine and mill sites in Canada operated safely during 2015.

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

1 INTRODUCTION

1.1 Background

The Canadian Nuclear Safety Commission (CNSC) regulates Canada's operating, historic and decommissioned uranium mines and mills 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.

The CNSC acts in accordance with the requirements of the *Nuclear Safety and Control Act* (NSCA), and its associated regulations. Each year, the CNSC produces a regulatory oversight report on the operating performance of Canada's uranium mines and mills licensees and licensed facilities. The scope of previous regulatory oversight reports has been limited to operating facilities. During the 2015 Commission meeting on the Beaverlodge update, Commission members requested that annual updates on historic and decommissioned uranium mine and mill sites be similarly combined into a single report. CNSC staff have compiled all pertaining updates into this report. It describes:

- the CNSC's regulatory efforts, public information and community engagement, and Independent Environmental Monitoring Program
- the safety and control areas (SCAs) performance rating for operating, historic and decommissioned uranium mine and mill sites regulated by the CNSC
- licensee information on operation, licence changes, major developments and significant events
- performance data on the SCAs of radiation protection, environmental protection, and conventional health and safety for each licensed facility

This report summarizes CNSC staff's assessment of the following regulated uranium mine and mill sites:

- operating facilities
  - Cigar Lake
  - McArthur River
  - Rabbit Lake
  - Key Lake
  - McClean Lake
- historic (remediating) sites
  - Gunnar
  - Lorado
  - Deloro
- decommissioned sites
  - Beaverlodge
  - Cluff Lake
  - Rayrock
  - Port Radium
  - Agnew Lake
  - Madawaska
  - Bicroft
  - Dyno
  - Elliot Lake
  - Denison and Stanrock

The information presented covers the 2015 calendar year and, where possible, makes comparisons to previous years and shows trends. The information available is related to the amount of regulatory effort. The CNSC applies a risk-informed approach which is discussed further in the next section.

1.2 CNSC regulatory efforts

1.2.1 Licensing and compliance

The CNSC ensures licensee compliance through verification, enforcement and reporting activities. An approved licence will contain the terms of the licence, the activities licensed and licence conditions. Tables summarizing the operating, historic and decommissioned uranium mine and mill licences can be found in appendix A. For operating mines and mills, a licence conditions handbook (LCH) accompanies each licence. Any changes made to the LCHs during 2015 appear in appendix A.

CNSC staff develop compliance plans for each site, commensurate with the risk associated with these facilities. CNSC staff validate the risk assessment of each facility by conducting regulatory activities including onsite inspections, assessments, reviews and evaluations of licensee programs, processes and reports. CNSC staff recognize that the level of risk must be considered to ensure that resources and controls are appropriately allocated and applied. Changes to the compliance plans are made on an ongoing basis in response to events, facility modifications and changes in licensee performance.

In 2015, CNSC staff performed 30 inspections at the five uranium mine and mill facilities and 14 inspections at the historic and decommissioned sites.
A breakdown of the number of CNSC staff inspections at the operating mine and mill facilities as well as at the historic and decommissioned sites can be found in sections 2.1 and 8.1, respectively. The findings from these inspections were provided to the licensees in detailed inspection reports. Enforcement actions arising from the findings were recorded in the CNSC regulatory information bank to ensure these actions were tracked to completion. CNSC staff have verified that licensees have complied with the conditions of enforcement actions and that all actions have been closed.

1.2.2 Safety and control area framework

CNSC staff use the SCA framework in evaluating each licensee's safety performance. The framework includes 14 SCAs which are further subdivided into specific areas that define its key components. Appendix B provides definitions of these SCAs and their specific areas.

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

- FS – fully satisfactory
- SA – satisfactory
- BE – below expectations
- UA – unacceptable

A discussion of rating methodologies and definitions appears in appendix C.

This report provides operating uranium mines' and mills' performance ratings for all 14 SCAs and, where applicable, for the historic and decommissioned sites. It focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs which cover many of the key performance indicators for these facilities and sites.

Through 2015, all SCA performance ratings for the uranium mine and mill facilities, historic and decommissioned sites were rated "satisfactory", with the exception of the Deloro mine site which received a rating of "below expectations" in management systems. An order was issued to the licensee as a result.

In 2015, results from regulatory oversight activities conducted by CNSC staff concluded that uranium mine and mill facilities and historic and decommissioned sites met the following performance expectations:

- Radiation protection measures were effective and results remained as low as reasonably achievable (ALARA). No worker exceeded regulatory effective dose limits.
- Environmental protection programs were effective, and emissions and effluents remained ALARA.
- Conventional health and safety programs continued to protect workers.

Appendix D contains the SCA performance ratings for the operating mines and mills from 2011 to 2015.

1.2.3 CNSC Independent Environmental Monitoring Program

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

The CNSC has implemented its Independent Environmental Monitoring Program (IEMP) to confirm that the public and environment around regulated nuclear facilities are safe. The IEMP is a tool that complements the CNSC's ongoing compliance verification program. It involves taking samples from public areas around the sites, and measuring and analyzing the amount of radiological and hazardous substances in those samples.

In 2014, samples were collected in a number of publicly accessible areas around the Key Lake and McArthur River operations under the CNSC's IEMP. The results appear on the CNSC's IEMP Web page. Based on the results obtained, the CNSC confirmed that the public and the environment around the Key Lake mill and McArthur River mine are safe and that there are no health impacts.

A five-year plan for performing IEMPs at operating uranium mines and mills was established in 2015. As part of this plan, a sampling campaign took place around the McClean Lake operation in the summer of 2016. Results will be published on the CNSC's IEMP Web page.

CNSC staff are currently developing the sampling cycle plan for the remediating and decommissioned sites to ensure that independent monitoring occurs at these sites at appropriate times. During 2015, a three- to five-year cycle plan at the Denison and Rio Algom sites was developed. A number of environmental samples were collected in publicly accessible areas around the city of Elliot Lake/Serpent River watershed as part of this plan. Also under the IEMP, publicly accessible areas around the Deloro mine site were sampled in 2016. The Gunnar mine site will be sampled once the remediation activities are completed. The 2015 IEMP results indicate that the public and the environment in the vicinity of these sites are protected and safe and that there are no adverse environmental and health effects. Results will continue to be provided at the CNSC's IEMP Web page.

1.3 Public information and community engagement

The CNSC is committed to keeping the public informed of regulatory activities occurring at operating mine and mill facilities, and historic and decommissioned sites. Ongoing CNSC public engagement efforts include publishing newsletters, updating website information and maintaining a social media presence. During public engagement activities, the CNSC often staffs an information booth to provide important information on its regulatory role and mandate, as well as to answer any questions that community members may have.

To ensure licensees provide open and transparent information to the public, in 2013 the CNSC published new regulatory requirements in RD/GD 99.3, *Public Information and Disclosure.* Under the new requirements, licensees were compelled to maintain and implement public information and disclosure programs. These programs are supported by disclosure protocols, outlining the type of information on the facility or site 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 is effectively communicated about the health, safety and security of persons and the environment and other issues associated with the lifecycle of nuclear facilities. In 2015, CNSC staff confirmed through regulatory oversight activities, that licensees' implemented programs are in compliance with RD/GD 99.3.

Licensees and CNSC staff continued regular communication with interested communities in 2015. As part of their public information program and outreach activities, licensees and CNSC staff participated in Northern Saskatchewan Environmental Quality Committee meetings and facility tours. The committee represents more than 30 communities throughout the greater northern Saskatchewan region, many of which are Indigenous.

Indigenous engagement

The CNSC is committed to ongoing engagement and relationship building with interested Indigenous communities. In this regard, First Nation and Métis communities with interest in Canada's uranium mines and mills were provided a copy of this document. The CNSC has also made available, through its Participant Funding Program, financial support for participation in the review of this report. In addition, during 2015, CNSC staff provided interested Indigenous communities with updates on its IEMPs at the mines, mills, historic and decommissioned sites.

To ensure licensees engage Indigenous communities, in February 2016 the CNSC published REGDOC-3.2.2, *Aboriginal Engagement*, which sets out requirements and guidance for licensees that propose projects which may raise the Crown's duty to consult. Throughout 2015, licensees continued to host meetings to discuss their operations with Indigenous communities. CNSC staff attended many of these meetings, including participating in a licensee organized high school science fair.

1.4 Mount Polley event – CNSC follow-up

This section provides an update on CNSC staff activities since the Commission presentation in October 2014 in response to the lessons learned from the August 2014 Mount Polley dam breach event.

A breach of the tailings pond dam at the Mount Polley copper/gold mine in British Columbia occurred on August 4, 2014 and 25 million m^3 of contaminated water and tailings were released into nearby water bodies. An independent expert panel investigating the cause of event concluded that the main factor contributing to the dam failure was a flaw in the geotechnical investigation and design.

Tailings pond dams are also associated with uranium mines and mills. There are 17 above ground tailings management facilities located at operating and decommissioned uranium mine sites in Saskatchewan and Ontario. In Saskatchewan, there are above ground tailings impoundments at the Key Lake, Rabbit Lake and Cluff Lake mine sites. The tailings in these impoundments are dry, dewatered and consolidated. In Ontario, there are five sites that are water covered; all others are dry.

Immediately after the Mount Polley event, CNSC staff conducted a review of all existing tailings dams at both operating and decommissioned uranium mines. CNSC staff:

- directed licensees to re-evaluate hazards based on present day guidance and methods defining the design basis; licensees concluded that their tailings management areas are operating as designed and that their dams are safe
- performed a detailed technical review of the Mount Polley report and confirmed that uranium tailings dams are protected from similar modes of dam failure
- reviewed all dam safety assessments and confirmed that all uranium mine tailings dams and their associated structures are in good condition and are safe
- carried out focused geotechnical inspections of all dam structures and confirmed site conditions, in addition to carrying out baseline compliance geotechnical inspections
- carried out a systematic review of CNSC regulations and guidance on dam safety and identified no immediate regulatory actions necessary to provide additional protection

Based on their review, CNSC staff concluded that all CNSC regulated dams have safe designs and are not at risk to an event similar to Mount Polley. Nevertheless, CNSC staff expect that future submissions for dams or their safety reviews will be in accordance with Canadian best practice that reflects lessons learned from the Mount Polley incident (e.g., the Canadian Dam Safety Guidelines that are currently being revised by the Canadian Dam Association). CNSC staff will work with licensees on the consideration of these guidelines once they have been updated.

SECTION I: OPERATING URANIUM MINES AND MILLS

2 OVERVIEW

Section I of this report focuses on the uranium mines and mills currently operating in Canada. The facilities listed are located within the Athabasca Basin of northern Saskatchewan and are shown in figure 2.1. They include:

- Cigar Lake mine
- McArthur River mine
- Rabbit Lake mine and mill
- Key Lake mill
- McClean Lake mine and mill

Figure 2.1: Location of uranium mines and mills in Saskatchewan

The 2015 uranium production data for these five operating mine and mill facilities is shown in table 2.1. The CNSC confirmed all facilities operated within their authorized annual production limits in 2015.

Table 2.1: Uranium mines and mills production data, 2015

Production data	Cigar Lake	McArthur River	Rabbit Lake[1]	Key Lake[2]	McClean Lake[3]
Mining – ore tonnage (tonnes/year)	26,103	88,236	309,505	Not applicable	Not applicable
Mining – average ore grade mined (% U expressed as U_3O_8)	22.35	10.13	0.63	Not applicable	Not applicable
Mining – U mined (Mkg U/year)	4.95	7.58	1.62	Not applicable	Not applicable
Milling – mill ore feed (tonnes/year)	Not applicable	Not applicable	313,712	165,556	25,517
Milling – average mill feed grade (% U expressed as U_3O_8)	Not applicable	Not applicable	0.64	5.26	17.56
Milling – mill recovery (% of U)	Not applicable	Not applicable	97.14	99.35	98.99
Milling – U concentrate produced (Mkg U/year)	Not applicable	Not applicable	1.62	7.3	4.3
Authorized annual production (Mkg U/year)	9.25	9.6	4.25	9.6	5.0

1 At Rabbit Lake, the difference in the mine ore grade and the mill feed grade reflects the practice of blending stockpiled material with newly mined ore.
2 At Key Lake, McArthur River ore is blended with stockpiled, lower-grade material to produce a lower grade mill feed.
3 The McClean Lake mill has been designed to mill high-grade ore from Cigar Lake without any blending or dilution.

Licensees are required to develop preliminary decommissioning plans and associated financial guarantees to ensure work activities and installations are financially covered and work is guaranteed for completion with no liability to the Government of Canada. Financial guarantee values for the operating mine and mill facilities range from approximately $43 million at the McClean Lake operation to $218 million at the Key Lake operation. The values of the financial guarantees are listed in appendix E.

2.1 CNSC regulatory efforts

The CNSC regulates the five operating mines and mills under separate licences. A list of the licences can be found in appendix A. CNSC staff verified compliance with regulatory requirements through inspections, desktop reviews of reports and licensee programs, which are supplemented with meetings, presentations and facility visits.

CNSC staff performed 30 onsite inspections in 2015 at the five operating uranium mine and mill facilities. These resulted in 34 enforcement actions and 42 recommendations, as shown in table 2.2. The findings resulting from these inspections were provided to the licensees in inspection reports. CNSC staff reviewed and verified that corrective actions taken by each licensee were appropriate and acceptable. All enforcement actions were dealt with appropriately by licensees and are considered closed by CNSC staff.

Table 2.2: CNSC staff inspections at uranium mine and mill facilities

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake	Total
Number of inspections	6	6	6	6	6	30
Estimated inspection person days*	106	102	86	89	118	501
Directives**	0	0	1	0	0	1
Action notices**	8	3	4	6	12	33
Recommendations	8	8	3	2	21	42

* Includes the time to plan, execute and complete the inspection report.
** Enforcement action total includes directives and action notices.

Other regulatory bodies that conduct inspections at the operating facilities include Saskatchewan's Ministry of Environment and Ministry of Labour Relations and Workplace Safety, and Environment and Climate Change Canada. CNSC staff take into account the findings from these regulatory bodies when assessing licensee performance. When logistically reasonable, joint inspections are conducted with other federal, provincial or territorial regulatory agencies.

2.2 Performance

The SCA performance ratings of the operating mine and mill facilities are presented in table 2.3. For 2015, CNSC staff concluded that the performance of all operating uranium mines and mills was "satisfactory" for all SCAs. Appendix D contains the SCA ratings for each facility from 2011 to 2015.

Table 2.3: Uranium mines and mills SCA performance ratings, 2015

Safety and control area	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
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

This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs that cover many of the key performance indicators for these facilities.

2.3 Radiation protection

Uranium mine and mill licensees in Canada are required to implement and maintain radiation protection programs in accordance with the *Radiation Protection Regulations*. Each program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained below regulatory limits and as low as reasonably achievable (ALARA).

For 2015, CNSC staff rated the radiation protection SCA at all five uranium mine and mill facilities as “satisfactory” based on regulatory oversight activities.

Radiation protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	SA

Radiological hazard control

Sources of radiation exposure at uranium mines and mills include:

- gamma radiation
- long-lived radioactive dust
- radon progeny
- radon gas

These hazards were controlled by licensees' programs and practices through the effective use of time, distance and shielding, ventilation, contamination control and personal protective equipment.

Radiation protection program performance

CNSC staff conducted regulatory oversight activities in the area of radiation protection (RP) at all operating mine and mill facilities during 2015 in order to verify compliance with regulatory requirements of the licensees' implementation of their RP programs.

The RP programs include codes of practice that set out licensee administrative levels and action levels for doses of radiation. Action levels are developed, which if reached, may indicate a loss of control of part of a licensee's RP program and triggers a requirement for specific action to be taken. Licensees are responsible for identifying the parameters of their programs that represent timely indicators of potential losses of control. 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 and notify the CNSC, and if applicable, to restore the effectiveness of the RP program. The five operating uranium mine and mill facilities listed have the same maximum action level of 1 millisievert (mSv) per week and 5 mSv per quarter of a given year. A brief description of action level exceedances that occurred in 2015 and the corrective actions implemented are provided in appendix I. CNSC staff are satisfied with the actions taken by licensees to address these action level exceedances.

CNSC staff confirmed the RP programs and practices at operating mines and mills continued to be effective in controlling radiological exposure to workers.

Application of ALARA

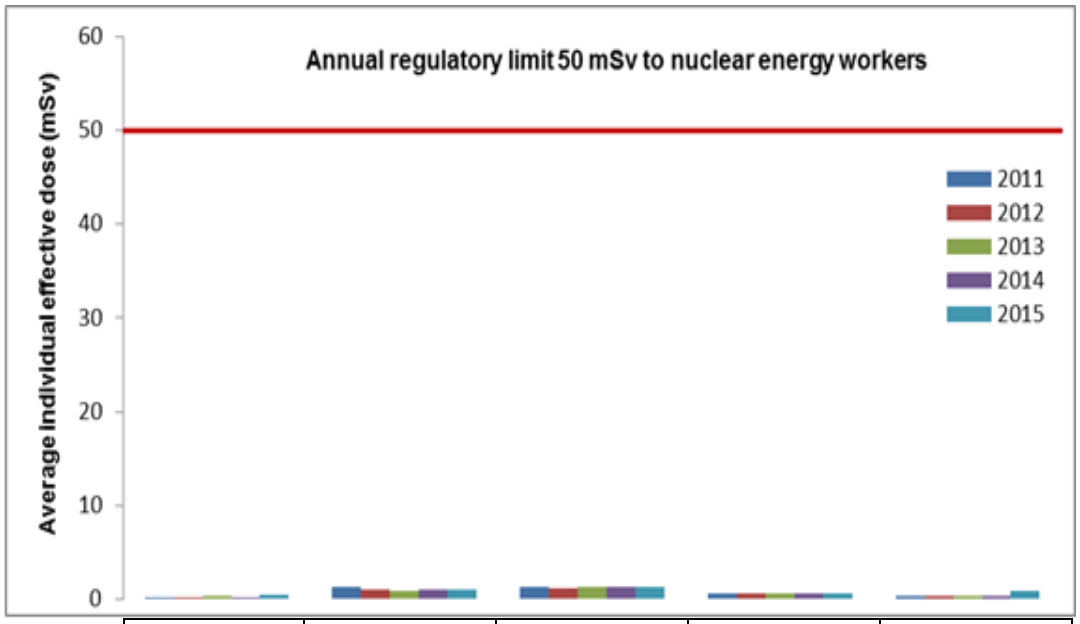
CNSC staff verified the uranium mine and mill facilities continued to maintain and implement RP programs based on the ALARA principle. These facilities set objectives to keep doses well below the regulatory limit. If action levels were exceeded, they were reported to the CNSC.

Worker dose control

As defined in the NSCA, nuclear energy workers (NEWs), whether permanent employees or contractors are designated based on work practices and activities. At all operating mines and mills, NEWs are issued optically stimulated luminescence dosimeters (OSLD), which measure external gamma radiation exposure and resulting doses. Where required, workers also wear personal alpha dosimeters (PAD) to measure alpha radiation exposure from radon progeny and radioactive dust. OSLD and PAD readings are measured by a CNSC-licensed dosimetry provider. Where direct monitoring through dosimeters is not warranted, approved dose estimation methods (such as area/group monitoring and time cards) are used in accordance with CNSC regulatory guidance. All licensees met regulatory requirements for the use of licensed dosimetry.

Figures 2.2 and 2.3 show the average individual effective dose and maximum individual effective dose during the 2011 to 2015 reporting period for the five operating mine and mill facilities. In 2015, no worker at any facility exceeded the regulatory individual effective dose limit of 50 mSv in a one-year dosimetry period nor the 100 mSv limit over a five-year dosimetry period.

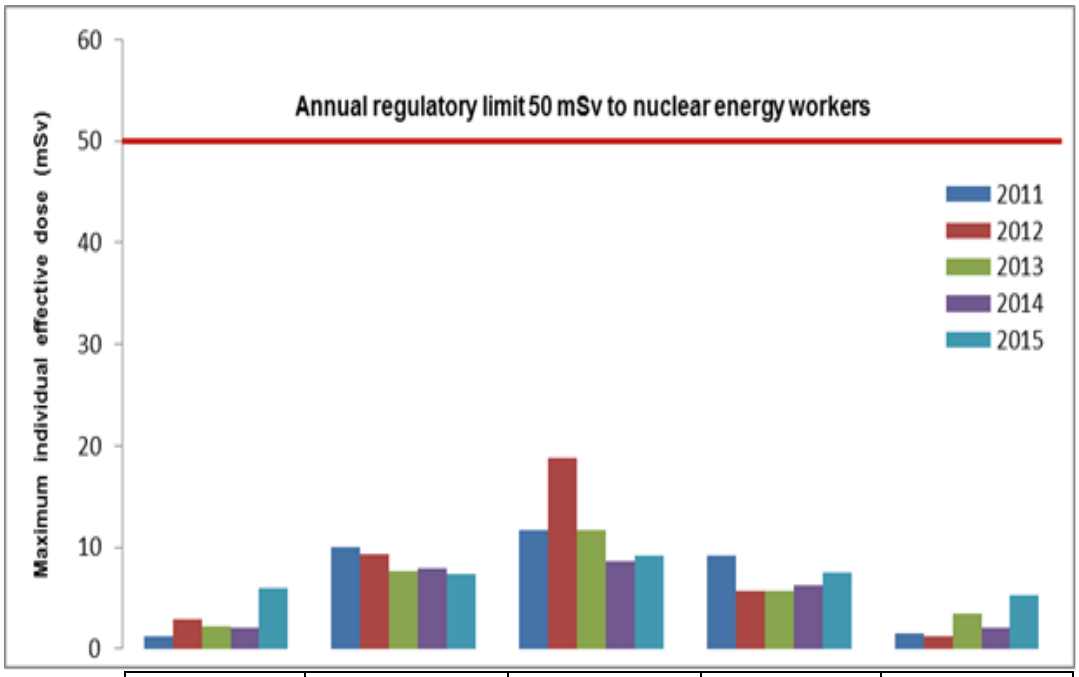
Figure 2.2: Uranium mines and mills comparison of average individual effective dose to NEWs, 2011-15 (mSv)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	0.13	1.32	1.36	0.67	0.33
2012	0.14	0.97	1.22	0.61	0.32
2013	0.27	0.89	1.30	0.62	0.36
2014	0.16	1.03	1.32	0.63	0.37
2015	0.45	1.00	1.36	0.55	0.89

* The annual regulatory limit illustrated applies to individual effective dose, and is shown for reference only.

Figure 2.3: Uranium mines and mills comparison of maximum individual effective dose to NEWs, 2011–15 (mSv)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	1.30	10.07	11.66	9.14	1.56
2012	2.87	9.26	18.80	5.76	1.30
2013	2.21	7.58	11.67	5.67	3.44
2014	2.03	7.91	8.64	6.21	2.03
2015	5.99	7.40	9.14	7.56	5.28

In 2015, the highest individual effective dose to a uranium mine and mill worker was 9.14 mSv at the Rabbit Lake operation. The increases to the average individual effective doses and maximum individual effective doses for Cigar Lake operation and McClean Lake operation were due to increased production rates.

Appendix F displays the number of NEWs with the corresponding average individual effective dose and maximum individual effective dose for each operating facility during the 2011 to 2015 period.

Estimated dose to the public

Uranium mine and mill operations are remote from local populations. A public radiation dose limit of 1 mSv per year above natural background radiation has been set to ensure the protection of non-NEWs' health (including the public). Radiological exposures measured at the licensed facility boundaries are near background radiation levels, ensuring the public is protected.

In 2015, based on the outcome of inspections and reviews of the radiation protection programs, radiological hazard control, worker dose control, and application of ALARA, CNSC staff were satisfied that uranium mine and mill licensees controlled radiation doses to workers at levels well below the regulatory limits, as well as keeping doses ALARA.

2.4 Environmental protection

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

Based on regulatory oversight activities, CNSC staff rated the 2015 performance of all five uranium mine and mill facilities for the environmental protection SCA as "satisfactory". Environmental protection programs were effectively implemented and met regulatory requirements for all uranium mines and mills.

Environmental protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	SA

Environmental management system

Licensees develop and maintain environmental management systems which provide a framework for integrated activities related to environmental protection during facility operation. The environmental management systems are described in approved environmental management programs and include activities such as establishing annual environmental objectives, goals and targets. Licensees audit their programs at least once every year. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Environmental risk assessment

The CNSC uses site-specific environmental risk assessments (ERAs) as a regulatory tool throughout the lifecycle of uranium mine and mill facilities. Applicants use ERAs during initial environmental assessments for new facilities or for new activities at existing facilities. The ERA identifies mitigation technologies or practices and predicts physical disturbances; releases to the atmosphere, surface water and groundwater; changes to the physical environment and any biological effects that may occur as a result of a new facility or activity. CNSC staff review ERAs to determine the potential risks to human health and the environment and to ensure the implementation of adequate mitigation measures. During operations, CNSC staff periodically review the ERA predictions as criteria for assessing environmental performance.

Assessment and monitoring

Each uranium mine and mill licensee has an environmental monitoring program that monitor releases of nuclear and hazardous substances to the environment and characterize and monitor the quality of the environment associated with the licensed facility.

Environmental monitoring programs set out licensee administrative levels and action levels for controlling effluents released to the environment, as well as assessing potential impacts to the environment. Exceedance of an administrative level indicates that an operating parameter is at the upper range of normal operations. Such an event triggers an internal review by the licensee. Exceedance of an action level indicates a potential loss of control of the environmental protection program which is based on the approved facility design envelope, and triggers actions that must be taken by the licensee to correct the problem. An action level thus provides an early warning system for identifying when there may be potential for major deviations in operating performance outside normal operation that requires notification to the CNSC, an immediate investigation, subsequent corrective actions and preventative measures to be taken in order to restore the effectiveness of the environmental protection program. It is important to recognize that an exceedance of an action level does not imply a potential risk to the environment, but identifies that the operating parameter may be outside the norm based on the facility design. Taking immediate corrective action ensures releases remain lower than the regulatory discharge limits. Facility administrative and action levels are determined through the identification and proper operation of available treatment technologies, as well as facility-specific environmental risk studies.

CNSC staff have reviewed risk assessments and environmental monitoring of uranium mine and mill sites and concluded that the environment is protected.

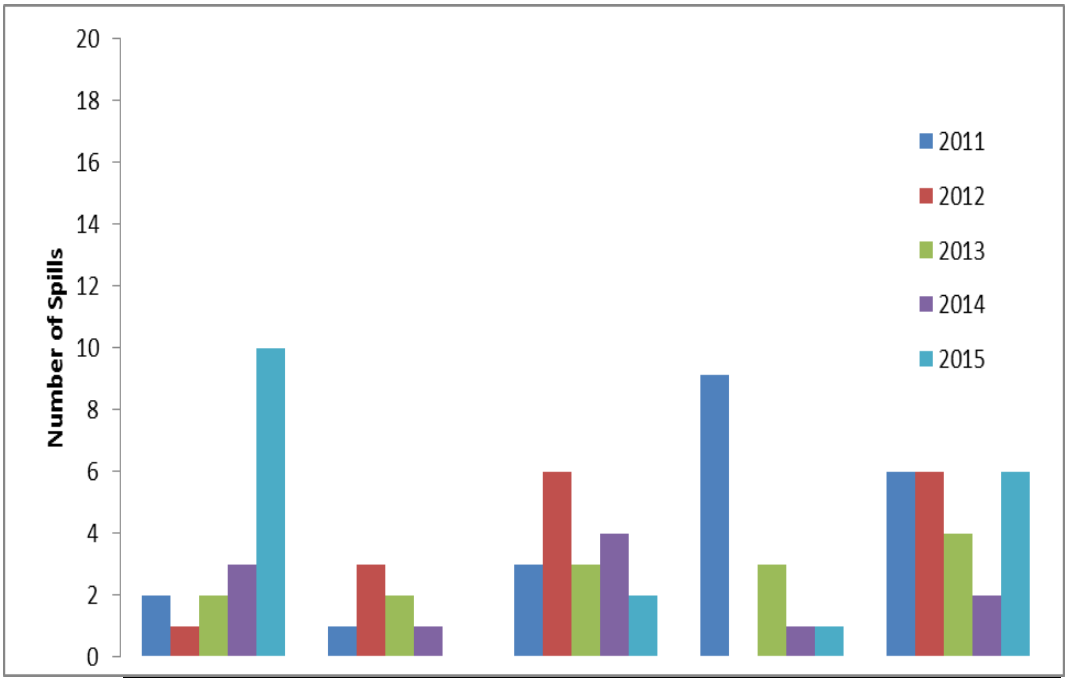
Protection of the public

According to regulatory requirements, each licensee must demonstrate that the public is protected from exposures to hazardous substances released from the facility. Licensees are required to report to the regulatory authorities, including the CNSC, any unauthorized release of hazardous or radioactive substances to the environment (spills).

Figure 2.4 depicts the number of environmental reportable spills for uranium mine and mill facilities in 2015. In each case, CNSC staff reviewed the licensee's actions to ensure effective remediation and prevention, and were satisfied with actions taken by the licensee. The CNSC rated all 2015 spills as "low significance" resulting in no residual impact to the environment.

The site-specific sections and appendix G further describe each reportable spill and any corrective actions taken by the licensee in response to the spill. The CNSC spill rating definitions are also found in appendix G.

Figure 2.4: Uranium mines and mills environmental reportable spills, 2011–15



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	2	1	3	9	6
2012	1	3	6	0	6
2013	2	2	3	3	4
2014	3	1	4	1	2
2015	10	0	2	1	6

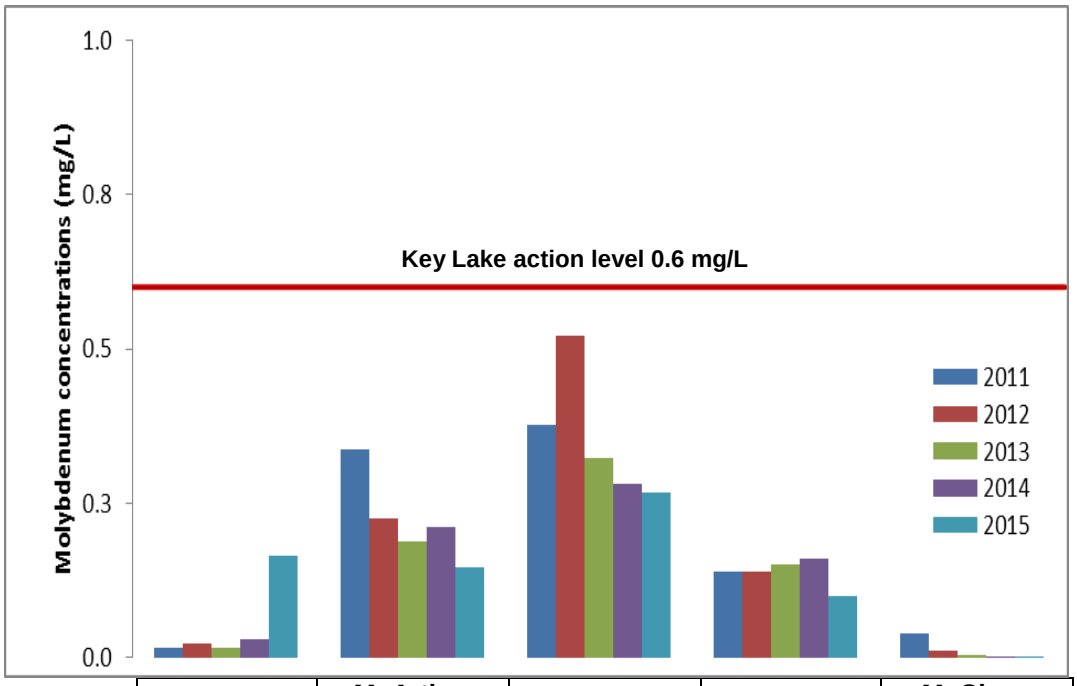
Effluent and emissions control

Treated effluent released to the environment

Environmental risk assessments and environmental monitoring data collected prior to 2009 identified releases of molybdenum, selenium and uranium as constituents of potential concern. As a result, licensees were required to improve engineering controls and treatment technologies to reduce effluent releases of these contaminants. In 2015, the treatment technologies implemented continued to keep these contaminant concentrations stable and at acceptable levels. Figures 2.5 to 2.7 display the 2015 average annual effluent concentrations for molybdenum, selenium and uranium at the five operating mine and mill facilities.

In the absence of federal or Province of Saskatchewan limits for molybdenum, the CNSC requires licensees to develop facility-specific effluent controls within their environmental protection program codes of practice. The 2011 to 2015 molybdenum average effluent concentrations for the five facilities were below the Key Lake code of practice action level. The Key Lake action level for molybdenum is the most stringent of the five operating uranium mines and mills and is shown for reference only.

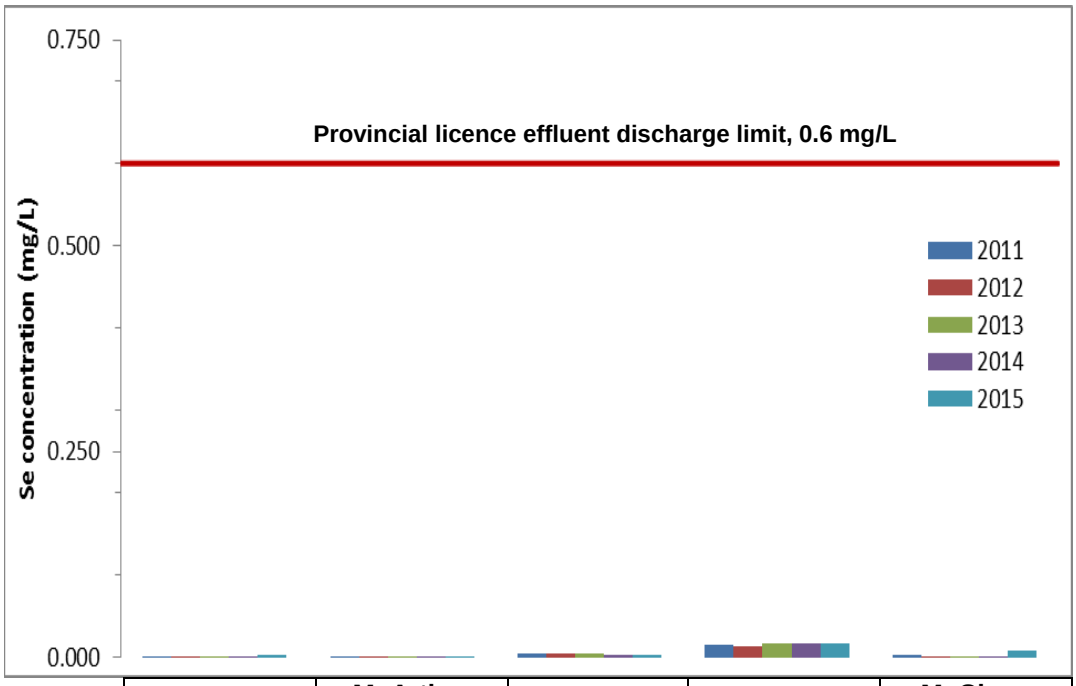
Figure 2.5: Annual average concentration of molybdenum in effluent released to the environment, 2011–15 (mg/L)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	0.0157	0.3380	0.3760	0.1400	0.0400
2012	0.0236	0.2251	0.5220	0.1400	0.0114
2013	0.0169	0.1878	0.3240	0.1500	0.0052
2014	0.0303	0.2121	0.2820	0.1600	0.0024
2015	0.1662	0.1460	0.2680	0.1000	0.0024

No federal limits are currently established for selenium and uranium in effluent discharge. The Province of Saskatchewan's licensed effluent discharge limits for selenium and uranium are 0.6 mg/L and 2.5 mg/L, respectively. The CNSC expects performance well below these limits and requires licensees to continually minimize effluent contaminant concentrations to be ALARA. Figures 2.6 and 2.7 demonstrate that both selenium and uranium concentrations in treated effluent that was released to the environment in 2011 to 2015 from operating mine and mill facilities remained below the provincial licence effluent discharge limit.

Figure 2.6: Annual average concentration of selenium (Se) in effluent released to the environment, 2011–15 (mg/L)

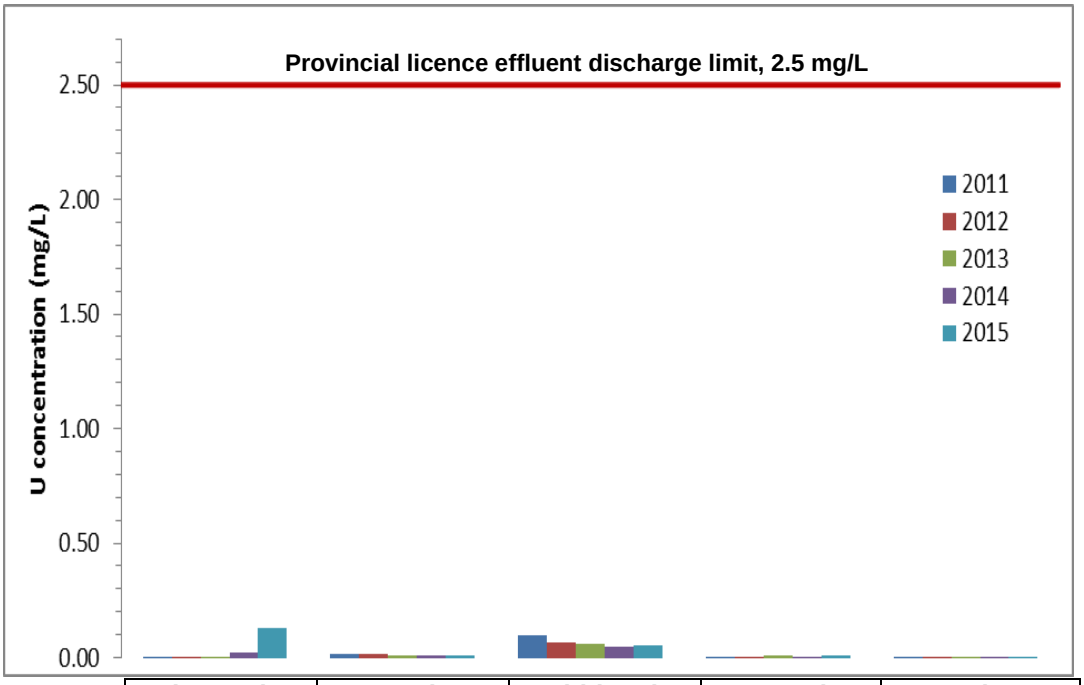


	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	0.0006	0.0023	0.0050	0.0160	0.0040
2012	0.0007	0.0016	0.0058	0.0140	0.0014
2013	0.0005	0.0014	0.0052	0.0170	0.0004
2014	0.0009	0.0017	0.0042	0.0180	0.0007
2015	0.0038	0.0025	0.0042	0.0180	0.0092

In 2006, a review titled Uranium Effluent Treatment Process identified a concentration of uranium in effluent of 0.1 mg/L as a potential treatment design objective that could be achieved and is protective of the environment. The CNSC uses this value as an interim objective for uranium mine and mill facilities.

At the Cigar Lake operation, increases in uranium concentrations were observed in early 2015 that reflect optimization of operations. Results returned to well below the CNSC's objective level during the second half of 2015. This is further discussed in section 3.3

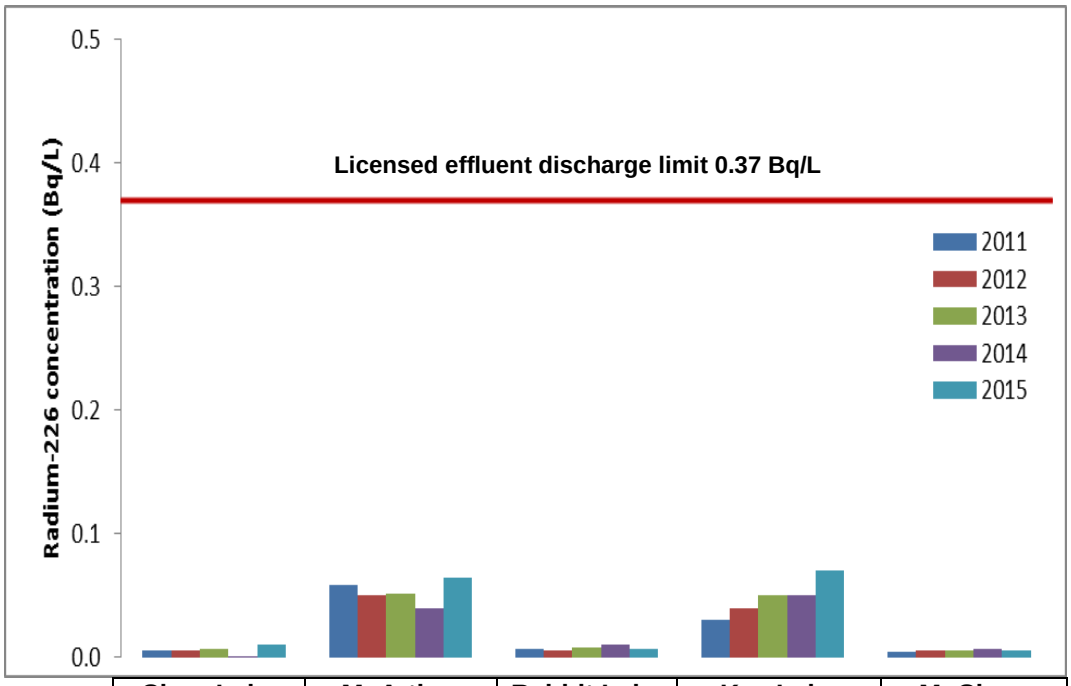
Figure 2.7: Annual average concentration of uranium (U) in effluent released to the environment, 2011–15 (mg/L)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	0.0002	0.0147	0.0970	0.0050	0.0030
2012	0.0006	0.0141	0.0650	0.0060	0.0017
2013	0.0011	0.0107	0.0630	0.0080	0.0015
2014	0.0193	0.0097	0.0460	0.0060	0.0018
2015	0.1310	0.0089	0.0520	0.0080	0.0042

In addition to the above constituents of potential concern, a graph showing concentrations of radium-226 is provided in figure 2.8. The 2011 to 2015 radium-226 annual average effluent concentrations for the five facilities was well below the CNSC's licence-authorized effluent discharge limit of 0.37 Bq/L.

Figure 2.8: Annual average concentration of radium-226 in effluent released to the environment, 2011–15 (Bq/L)



	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2011	0.006	0.059	0.007	0.030	0.005
2012	0.006	0.051	0.006	0.040	0.006
2013	0.007	0.052	0.008	0.050	0.006
2014	0.008	0.040	0.010	0.050	0.007
2015	0.010	0.065	0.007	0.070	0.006

Uranium mine and mill facilities also analyze treated effluent for concentrations of various substances, such as arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. Table 2.4 displays the annual average parameter concentration values in effluent for these substances released in 2015, as well as the discharge limits described in the *Metal Mining Effluent Regulations* (MMER). All metal mines and mills in Canada are subject to the MMER of the federal *Fisheries Act*. The CNSC incorporates the effluent limit requirements of the MMER in uranium mine and mill licences. In 2015, all treated effluent released to the environment from licensed mining and milling activities for the above substances met the effluent discharge limits stipulated in the CNSC operating licences and the MMER.

Table 2.4: Annual average parameter concentration values in effluent released to the environment, 2015

Parameters	MMER discharge limits	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Arsenic (mg/L)	**0.5**	0.0439	0.0029	0.004	0.006	0.0034
Copper (mg/L)	**0.3**	0.0004	0.0011	0.0030	0.030	0.0030
Lead (mg/L)	**0.2**	0.0001	0.0009	0.0001	0.01	0.0001
Nickel (mg/L)	**0.5**	0.0061	0.0035	0.0057	0.071	0.0181
Zinc (mg/L)	**0.5**	0.0075	0.0016	0.001	0.009	0.0006
TSS (mg/L)	**15**	1.4	1.0	2.0	2.8	2.0
pH	**6.0–9.5**	6.84	7.32	7.12	6.4	7.30

In 2015, all treated effluent released to the environment from the licensed mining and milling activities met the effluent discharge limits stipulated in the CNSC operating licences.

CNSC staff will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

Air emissions released to the environment

Uranium mines' and mills' environmental programs include monitoring the effects of operations on the surrounding air and soil. The licensees measure airborne particulate levels and concentrations of parameters, as well as the concentration of radon gas. They also monitor contaminant concentrations in soil and terrestrial vegetation to verify that operational impacts are minimized and below regulatory limits.

Facilities with milling operations perform stack tests to monitor atmospheric emissions from acid plants, yellowcake dryers, calciner operations, packaging, grinding and ammonium sulphate operations. Other measured parameters (e.g., ambient radon and stack testing for sulphur dioxide, uranium and heavy metals) verify facility design and evaluate the operations against predictions made in environmental risk assessments.

The operating mines and mills have demonstrated satisfactory performance on mitigating and monitoring the effects of their operations on the surrounding air and soil. The air and soil results around the facilities indicate slightly higher than background concentrations for some samples collected in the immediate vicinity of activities; however, the concentrations decrease to background levels within a short distance. The monitoring results indicate negligible impacts from atmospheric releases and confirm all uranium mines and mills are in compliance with their programs and provincial standards.

Treated mining/milling effluent: a comparison of the uranium mining sector to other metal mining sectors across Canada

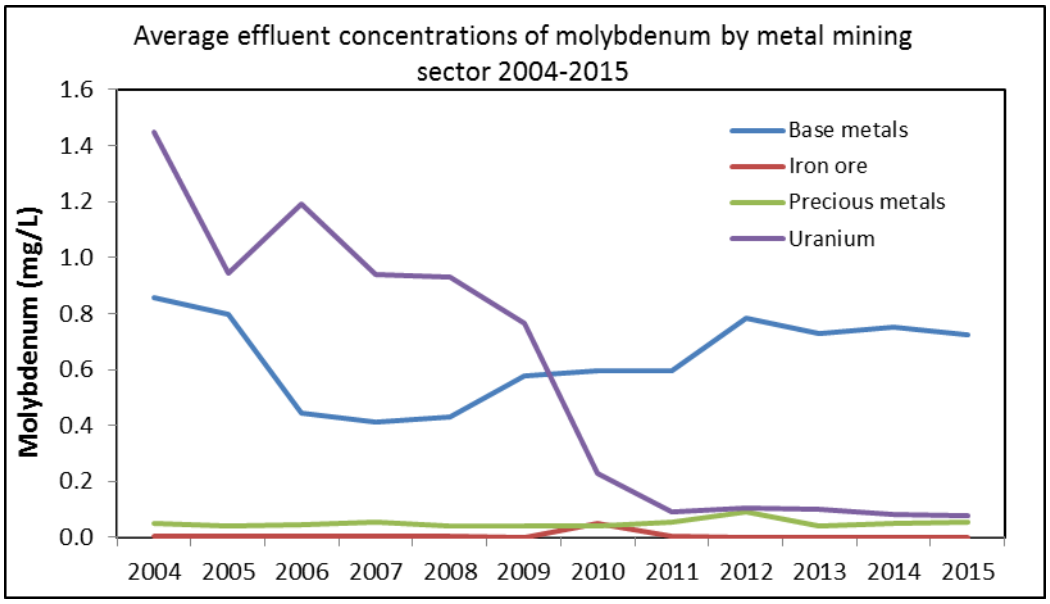
As noted earlier, metal mines and mills in Canada are subject to the MMER of the federal *Fisheries Act*. Compliance with the MMER limits provides a good effluent treatment comparison of the mining sector to other metal mining sectors across Canada. The effluent treatment quality of the uranium mine and mill facilities compares favourably to other mining sectors of base metal, precious metal and iron mines.

The data used for analysis and comparison is acquired from Environment and Climate Change Canada. MMER data from 2014 is used for comparison within this 2015 report since it is the most current sector-specific MMER information available, with the exception of molybdenum and selenium for which 2015 data is available. The mines reporting under the MMER, and which released treated effluent in 2014, are grouped into four metal mining sectors based on the primary metal produced. The metal mining sectors are:

- uranium – five mines
- base metals (such as copper, nickel, molybdenum or zinc) – 49 mines
- precious metals (such as gold or silver) – 48 mines
- iron – seven mines

Molybdenum is a parameter requiring routine monitoring of treated effluent subject to the MMER. Figure 2.9 shows continuous improvement by the uranium sector in reducing molybdenum in effluent. In 2015, molybdenum concentrations in uranium mining sector effluent were similar to those measured in the effluents of precious metal and iron mines, and less than in the effluents for base metal mines.

Figure 2.9: Average treated effluent concentration of molybdenum by metal mining sector, 2004–15



In mid-2012, the MMER added the requirement for monitoring selenium. Table 2.5 summarizes the average selenium concentration in treated effluent from each mining sector using data collected since 2012. Selenium concentration in effluent of the uranium sector was similar to that of other metal mining sectors in Canada.

Table 2.5: Average selenium concentration in treated effluent by metal mining sector, last half of 2012 and all of 2013–15

Year	Metal mining sector (mg/L)			
	Uranium	Base metals	Precious metals	Iron
2012/2013	0.003	0.005	0.005	0.001
2014	0.004	0.006	0.005	0.001
2015	0.004	0.005	0.004	0.004

Metal Mining Effluent Regulations performance indicators

The MMER specifies the maximum concentration limits in effluent for the following regulated parameters: arsenic, copper, lead, nickel, zinc, radium-226, total suspended solids and an allowable pH range. Effluent must also be non-toxic and pass the trout acute lethality test. The effluent treatment performances of the four metal mining sectors are compared using the following three performance indicators:

1) Compliance with the effluent concentration limits and pH

Table 2.6 illustrates the number of mines out of compliance with MMER effluent standards for at least one regulated parameter (excluding toxicity test in 2014). This data is used to assess if compliance with the parameters of the MMER is a sector-wide concern.

Two base metal mines and one iron mine had effluent with radium concentrations above the MMER limit for portions of the year. The uranium mines were in full compliance with the provisions of the MMER.

Table 2.6: Distribution of MMER effluent non-compliance by mining sector, 2014

Parameter	Mining sector			
	Uranium	Base metals	Precious metals	Iron
Arsenic	0	0	1	0
Copper	0	2	0	0
Lead	0	0	0	0
Nickel	0	5	0	0
Zinc	0	3	1	0
Total suspended solids	0	7	5	5
Radium-226	0	2	0	1
pH range	0	3	1	2
Number of mines out of compliance with at least one parameter*	0	15	8	5
Number of mines	5	49	48	7

* A mine may have more than one parameter out of compliance, thus the number of mines out of compliance with at least one parameter may not equal the sum of the number of mines out of compliance by parameter.

2) Annual average effluent concentrations in the metal mining sectors

Table 2.7 presents the 2014 annual average effluent concentrations for parameters in comparison of the metal mine sectors. CNSC staff note the base metal and iron mines effluent concentration for radium-226 is comparative to uranium mines.

Table 2.7: A sector comparison of average effluent parameter concentrations, 2014

Parameter*	MMER discharge limits	Uranium	Base metals	Precious metals	Iron
Arsenic (mg/L)	**0.5**	0.004	0.007	0.034	0.0016
Copper (mg/L)	**0.3**	0.003	0.058	0.016	0.004
Lead (mg/L)	**0.2**	0.0002	0.004	0.001	0.001
Nickel (mg/L)	**0.5**	0.019	0.187	0.021	0.007
Zinc (mg/L)	**0.5**	0.009	0.062	0.015	0.023
TSS (mg/L)	**15**	1.0	4.5	5.9	27.2
Radium-226 (Bq/L)	**0.37**	0.020	0.024	0.009	0.020
pH	**6.0–9.5**	7.0	7.7	7.5	7.3

* Uranium is not included as it is not a regulated parameter in MMER.

3) Toxicity test results

Effluent toxicity is measured using the rainbow trout acute lethality test. The rainbow trout acute lethality test has become the world standard toxicity test for fresh-water, cool-climate conditions and has been part of Canadian regulations and guidelines for three decades. In this test, rainbow trout fingerlings or swim-up fry (0.3 g to 2.5 g wet weight) are reared under controlled conditions. They are then placed in undiluted effluent for 96 hours. If fewer than half of the fish survive, the effluent is deemed acutely lethal. Effluent must be non-acutely lethal to pass the test as a requirement of the MMER.

Table 2.8 displays the number of pass and fail results of the rainbow trout acute lethality tests for the metal mining sectors in 2014. The uranium mining metal sector passed all required tests in 2014.

Table 2.8: A sector comparison of pass/fail results of rainbow trout acute lethality tests in 2014

	MMER limit	Uranium	Base metals	Precious metals	Iron
Rainbow trout acute lethality test	**Pass**	31	392	383	162
	Fail	0	3	4	3

A mine is considered compliant if, throughout the year, the effluent passes all trout acute lethality tests. Table 2.9 summarizes the performance of the metal mining sectors. As shown in table 2.9, the uranium mine and mill facilities passed all acute lethality tests from 2010 to 2014.

Table 2.9: Percentage of mines in each metal mining sector passing all trout acute lethality tests, 2010–14

Metal mining sector	2010	2011	2012	2013	2014
Uranium	100%	100%	100%	100%	100%
Base metals	90%	85%	98%	93%	98%
Precious metals	96%	96%	94%	86%	96%
Iron	80%	83%	100%	100%	71%

Eastern Athabasca Regional Monitoring Program

The Eastern Athabasca Regional Monitoring Program (EARMP) was established by the Province of Saskatchewan in 2011. It monitors the safety of traditionally harvested country foods through analysis of water, fish, berries and mammal chemistry from representative northern Saskatchewan communities. The program contractor is a northern Saskatchewan Indigenous-owned business. Community members take part in the monitoring program by collecting samples. Harvesting and consuming traditional country foods are an important part of the culture in northern Saskatchewan. The intent of the EARMP is to provide confidence and transparent communication with community members that traditional country foods remain safe to eat today and for future generations. The complete report and data is available at earmp.ca.

CNSC staff support the EARMP and are working towards collaboration opportunities on this valuable program, which may include using the Participant Funding Program to further promote community involvement.

The evaluation of the country food data from previous years, leading up to five years of data collection, has confirmed that operating uranium mines and mills are not affecting the safety of country foods at nearby communities. The results indicated that radiological and non-radiological exposures to residents from consuming country foods were similar to exposures of the general Canadian population and were below values that are considered to be protective of health effects.

2.5 Conventional health and safety

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and protect personnel and equipment. Uranium mines and mills must develop, implement and maintain effective safety programs to promote safe and healthy workplaces and minimize incidences of occupational injuries and illnesses.

For 2015, CNSC staff rated the conventional health and safety SCA at the uranium mine and mill facilities as “satisfactory” based on regulatory oversight activities.

Conventional health and safety ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
SA	SA	SA	SA	SA

Practices

Licensees are expected to identify potential safety hazards, assess associated risks, and introduce the necessary materials, equipment, programs and procedures to effectively manage, control and minimize these risks. CNSC staff work with Saskatchewan Ministry of Labour Relations and Workplace Safety to provide regulatory oversight of conventional health and safety in uranium mines and mills. CNSC staff's compliance verification activities include inspections, reviews of compliance reports and health and safety events. CNSC staff confirmed the mine and mill facilities implemented effective management of conventional health and safety in their activities.

Figure 2.10: McClean Lake – emergency response exercise

Awareness

CNSC staff observed that the conventional health and safety programs at the facilities continued to provide education, training, tools and support to workers. Each facility promotes the notion that safety is the responsibility of all individuals. This message is reinforced by management, supervisors and workers. Management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems. CNSC staff concluded that facilities are committed to accident prevention, safety awareness and focus on safety culture (see figure 2.10).

Performance

A key performance measure for conventional health and safety is the number of lost-time injuries (LTIs) that occur per facility. A LTI is a workplace injury that results in the worker being unable to return to work for a period of time. In reviewing LTIs, CNSC staff also consider the injury's severity and frequency rates. Table 2.10 shows the number of LTIs at the uranium mine and mill facilities along with severity and frequency rates, and the number of full-time equivalent (FTE) workers onsite during 2015.

Table 2.10: Total number of FTE workers, number of LTIs, severity rate and frequency rate, 2015

Total number of FTE workers and LTI statistics	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total number of FTE workers[1]	602	749	610	505	793
Number of LTIs[2]	4	0	2	0	3
Severity rate[3]	17.06	0	55.3	0	27.7
Frequency rate[4]	0.56	0	0.33	0	0.4

1 **Total number of workers** (employees and contractors) expressed as FTEs.
FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time injury** - an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.

4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/# of hours worked in last 12 months)] x 200,000.

During 2015, there were three LTIs at the McClean Lake operation, two at the Rabbit Lake operation, four at the Cigar Lake operation and none at the McArthur River and Key Lake operations. Appendix H describes the 2015 LTIs and corrective actions taken by each licensee. CNSC staff and Saskatchewan Ministry of Labour Relations and Workplace Safety monitor and review each reportable injury to ensure the cause is identified and satisfactory corrective actions are taken. When applicable, injury information is shared amongst the facilities for lessons learned to improve safety. The injury statistics demonstrate satisfactory performance of the uranium mine and mill operations to keep workers safe from occupational injuries.

Lost-time injuries: comparison of the uranium mining sector to other mining sectors

Table 2.11 displays the various safety statistics of mining sectors within Saskatchewan. The uranium mining and milling sector exhibits similar performance to other mining sectors for LTIs and frequency rate when contractors are excluded. The uranium sector is compared excluding contractors because statistics for the other sectors do not include contractors. The uranium mines and mills were the worst performer in severity rate meaning that their LTI's resulted in the most lost-time work due to injuries. However, a favorable comparison of frequency rate is displayed by the uranium mines and mills.

Table 2.11: Safety statistics of mining sectors in Saskatchewan, 2015

Mining sector	Number of LTIs	Frequency rate (200,000 person-hours)	Severity rate (200,000 person-hours)
Potash (underground)*	14	0.3	15.8
Solution (potash)*	1	0.2	0.4
Minerals (sodium sulphate, sodium chloride)*	1	0.6	18.5
Hard rock (gold, diamond)*	6	0.3	0.4
Coal (strip mining)*	4	0.8	20.5
Uranium*	4	0.3	25.0
Uranium (including contractors)**	8	0.3	20.0

* Source: Saskatchewan Ministry of Labour Relations and Workplace Safety.
** Statistics for all the other mining sectors does not include contractors.

2.6 Significant events

Key Lake mill calciner event – CNSC follow up

In January and February 2015, two Key Lake mill events resulted in exceedances of the weekly dose action levels and were reported to the Commission as event initial reports. These events were related to malfunctions and component failures with the existing vertical calciner.

The first event occurred on January 14, and was reported to the Commission at the February 4 Commission meeting. Following the event, CNSC staff completed an inspection. Repairs to the calciner were conducted, and the licensee, Cameco, developed a safe startup plan that included enhanced radiation monitoring as required by CNSC staff. The mill was safely restarted on January 21, 2015 with monitoring data showing no evidence of recurrent contamination. CNSC staff continued to review the situation through ongoing monitoring reports.

On February 16, there was a second event involving the same calciner, although the causes were not the same. As a result, the mill, including the calciner, was immediately shut down, and the event reported to the CNSC. CNSC staff conducted an inspection of this event verifying the initial assessment of cause, corrective actions taken and Cameco's safe startup plan. CNSC staff were satisfied with the corrective actions.

CNSC staff conducted follow-up compliance verification inspections at the Key Lake operation and assessed the corrective actions are acceptable. Details of these events and corrective actions taken by the licensee are found in appendix I.

Following the February event, CNSC staff issued requests according to subsection 12(2) of the *General Nuclear Safety and Control Regulations* to all operating uranium mills in order to obtain the following information:

- design and operational features that help prevent unplanned release of yellowcake
- equipment, processes and procedures that monitor and identify any weakening of containment systems that might lead to unplanned release of yellowcake
- radiation monitoring equipment and procedures that will quickly identify any unplanned release of yellowcake
- reports on corrective actions and implementation schedules for short-term and long-term measures to address any significant gaps

Onsite inspections were conducted at Key Lake in July 2015 to verify the 12(2) responses were being implemented. These inspections confirmed that the commitments made by the Key Lake licensee in its follow up to the reportable events were being addressed. Corrective actions identified from the event investigations were tracked and implemented by Cameco using their internal corrective action program. Cameco's corrective actions included improvements to engineering controls, and enhanced radioactive dust and contamination monitoring was implemented to provide additional surveillance to the calciner area. Based on the above corrective actions and commitments made by Cameco in its response to the 12(2) request, and CNSC staff verification activities, CNSC staff considered the 12(2) response acceptable.

In response to the CNSC subsection 12(2) request, AREVA's McClean Lake operation submitted a preliminary response providing an overview of the calcining circuit and explaining the differences between the Key Lake and the McClean Lake calcining circuits. AREVA later provided a detailed report of its calciner operations, including corrective actions to enhance worker protection, which CNSC staff reviewed and found acceptable. A subsequent follow-up inspection verified implementation of corrective actions taken by AREVA at the McClean Lake operation. CNSC staff were satisfied that AREVA took appropriate steps to avoid similar incidences that had occurred at Key Lake.

Cameco's Rabbit Lake operation does not use a calciner, but uses a drier in preparing yellowcake product for packaging. Notwithstanding this, CNSC site inspections verified the safe state of yellowcake processes, improved air and radiation monitoring measures, and that lessons learned from the Key Lake event had been applied at the Rabbit Lake operation. CNSC staff were satisfied with the responses and corrective actions taken by Cameco.

In September 2016, the CNSC sent letters to Cameco and AREVA formally verifying acceptance of the actions taken in response to the 12(2) requests. CNSC staff will continue to monitor the calciner and drying operations through compliance inspections and reviews.

Saskatchewan forest fires, 2015

Forest fires in northern Saskatchewan occur annually as part of the natural ecosystem. In 2015, the number of fires and areas burned were significantly higher than the 10-year average. These fires affected a large portion of northern Saskatchewan, either through the impact of smoke on air quality, disruptions to normal business activities, or the direct safety of several northern communities. Most of the fires were located to the south of the operating uranium mines and mills. A number of the 13,000 people evacuated from the northern communities were uranium mine and mill workers. Figure 2.11 shows an example of firefighting efforts that took place in northern Saskatchewan.

Figure 2.11: Firefighting efforts in the La Ronge area, 2015

Photo: Saskatchewan Ministry of Environment.

Licensees have CNSC-approved emergency management programs that outline practiced responses to emergency situations including wildfires. Facilities have firefighting equipment and personnel are trained to respond to site emergencies, including fires.

Although there were no fires in close proximity to uranium mine and mill operations that required firefighting efforts, licensee corporate crisis management plans were activated to manage delays in the transportation of personnel and critical supplies.

The CNSC monitored the fire situation closely providing regular updates to senior management and posting information on its internal and external websites. A fire status update was also provided at the August 20, 2015 Commission meeting.

3 CIGAR LAKE OPERATION

Cameco Corporation operates the Cigar Lake mine located approximately 660 kilometres north of Saskatoon, Saskatchewan. The Cigar Lake operation, shown in figure 3.1, is the world's second-largest known high-grade uranium deposit, second to Cameco's McArthur River operation.

The Cigar Lake orebody was discovered in 1981. The first mine shaft was completed in 1990 to support underground exploration and testing of mining methods. A construction licence was granted in late 2004 after the completion of an environmental assessment.

On April 3, 2013 a public Commission hearing was held in Saskatoon for the renewal of the Cigar Lake licence. The Commission issued an eight-year licence valid from July 1, 2013 to June 30, 2021.

Figure 3.1: Aerial view of Cigar Lake

Table 3.1 shows mining production data for 2011 through 2015. Ore mining rates and grades were ramped up during 2015 to achieve scheduled production.

Table 3.1: Cigar Lake mining production data, 2011–15

Mining	2011	2012	2013	2014	2015
Ore tonnage (tonnes/year)	No mining	No mining	234	3,318	21,603
Average ore grade mined (% U_3O_8)	No mining	No mining	1.4	7.2	22.35
Uranium mined (Mkg U/year)	No mining	No mining	0.04	0.2	4.95
Authorized annual production (Mkg U/year)	No mining	No mining	9.25	9.25	9.25

Conversion factor of 2.599779167 lbs of U_3O_8

Uranium ore is ground into ore slurry, loaded into containers and transported to the McClean Lake operation for milling. Through 2015, there were 2,340 shipments transporting 12,038,319 pounds of uranium concentrate to the McClean Lake mill. As of December 31, 2015 the proven and probable reserves at the Cigar Lake operation amounted to 84.8 million kilograms of uranium.

Surface construction activities in 2015 included upgrades to the modular freeze plant, and surface preparation and tree clearing for construction of the new surface freeze pad scheduled to be completed in 2016. The mine design was modified in March 2015 to accommodate the surface freeze operations.

Commissioning activities for process areas were completed in early 2015. On May 22, the Cigar Lake operation formally announced that it had met all criteria necessary to achieve commercial production including production cycle times and process specifications. In June, a third jet-boring system was also commissioned. No major concerns were reported to CNSC staff during the commissioning of mining activities. In early 2017, Cameco will make a formal report to the Commission on the results of its commissioning activities.

3.1 Performance

The Cigar Lake SCA ratings for the five-year period, 2011 to 2015, are shown in appendix D. For 2015, CNSC staff rated all 14 SCAs for Cigar Lake as satisfactory. This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs that cover many of the key performance indicators for these facilities.

3.2 Radiation protection

For 2015, CNSC staff continued to rate the radiation protection SCA as satisfactory based on regulatory oversight activities.

Cigar Lake radiation protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Radiological hazard control

The main source of radiological exposure at the Cigar Lake operation is from mining and processing of high-grade uranium ore. The effective dose contributors to workers at Cigar Lake were as follows: radon progeny (42.1 percent), gamma radiation (39 percent) and long-lived radioactive dust (LLRD) (18.9 percent). Radon progeny is controlled through ventilation, gamma radiation is controlled through the effective use of time, distance and shielding, and LLRD through ventilation, contamination control and personal protective equipment.

Radiation protection program performance

In 2015, the radiation protection program and practices at the Cigar Lake operation continued to be effective in controlling radiological exposure to workers. There were no effective dose action levels or regulatory exceedances at the Cigar Lake operation in 2015.

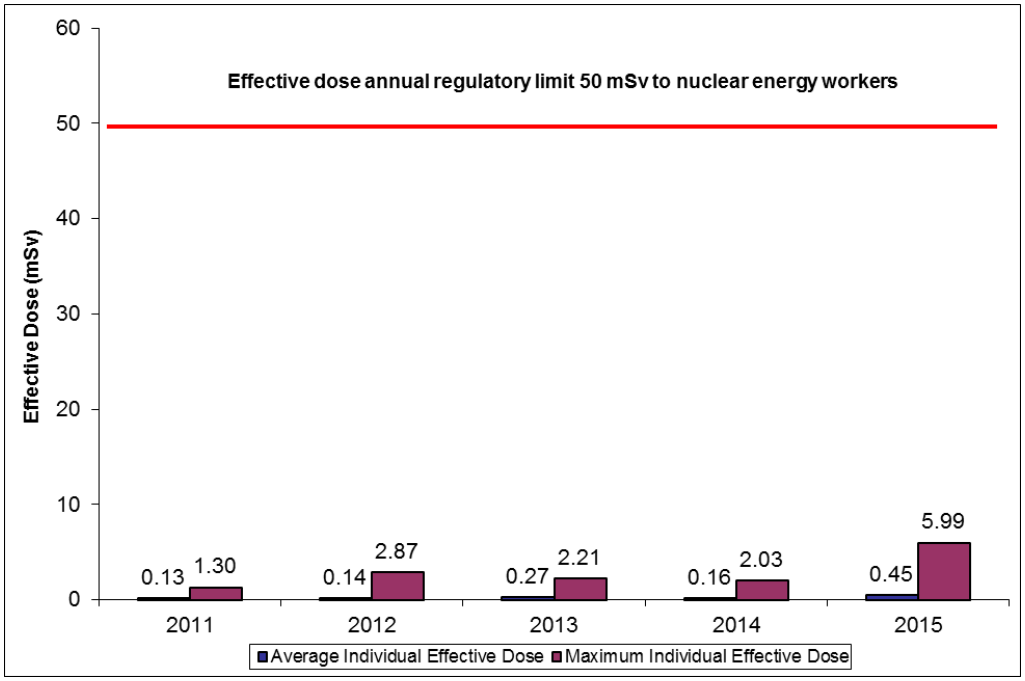
Application of ALARA

CNSC staff have verified through regulatory oversight activities that Cameco continues to maintain worker exposures ALARA. To ensure worker exposures are optimized during production increases at Cigar Lake, Cameco has established production-based dose targets to monitor worker exposures. Additional workplace monitoring has been established to identify further opportunities for improvement as various grades and amounts of ore are processed. To date, worker exposures are consistent with expected values. In addition, Cameco continues to implement enhanced exposure monitoring for workers in higher dose categories. The CNSC concluded that the radiation protection program remains effective in ensuring that maximum individual exposures remain ALARA.

Worker dose control

During 2015, the average individual effective dose for NEWs was 0.45 mSv and the maximum individual effective dose was 5.99 mSv. This is an increase from previous years, attributed to transitioning from a construction and commissioning activities to an operating mine. Figure 3.2 displays the average individual effective dose and the maximum individual effective dose for Cigar Lake's NEWs from 2011 to 2015.

Figure 3.2: Cigar Lake individual effective dose to NEWs, 2011–15



* The effective dose annual limit illustrated applies to the maximum individual effective dose.

CNSC staff are satisfied that the Cigar Lake operation is adequately controlling radiation doses to workers and keeping levels below the regulatory limits.

3.3 Environmental protection

For 2015, CNSC staff continued to rate the environmental protection SCA as satisfactory. The Cigar Lake environmental protection program was effectively implemented and met all regulatory requirements.

Cigar Lake environmental protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Environmental management system

Cigar Lake's environmental management system is described in its approved environmental program and includes activities such as establishing annual environmental objectives, goals and targets. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Assessment and monitoring

In accordance with Cigar Lake's environmental protection program, effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits were performed.

Through compliance activities, CNSC staff concluded that the Cigar Lake operation's environmental monitoring met regulatory requirements and treated effluent discharge complied with licence requirements during 2015. There were no exceedances of environmental code of practice action levels.

Protection of the public

In 2015, 10 events reported to CNSC staff were submitted as releases of hazardous substances to the environment:

- 57 kg of anhydrous ammonia was released into the atmosphere due to failed condenser coils
- 45 kg of anhydrous ammonia was released into the atmosphere due to failed condenser coils
- 45 kg of anhydrous ammonia was released into the atmosphere due to failed condenser coils
- 453 kg of anhydrous ammonia was released into the atmosphere due to failed condenser coils
- 45 kg of anhydrous ammonia was released into the atmosphere due to failed condenser coils
- 0.010 m^3 (10 L) of liquid anhydrous ammonia was released into secondary containment and then vaporized to the atmosphere due to failed condenser coils
- 3 m^3 (3,000 L) of mine water was released to the ground through a leaking pipeline
- 730 m^3 (730,000 L) of treated effluent was released to the ground through a damaged pond liner
- 19 m^3 (19,000 L) of calcium chloride brine was released to the ground due to packer failure in a surface freeze hole
- 0.0005 m^3(0.5 L) of liquid anhydrous ammonia was released into secondary containment and then vaporized to the atmosphere due to failed condenser coils

Seven of these 10 events were attributed to failures of condenser coils. These seven failures were due to a combination of extreme temperatures, materials of construction and high load. Cameco has since replaced its aluminum condenser coils with steel. This was confirmed in an August 2016 inspection by CNSC staff. The replaced coils are expected to prevent similar events.

Appendix G contains a brief description of the spills, corrective actions taken by the licensee, CNSC staff's assessment of those actions and the significance ratings for 2015. CNSC spill rating definitions are also found in appendix G.

Due to timely response and effective corrective actions implemented by the Cigar Lake operation, there were no residual impacts to the environment. CNSC staff were satisfied with Cigar Lake operation's reporting of spills and the corrective actions taken. The CNSC rated all these spills as low significance. Figure 2.4 displays the number of environmental reportable spills at the Cigar Lake operation from 2011 to 2015.

Effluent and emissions control

Treated effluent released to the environment

At the Cigar Lake operation during the 2011 to 2015 review period, parameter concentrations in treated effluent were low and remained below treated effluent discharge limits.

As discussed in section 2.4, constituents of potential concern (COPC) in treated effluent at the uranium mine and mill facilities are molybdenum, selenium and uranium. At the Cigar Lake operation throughout 2015, concentrations for these constituents (shown in figures 2.5 to 2.7) remained well below their respective action levels or provincial licence effluent discharge limits. At the beginning of 2015, increases in concentrations were observed in these constituents, including exceedances of the uranium objective value. These increases were a result of lower-than-expected pH levels and the volume of mine water being treated in the first quarter of 2015. Following continued optimization of the operation's waste water treatment system, concentrations returned to typical values during the second half of 2015.

In addition to the COPC, the Cigar Lake operation also analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH. As shown in section 2.4, the Cigar Lake operation continues to meet the MMER discharge limits.

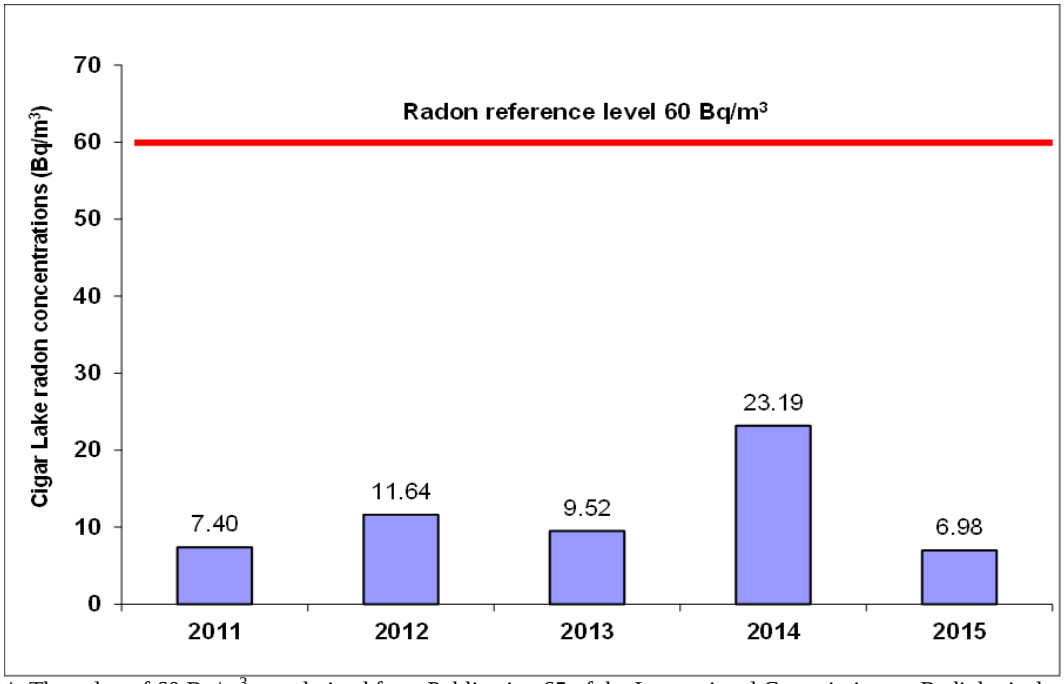
The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

Air emissions released to the environment

The Cigar Lake operation also maintains an air and terrestrial monitoring program. Atmospheric monitoring at the Cigar Lake facility includes ambient radon, total suspended particulate (TSP), soil sampling and lichen sampling to assess the impact of air emissions.

Environmental monitoring for radon concentrations is conducted using the passive method of track-etched cups. Eight monitoring stations are located in four quadrants around the immediate mine site. Figure 3.3 illustrates that the average concentrations of radon in ambient air for 2011 to 2015 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3. As the Cigar Lake facility transitioned into operation, an increase was noted in the concentrations of radon in ambient air, as expected. Concentrations remained well below the reference level.

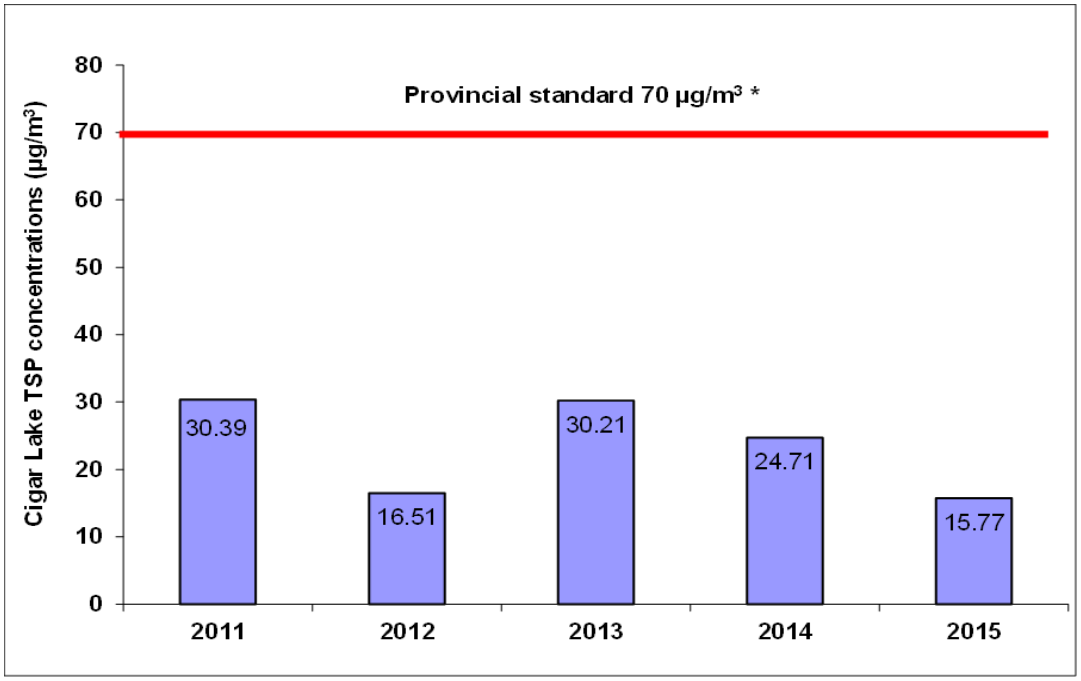
Figure 3.3: Cigar Lake average concentrations of radon in ambient air, 2011–15



* The value of 60 Bq/m^3 was derived from Publication 65 of the International Commission on Radiological Protection, *Protection Against Radon-222 at Home and at Work*,as referenced in the *Radiation Protection Regulations.* The reference level represents an incremental increase above natural dwelling radon levels that could result in a member of the public being exposed to an incremental dose of 1 mSv. Values are calculated as geometric means.

A high-volume air sampler (HVAS) was used to collect and measure TSP in air. The HVAS was located approximately 150 metres downwind from Headframe No.1 and the mine ventilation exhaust at the Cigar Lake operation. The TSP levels were below provincial standards (see figure 3.4). The mean concentrations of metal and radionuclides adsorbed to TSP were low and below the reference annual air-quality levels identified in table 3.2.

Figure 3.4: Cigar Lake concentrations of TSP, 2011–15



* The Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities is shown. The ambient air quality standards for TSP have been revised under the *Saskatchewan Environmental Management and Protection Regulations* and will be updated when the approval to operate document issued by the Province of Saskatchewan is renewed.
Values are calculated as geometric means.

TSP samples are also analyzed for concentrations of metals and radionuclides.

Table 3.2: Cigar Lake concentrations of metal and radionuclides in air, 2011–15*

Parameter	Reference annual air quality levels	2011	2012	2013	2014	2015
As (µg/m^3)	**0.06** (1)	0.00038	0.00025	0.00025	0.00025	0.00031
Mo (µg/m^3)	**23** (1)	0.00021	0.00028	0.00021	0.0001	0.0001
Ni (µg/m^3)	**0.04** (1)	0.00124	0.00101	0.00104	0.00067	0.00062
Pb (µg/m^3)	**0.10** (1)	0.0018	0.0016	0.0007	0.0013	0.0009
Se (µg/m^3)	**1.9** (1)	0.00005	0.00004	0.00003	0.00003	0.00003
Pb^{210} (Bq/m^3)	**0.021** (2)	0.000333	0.000338	0.000268	0.00025	0.000315
Po^{210} (Bq/m^3)	**0.028** (2)	0.000106	0.000106	0.000074	0.000086	0.000095
Ra^{226} (Bq/m^3)	**0.013** (2)	0.000014	0.000005	0.000004	0.000008	0.000014
Th^{230} (Bq/m^3)	**0.0085** (2)	0.000008	0.000026	0.000011	0.00001	0.000014
U (µg/m^3)	**0.06** (1)	0.00012	0.00009	0.00007	0.00008	0.00055

1 Reference annual air quality levels derived from Ontario 24-hour Ambient Air Quality Criteria (OMOE 2012).

2 Reference level from International Commission on Radiological Protection (ICRP) Publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack.*

* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or Province of Saskatchewan limits are currently established.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place to determine if there is influence from aerial deposition. This program includes triennial measurements of metals and radionuclides in lichen and in soil. No lichen or soil samples were collected in 2015. The next sampling is scheduled to occur in 2016. Lichen and soil samples were collected in 2013, as required by the triennial sampling program. Sampling results are discussed in the 2013 regulatory oversight report. The 2013 data displayed that the concentrations of metals and radionuclides in lichen were similar to reference stations and historical data. CNSC staff concluded that the level of airborne particulate contaminants was acceptable and did not pose a risk to the lichen consumers such as caribou. The 2013 soil samples displayed that concentration of metals were below the levels described in the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, and radionuclide concentrations were low and near, or at, background levels and analytical detection limits. CNSC staff concluded that the level of airborne particulate contaminants produced by the Cigar Lake operation is acceptable and does not pose a risk to the environment.

Environmental risk assessment

The CNSC uses environmental risk assessments to ensure that people and the environment are protected. The Cigar Lake Environmental Performance Report and updated Environmental Risk Assessment will be received in 2016.

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Cigar Lake met performance objectives and all applicable regulatory requirements.

3.4 Conventional health and safety

For 2015, CNSC staff continued to rate the conventional health and safety SCA as satisfactory.

Cigar Lake conventional health and safety ratings

2011	2012	2013	2014	2015
SA	SA	FS	SA	SA

Practices

CNSC staff monitored the implementation of the Cigar Lake operation's safety and health management program to ensure the protection of workers. The program includes planned internal inspections, a safety permit system, occupational health committees, training and incident investigations. Cameco's incident reporting system includes reporting, trending and investigation of near misses. This helps to reduce future incidents that could cause injury. CNSC staff verified the conventional health and safety work practices and conditions achieved an adequate degree of personnel safety at the Cigar Lake operation.

Performance

Table 3.3 summarizes LTIs at the Cigar Lake operation from 2011 to 2015. There were four LTIs at the Cigar Lake operation in 2015 and one reclassification of an event which occurred in 2014. Appendix H contains a brief description of these LTIs and the corrective actions taken by the licensee. CNSC staff assessed and were satisfied with the follow-up actions taken by the Cigar Lake operation.

Table 3.3: Cigar Lake total number of FTE workers and LTIs, severity rate and frequency rate, 2011–15

Year	2011	2012	2013	2014	2015
Total number of FTE workers[1]	971	1,277	1,570	833	602
Number of LTIs[2]	1	0	4	1*	4
Severity rate[3]	1.65	0.0	5.57	0.0	17.06
Frequency rate[4]	0.1	0.0	0.25	0.12*	0.56

1 **Total number of workers** (employees and contractors) expressed as FTE. FTE = total person-hours / 2,000 hours worked per employee per year.
2 **Lost-time injury** is an injury that takes place at work and results in the worker being unable to return to work for a period of time.
3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.
4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/# of hours worked in last 12 months)] x 200,000.
* One event that occurred in 2014 was reclassified as an LTI in 2015. In the 2014 report, these numbers were 0.

Awareness

CNSC staff observed that the conventional health and safety programs at the Cigar Lake operation continued to provide education, training, tools and support to workers. Safety is the responsibility of all individuals. This message is promoted by managers, supervisors and workers. Site operation's management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems.

CNSC staff compliance verification activities concluded that Cigar Lake operation's health and safety program met regulatory requirements in 2015.

4 MCARTHUR RIVER OPERATION

Cameco Corporation operates the McArthur River mine, which is located approximately 620 kilometres north of Saskatoon, Saskatchewan. The McArthur River operation is the world's largest high-grade uranium mine (see figure 4.1).

Facilities at the McArthur River operation include an underground uranium mine, primary ore processing, ore slurry loading, waste management facilities, a water treatment plant, surface freeze plants, administration offices and warehouse buildings.

In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. Cameco's licence for the McArthur River operation expires on October 31, 2023.

Figure 4.1: Aerial view of McArthur River

McArthur River mining production data for 2011 to 2015 is shown in table 4.1. As of December 31, 2015 the McArthur River operation's proven and probable ore reserves were 1,395,100 tonnes at a grade of 10.94 percent for a total of approximately 129.4 million kilograms of uranium.

Table 4.1: McArthur River mining production data, 2011–15

Mining	2011	2012	2013	2014	2015
Ore tonnage (tonnes/year)	80,162	115,107	104,132	108,394	88, 236
Average ore grade mined (% U_3O_8)	11.17	7.78	8.83	8.73	10.13
Uranium mined (Mkg U/year)	7.59	7.6	7.8	8.02	7.58
Authorized annual production (Mkg U/year)	8.1	8.1	8.1	8.1	9.6

High-grade uranium ore is mined, mixed with water and ground in a ball mill to form slurry which is pumped to the surface. The ore slurry is loaded into containers and transported to the Key Lake operation for further processing. Low-grade mineralized rock is also transported to the Key Lake facility in covered haul trucks. These materials are then blended with high-grade ore slurry to create the mill ore feed.

4.1 Performance

The McArthur River operation SCA ratings for the five-year period of 2011 to 2015 are shown in appendix D. For 2015, CNSC staff continue to rate all SCAs as satisfactory. This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs which cover many of the key performance indicators for these facilities.

4.2 Radiation protection

For 2015, CNSC staff continued to rate the radiation protection SCA as satisfactory based on regulatory oversight activities.

McArthur River radiation protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Radiological hazard control

The main source of radiological exposure at the McArthur River operation is from mining and processing of high-grade uranium ore. The greatest contributor to effective dose was from exposures to radon progeny (64 percent), which is controlled through preventing the inflow of radon-bearing water entering mine workings and the effective use of ventilation. Gamma radiation (26.1 percent) and LLRD (9.8 percent) also contribute to effective doses. These hazards are controlled through the effective use of time, distance and shielding, and ventilation and contamination control.

Radiation protection program performance

In 2015, there were two events resulting in radiological action level exceedances:

- A raisebore operator exceeded the weekly action level of 1 mSv when an individual effective dose of 4.7 mSv was received in January 2015. This also resulted in an individual effective dose of 5.5 mSv for the first quarter which exceeded the quarterly action level of 5 mSv.
- Five underground workers exceeded the weekly action level of 1 mSv during an event in September 2015.

A brief description of the above events and corrective actions implemented are provided in appendix I. CNSC staff have assessed and were satisfied with the actions taken by the McArthur River operation to address these action level exceedances. The doses to workers remained below regulatory limits.

Overall, the radiation protection program and practices at the McArthur River operation continued to be effective in controlling radiological exposure to workers.

Application of ALARA

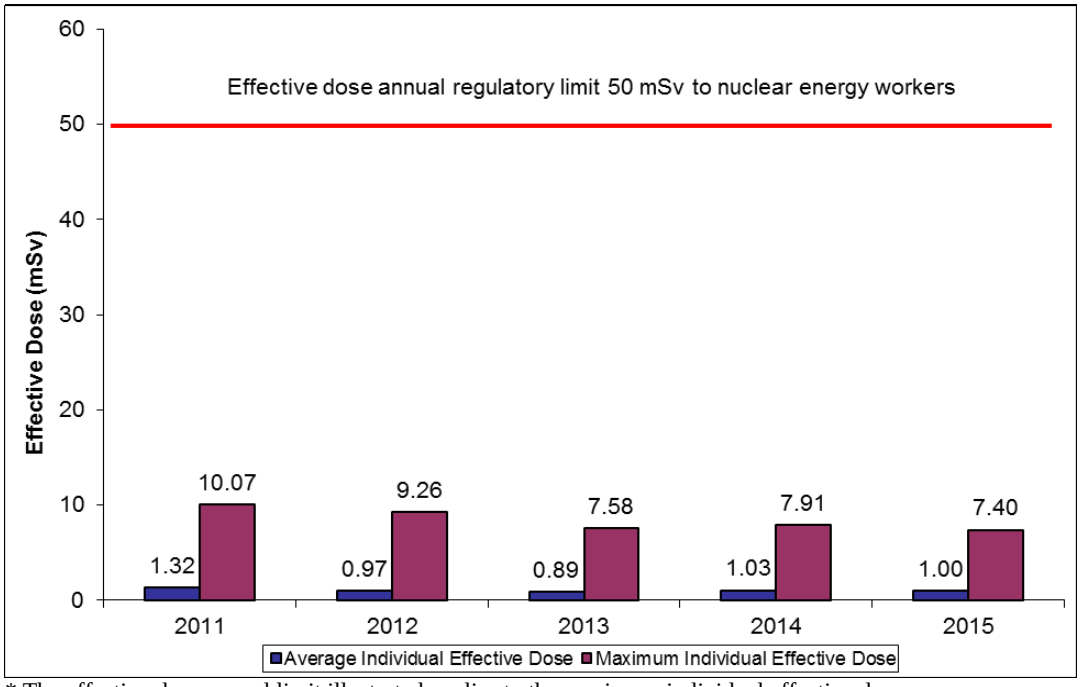
CNSC staff have verified through regulatory oversight activities that Cameco continues to maintain worker exposures ALARA.

In 2015, as an initiative to reduce radon progeny and LLRD hazard levels, the operation at McArthur River increased the overall ventilation capacity of the mine. This involved extensive rehabilitation work in the main exhaust shaft, including enhanced water capture and removal of old infrastructure. The gain in overall ventilation is estimated to be 180,000 cubic feet per minute.

Worker dose control

The average individual effective dose to NEWs was 1 mSv. Underground miners had the highest average individual effective dose at 2.55 mSv. The maximum individual effective dose was 7.4 mSv. Figure 4.2 shows that the average and maximum individual effective dose to NEWs from 2011 to 2015 were well below the annual regulatory limit of 50 mSv.

Figure 4.2: McArthur River individual effective dose to NEWs, 2011–15



* The effective dose annual limit illustrated applies to the maximum individual effective dose.

CNSC staff were satisfied that the McArthur River operation is adequately controlling radiation doses to workers and keeping levels below the regulatory limits.

4.3 Environmental protection

For 2015, CNSC staff continued to rate the environmental protection SCA as satisfactory based on regulatory oversight activities. The licensee's environmental protection program was effectively implemented and met all regulatory requirements.

McArthur River environmental protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Environmental management system

The environmental management system at the McArthur River operation includes activities such as establishing annual environmental objectives, goals and targets. The McArthur River operation conducts internal audits of its program at least once every year. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Assessment and monitoring

In accordance with McArthur River operation's environmental protection program, effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits were performed in 2015.

CNSC staff concluded that the McArthur River operation's environmental management system and monitoring programs met regulatory requirements and the licensee complied with treated effluent discharge requirements. There were no environmental action level exceedances during the 2011 to 2015 review period.

Protection of the public

Figure 2.4 depicts the number of spills at the McArthur River operation from 2011 to 2015. There were no releases of hazardous material to the environment (spills) from the licensed activities at the McArthur River operation during 2015.

Effluent and emissions control

Treated effluent released to the environment

Treated effluent released to the environment was well below regulatory requirements and has remained stable or improved over the past five years.

As discussed in section 2.4, constituents of potential concern (COPC) in treated effluent at the uranium mine and mill facilities are molybdenum, selenium and uranium (shown in figures 2.5 to 2.7). Molybdenum was the main COPC at the McArthur River facility. In response, process changes were implemented to reduce molybdenum concentrations in treated effluent. Molybdenum removal efficiency in treated effluent has improved. Concentrations have decreased from 0.3380 mg/L in 2011 to 0.1460 mg/L in 2015 (see figure 2.5).

In addition to the COPC, the McArthur River operation also analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH. As shown in section 2.4 the McArthur River operation continues to meet the MMER discharge limits.

The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

Figure 4.3 depicts part of the Read Creek drainage system downstream from the McArthur River operation.

Figure 4.3: Downstream from McArthur River

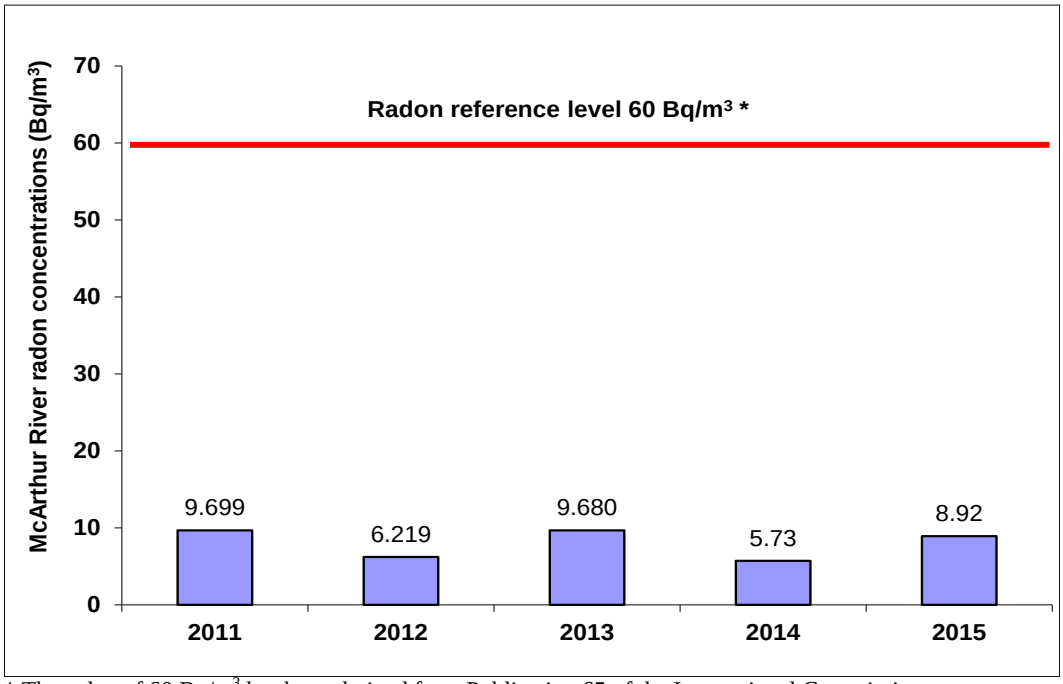
Air emissions released to the environment

The McArthur River operation maintains an air and terrestrial monitoring program to measure the influence of atmospheric deposition of metals and radionuclides.

Air quality monitoring consists of radon monitoring, high volume air sampling, lichen, soil, blueberry twigs and stems sampling. An analysis of blueberry chemistry was included to align with country foods studies.

A total of 12 monitoring locations are used for the monitoring of ambient radon using passive track-etched cups. Figure 4.4 shows the average concentrations of radon in ambient air for 2011 to 2015 were below the reference level for radon. Radon concentrations were similar to past performance with radon concentrations typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

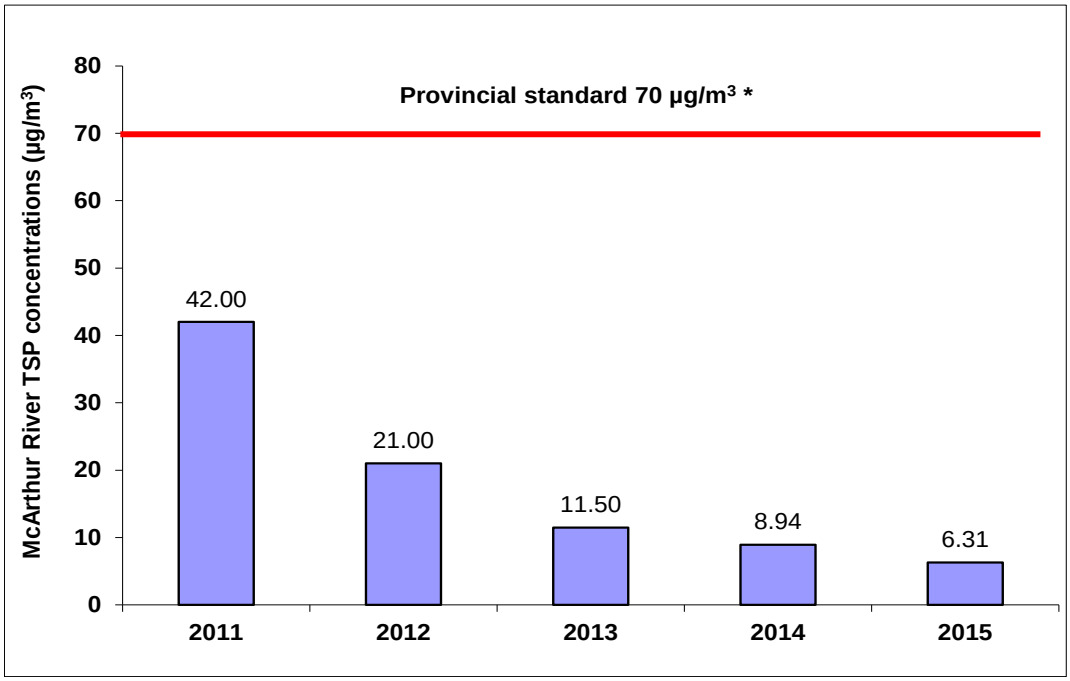
Figure 4.4: McArthur River concentrations of radon in ambient air, 2011–15



* The value of 60 Bq/m^3 has been derived from Publication 65 of the International Commission on Radiological Protection, *Protection Against Radon-222 at Home and at Work*, as referenced in the *Radiation Protection Regulations.* The reference level represents an incremental increase above natural dwelling radon levels that could result in a member of the public being exposed to an incremental dose of 1 mSv. Values are calculated as geometric means.

Two HVAS were used to collect and measure total suspended particulate (TSP) in air. One sampler was located in the vicinity of the main camp residence and the second located approximately 250 metres northwest in a location representative of ambient conditions. From the average of the two stations, the TSP levels are less than Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's Approval to Operate Pollutant Controlled Facilities (see figure 4.5).

Figure 4.5: McArthur River concentrations of total suspended particulate, 2011–15



* The Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities is shown. The ambient air quality standards for TSP have been revised under the Saskatchewan *Environmental Management and Protection Regulations* and will be updated when the approval to operate document issued by the Province of Saskatchewan is renewed. Values are calculated as geometric means.

TSP samples were also analyzed for concentrations of metals and radionuclides. The mean concentrations of metal and radionuclides adsorbed to TSP were low, and below reference annual air quality levels identified in table 4.2.

Table 4.2: McArthur River concentrations of metal and radionuclides in air, 2011-15*

Parameter	Reference annual air quality levels	2011	2012	2013	2014	2015
As (µg/m^3)	**0.06** (1)	0.0003	0.0003	0.0001	0.0001	0.0001
Cu (µg/m^3)	**9.6** (1)	0.0097	0.0119	0.0067	0.00835	0.00513
Ni (µg/m^3)	**0.04** (1)	0.0016	0.0012	0.0007	0.00085	0.00067
Pb (µg/m^3)	**0.10** (1)	0.0015	0.0018	0.0014	0.0012	0.00118
Se (µg/m^3)	**1.9** (1)	0.00006	0.00005	0.00003	0.0004	0.00004
Zn (µg/m^3)	**23** (1)	0.0247	0.7721	0.01065	0.01225	0.00980
Pb^{210} (Bq/m^3)	**0.021** (2)	0.00043	0.00045	0.00034	0.00032	0.00032
Po^{210} (Bq/m^3)	**0.028** (2)	0.00013	0.00012	0.00010	0.000095	0.000082
Ra^{226} (Bq/m^3)	**0.013** (2)	0.00003	0.00004	0.00001	0.000025	0.000013
Th^{230} (Bq/m^3)	**0.0085** (2)	0.00002	0.00001	0.00001	0.00001	0.00002
U (µg/m^3)	**0.06** (1)	0.0021	0.0012	0.0005	0.0005	0.0003

1 Reference annual air quality levels derived from *Ontario 24-hour Ambient Air Quality Criteria* (OMOE 2012).

2 Reference level from ICRP 96.

* Province of Ontario and ICRP annual air quality levels are shown for reference only. No federal or provincial limits are currently established.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place and includes triennial measurements of metals and radionuclides in soil and blueberry samples.

Soil and blueberry twig samples were collected in 2015 as required by the triennial sampling program. Results indicated that parameters measured were within historical ranges which are below, or at background levels and analytical detection limits. CNSC staff concluded the level of airborne particulate contaminants produced by the McArthur River operation is acceptable and does not pose a risk to the environment.

Blueberry twigs are monitored to determine if soil-born contaminants (when present) are being absorbed through the roots into the growing plant parts. The concentrations of metals and radionuclides in blueberry twigs have higher-than-background concentrations for some locations within the vicinity of onsite waste rock pads. The concentrations decrease within a short distance of the waste rock pads. Compared with historical data, the concentrations are not increasing over time. Blueberry twigs collected near the site boundary are either near or at background levels and have not been affected by site activities.

The area surrounding the McArthur River operation has been subject to forest fires in recent years. As a result, lichen sampling has been difficult. Scheduled sampling was unable to be completed as an insufficient amount of lichen tissue was available for analysis. Lichen are generally distributed sparsely in the local environment. It is well documented that lichen regrowth in northern climates is slow after a fire. Cameco conducted vegetation classification studies that identified some recovering lichen communities that could potentially be used as lichen sampling locations. Historic data from 1997 to 2003 does not suggest that constituents of potential concern were accumulating in lichen tissues above background concentrations.

Environmental risk assessment

The McArthur River environmental performance report for 2010 to 2014 was submitted to the CNSC and the Saskatchewan Ministry of Environment in 2015. CNSC staff reviewed the submission and concluded the monitoring programs and special studies were adequate, and provided the required information. It was also concluded that the report contained sufficient information to complete a review of the environmental performance of the McArthur River operation from 2012 to 2014 relative to predications contained in the environmental risk assessment. This assessment confirms the environment and human health in the vicinity of the McArthur River operation remains protected.

CNSC staff concluded that the environmental protection SCA at the McArthur River operation met performance objectives and all applicable regulatory requirements.

4.4 Conventional health and safety

For 2015, CNSC staff continued to rate the conventional health and safety SCA as satisfactory based on regulatory oversight activities.

McArthur River conventional health and safety ratings

2011	2012	2013	2014	2015
SA	SA	FS	SA	SA

Practices

To promote continued effective safety performance, the McArthur River operation has implemented a health and safety management program to identify and mitigate risks. The program includes a safety permit system, continued training, planned internal inspections, occupational health committees, and incident investigations. The incident reporting system includes reporting and investing near misses. This originates from recognition that the reporting of incidents offers significant value in reducing future incidents that could cause injury. CNSC staff verified the McArthur River conventional health and safety work practices and conditions achieved an adequate degree of personnel safety.

Performance

There were no LTIs reported in 2015 (see table 4.3).

Table 4.3: McArthur River total number of FTEs workers and LTIs, severity rate and frequency rate, 2011–15

Year	2011	2012	2013	2014	2015
Total number of FTE workers[1]	966	1,017	914	692	749
Number of LTIs[2]	3	2	0	0	0
Severity rate[3]	14.4	8.0	0	0	0
Frequency rate[4]	0.3	0.2	0	0	0

1 **Total number of workers** (employees and contractors) expressed as FTEs.
FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time injury** - an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.

4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/# of hours worked in last 12 months)] x 200,000.

Compliance verification activities confirmed that the McArthur River operation focuses on the prevention of accidents, reducing LTIs and number of injuries requiring medical treatment.

Awareness

CNSC staff observed that the conventional health and safety programs at the McArthur River operation continued to provide education, training, tools and support to workers. Safety is the responsibility of all individuals, and this notion is promoted by managers, supervisors and workers. Site operation's management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems.

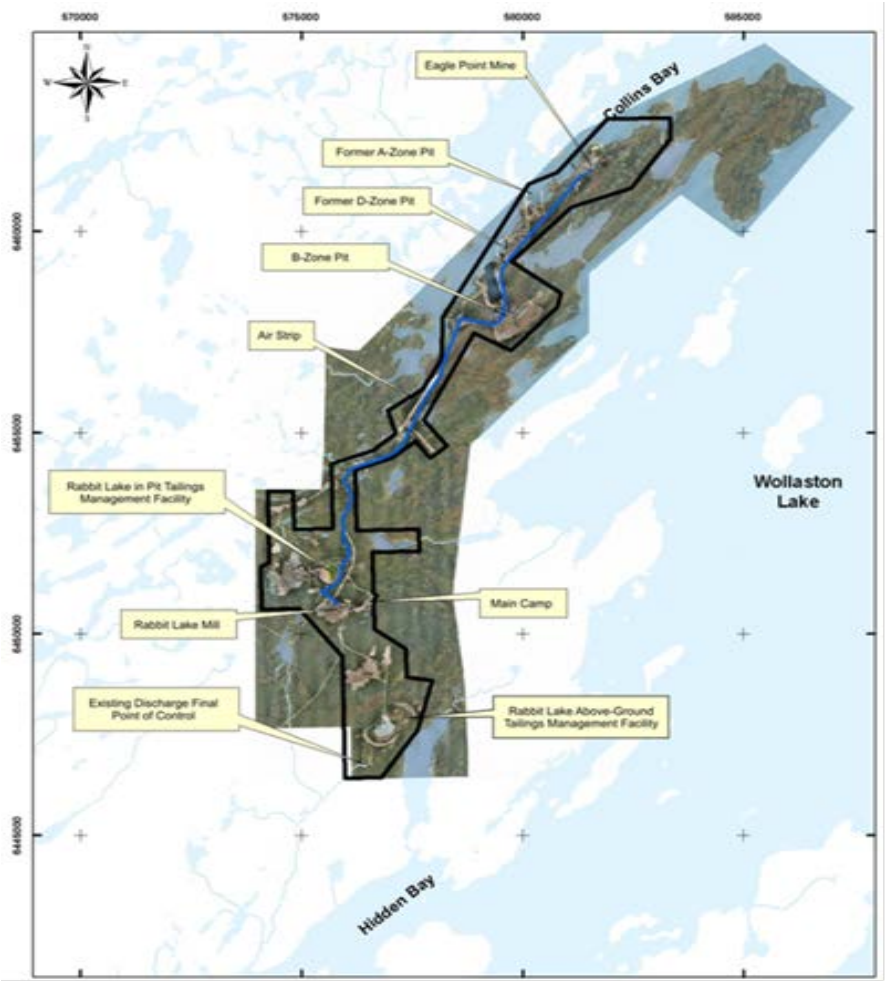
CNSC staff verified that the health and safety program at the McArthur River operation met regulatory requirements.

5 RABBIT LAKE OPERATION

The Rabbit Lake operation is located 750 kilometres north of Saskatoon, Saskatchewan (see figure 5.1). The site is owned and operated by Cameco Corporation and stretches across approximately 20 kilometres. The Eagle Point underground mine is located at the northern margin of the property. Moving southward, three mined-out and flooded pits, the A, D and B Zone pits, border Collins Bay of Wollaston Lake. The B Zone pit remains isolated from the bay by an intact dyke. In the central part of the property, the mined-out Rabbit Lake pit was converted to a tailings management facility. Adjacent to the in-pit tailings facility is the mill. South of the mill is the above ground tailings management facility (AGTMF), which has not received tailings since 1985. At the southern margin, after passage through settling polishing ponds, treated effluent continuously discharges eventually reaching Hidden Bay of Wollaston Lake.

In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. Cameco's licence for the Rabbit Lake operation expires on October 31, 2023.

Figure 5.1: Rabbit Lake site map



Mining production data for the Rabbit Lake operation is provided in table 5.1.

Table 5.1: Rabbit Lake mining production data, 2011–15

Mining	2011	2012	2013*	2014	2015
Ore tonnage (tonnes/year)	197,397	225,282	255,154	328,126	309,505
Average ore grade mined (% U_3O_8)	0.91	0.84	0.59*	0.56	0.63
Uranium mined (Mkg U/year)	1.51	1.62	1.28	1.57	1.62

* 2013 data corrected

Ore from the Eagle Point mine had been blended at the Rabbit Lake mill with previously mined, low-grade material to supplement uranium concentrate production. Table 5.2 presents the 2011 to 2015 milling data for the Rabbit Lake operation.

Table 5.2: Rabbit Lake milling production data, 2011–15

Milling	2011	2012	2013	2014	2015
Mill ore feed (tonnes/year)	209,040	260,299	334,976	386,970	313,712
Average annual mill feed grade (% U_3O_8)	0.83	0.71	0.54	0.49	0.64
Percent uranium recovery	96.8	96.8	97.2	97.3	97.1
Uranium concentrate produced (Mkg U/year)	1.46	1.48	1.59	1.60	1.62
Authorized annual production (Mkg U/year)	4.25	4.25	4.25	4.25	4.25

Proven and probable ore reserves with an average grade of 0.59 percent remaining at the Rabbit Lake operation were estimated at 4.59 Mkg of uranium in the 2015 annual report.

In 2015, the Rabbit Lake operation celebrated 40 years since the commencement of milling. On April 21, 2016 Cameco announced the start of a prolonged period of care and maintenance, suspending mining and milling operations at the Rabbit Lake facility.

A previous licence condition required the Rabbit Lake operation to develop and implement a site reclamation plan. Reclamation activities continued as follows:

- Active reclamation of the B Zone waste rock pile was ongoing with the installation of an engineered cover in 2012. The pile was subsequently hydro seeded. Environmental instrumentation was also installed to monitor reclamation performance. In 2015, CNSC staff observed a stable earthen cover with good vegetation growth on the B Zone pile. The flooded B Zone pit remains isolated from Wollaston Lake. CNSC staff will review the reclamation plan for the pit when the document is submitted by Cameco.
- Progressive, staged reclamation of the AGTMF continued in 2015. The AGTMF operated between 1975 and 1985. A conceptual decommissioning plan was developed in 1993. As part of that plan, a program was initiated to facilitate consolidation of the 6.3 million tonnes of tailings in the AGTMF. The majority of the ice lenses within the tailings have thawed. The bounding earth dams have been reshaped and armoured for long-term stability. Placement of an interim till cover on the facility was completed in 2013. A southern portion of the cover has been hydro seeded to protect the cover integrity and reduce water infiltration. The northern portion of the facility continues to be actively used for solid waste disposal. A final cover design will be submitted prior to decommissioning. In 2015, CNSC staff confirmed the safe state of the AGTMF.
- In 2005 and 2010 respectively, the dykes that separated the A Zone and D Zone pits from Wollaston Lake were purposely breached. In 2015, the water quality in the pits continued to be consistent with Wollaston Lake background values. The vegetation in the remediated areas surrounding the pits is well established (see figure 5.2).
- The Link Lakes were affected during early operation of the Rabbit Lake mine. Monitoring of the Link Lakes continued in 2015, demonstrating the stability of the system and that Wollaston Lake is protected.

Figure 5.2: Rabbit Lake – reclaimed flooded D Zone pit and waste rock pile

CNSC staff have verified the continuation of reclamation activities through desktop reviews of applications, reports and onsite inspections. CNSC staff will monitor and review Rabbit Lake operation's water management practices and reclamation activities to ensure the environment is protected during this period of care and maintenance.

The Rabbit Lake in-pit tailings management facility (RLITMF), shown in figure 5.3, is nearly at the end of its operational life. Active thawing of ice incorporated in the facility is required before decommissioning of the facility can begin. During the care and maintenance period beginning in 2016, the RLITMF will continue its function as part of the water management and treatment program at the Rabbit Lake facility.

Figure 5.3: Rabbit Lake – in-pit tailings management facility

In 2015, tailings were deposited into the RLITMF under a water cover. This method of tailings placement prevents the inclusion of ice in newly deposited tailings and reduces the release of radon and dust.

5.1 Performance

For 2015, CNSC staff rated all 14 SCAs as satisfactory based on regulatory oversight activities. Ratings at the Rabbit Lake operation for these 14 SCAs during the five-year period of 2011 to 2015 are shown in appendix D. This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs which cover many of the key performance indicators for these facilities.

5.2 Radiation protection

For 2015, CNSC staff continued to rate the radiation protection SCA as satisfactory based on regulatory oversight activities.

Rabbit Lake radiation protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Radiological hazard control

The sources of radiological exposure at the Rabbit Lake operation were from mining at the Eagle Point underground mine and from uranium ore milling at the Rabbit Lake mill. The effective dose contributors to underground workers at Rabbit Lake were radon progeny (56.4 percent), gamma radiation (32.2 percent), and LLRD (10 percent). Effective doses to NEWs from exposures to radon progeny and LLRD are controlled through the effective use of ventilation. Gamma radiation exposure is controlled through the application of time, distance and shielding.

Figure 5.4 shows CNSC staff conducting a swipe test to verify uranium concentrate drums are free of external contamination.

Figure 5.4: CNSC staff conducting a swipe test

Radiation protection program performance

In 2015, CNSC staff were satisfied that the radiation protection program and practices at the Rabbit Lake operation continued to be effective in controlling radiological exposure to workers. There were no action level exceedances reported at the Rabbit Lake operation in 2015.

Application of ALARA

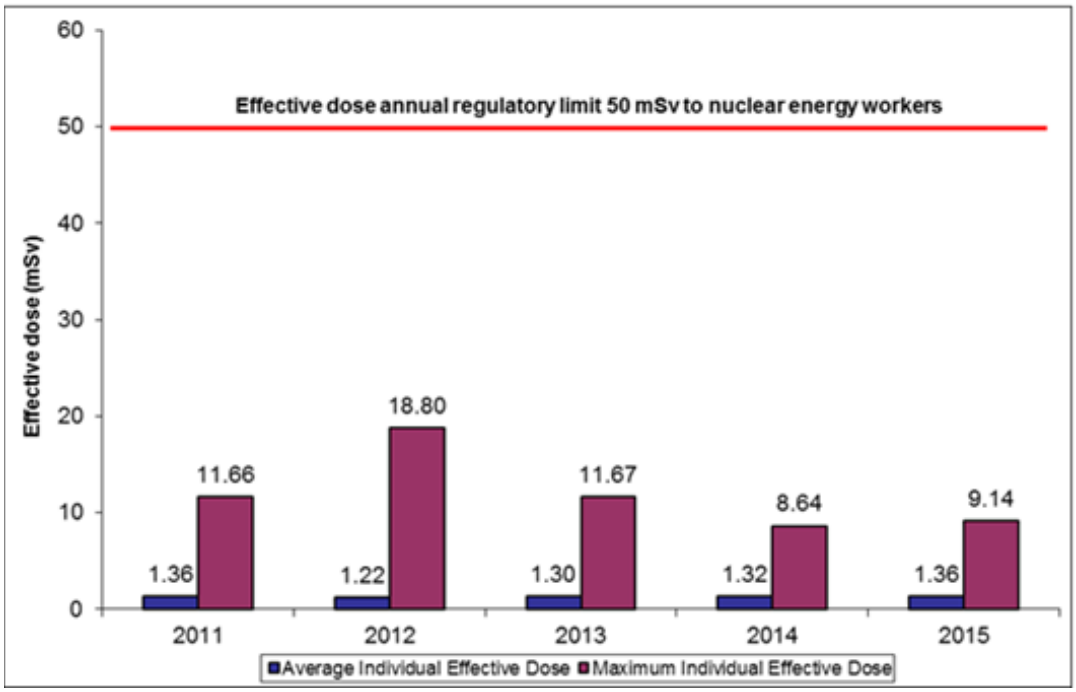
CNSC staff have verified through regulatory oversight activities that Cameco continues to maintain worker exposures ALARA.

In 2015, Rabbit Lake implemented six action plans with a focus on reducing radiation exposures, enhancing regulatory compliance and achieving overall site targets. In an effort to reduce exposures to radon progeny, guidelines have been established for assessing underground working areas and involving the engineering department in establishing corrective actions to address elevated radon progeny whenever possible. This program was in the development stage at the end of 2015 and continued into 2016. CNSC staff will continue to monitor progress in this area through compliance activities.

Worker dose control

Figure 5.5 displays the average annual individual effective doses for Rabbit Lake NEWs as relatively consistent over five years (2011 to 2015). The maximum individual effective dose remained low in 2015 at a level of 9.14 mSv. The average individual effective dose for NEWs in 2015 was 1.36 mSv, consistent with historical values. The average individual effective dose for mill workers and underground miners was 1.32 mSv and 3.57 mSv respectively, similar to values from previous years. Doses to workers continued to be well below the annual regulatory dose limit of 50 mSv.

Figure 5.5: Rabbit Lake – individual effective dose to NEWs, 2011–15



* The effective dose annual limit illustrated applies to the maximum individual effective dose.

Based on CNSC staff compliance verification activities, such as site inspections, reviews of licensees' reports, work practices, monitoring results, and individual effective dose results for 2015, CNSC staff were satisfied that the Rabbit Lake operation adequately controlled radiation doses to workers.

5.3 Environmental protection

For 2015, CNSC staff continued to rate the environmental protection SCA as satisfactory based on regulatory oversight activities. The licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Rabbit Lake environmental protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Environmental management system

Rabbit Lake operation's environmental management system is described in its approved environmental protection program, which includes activities such as establishing annual environmental objectives, goals and targets. The Rabbit Lake operation conducts internal audits of its program at least once every year. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Assessment and monitoring

During 2015, the Rabbit Lake environmental protection program was effectively implemented and met regulatory requirements.

CNSC staff concluded that the Rabbit Lake operation environmental management system and monitoring programs met regulatory requirements and all treated effluent discharged to the environment complied with licence requirements. There were also no exceedances of environmental action levels at the Rabbit Lake operation.

Protection of the public

There were two events classified as releases of hazardous material to the environment (spills):

- 23 m^3 (23,000 L) of treated effluent was released from a pipeline leak
- 0.010 m^3 (10 L) of contaminated process fluid was released while disconnecting a line

Appendix G provides a brief description of each spill and the actions taken by the licensee. The spills were remediated, with no residual impacts on the environment. CNSC staff assessed the corrective actions taken by the Rabbit Lake operation and found them to be acceptable. CNSC rated all the 2015 spills as low significance. Figure 2.4 displays the number of environmental reportable spills from 2011 to 2015 at the Rabbit Lake operation.

Effluent and emissions control

Treated effluent released to the environment

For previously identified COPC (i.e., uranium, molybdenum and, to a lesser extent, selenium), the effluent treatment system at the Rabbit Lake operation continues to meet performance expectations in reducing the concentrations of these parameters (shown in figures 2.5 to 2.7). Substantial water treatment modifications have been completed at the Rabbit Lake operation since 2007 to improve the quality of the treated effluent released to the environment. The licensee installed additional chemical treatment processes to reduce molybdenum. Molybdenum concentrations displayed continued reductions since additional effluent treatment processes were installed. In addition, the treatment circuit modifications have been successful in meeting the uranium target objective of 0.1 mg/L. Selenium concentrations have been stable.

In addition to the COPC, the Rabbit Lake operation also analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH in treated effluent. As shown in section 2.4 the Rabbit Lake operation continues to meet the MMER discharge limits.

In 2015, the concentrations of regulated parameters in treated effluent released to the environment were well below the regulatory limits. The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective. Figure 5.6 shows an area downstream of the Rabbit Lake operation discharge area.

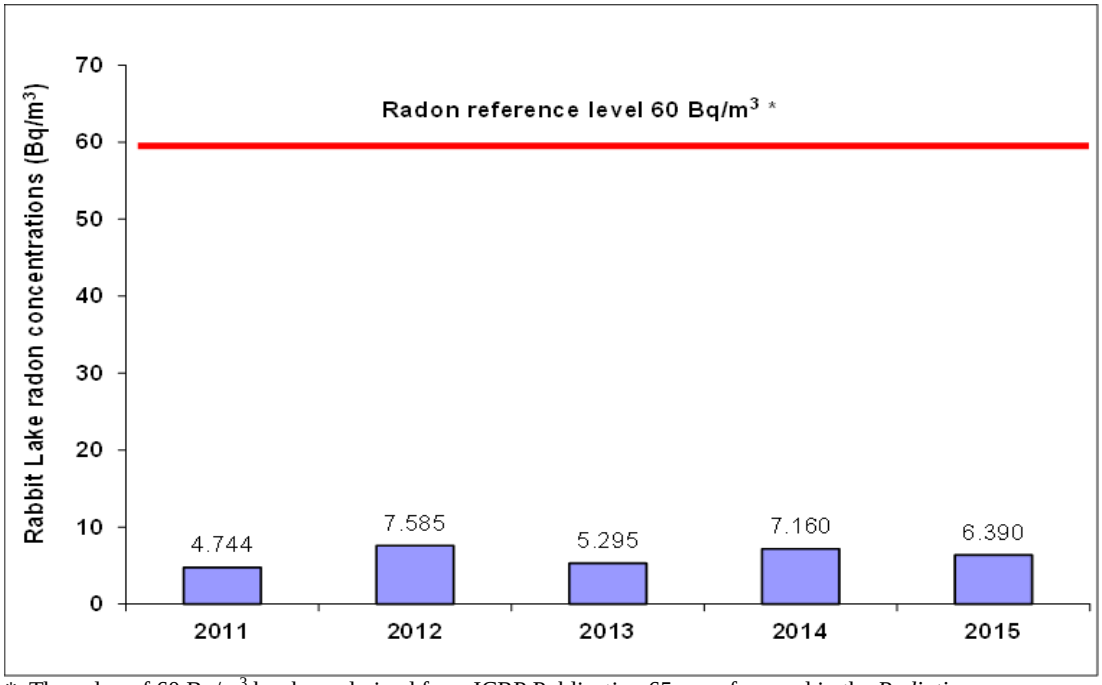
Figure 5.6: Rabbit Lake – downstream of effluent discharge area

Air emissions released to the environment

The Rabbit Lake operation maintains a terrestrial and air-monitoring program to monitor emissions and the effects of atmospheric deposition of metals and radionuclides. The atmospheric monitoring program includes ambient monitoring for radon, TSP and sulphur dioxide. Air monitoring results indicate negligible impacts.

Figure 5.7 shows that the average concentrations of radon in ambient air for 2011 to 2015 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

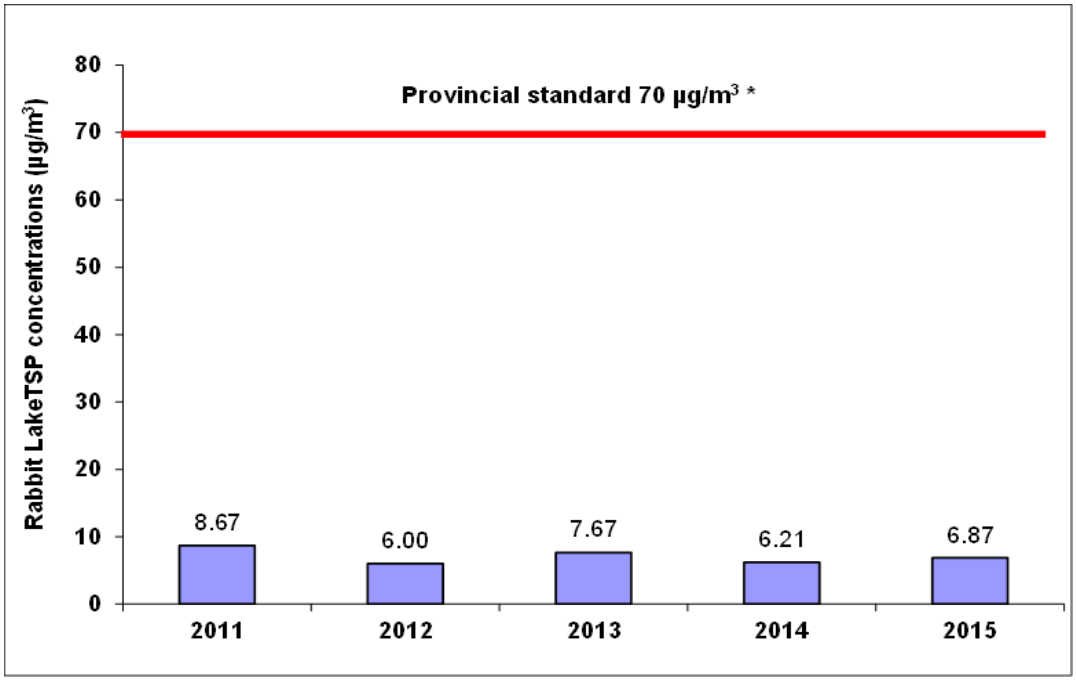
Figure 5.7: Rabbit Lake – concentrations of radon in ambient air, 2011–15



* The value of 60 Bq/m^3 has been derived from ICRP Publication 65, as referenced in the *Radiation Protection Regulations*. The reference level represents an incremental increase above natural dwelling radon levels that could result in a member of the public being exposed to an incremental dose of 1 mSv. Values are calculated as geometric means.

Three HVAS were used to collect and measure TSP in air. The HVAS units are located in the vicinity of the mill, B Zone ore pad and the Eagle Point mine. The TSP levels, from the average of the three stations, are below provincial standards (see figure 5.8). TSP samples were also analyzed for concentrations of metals and radionuclides. The mean concentrations of metals and radionuclides adsorbed to TSP are low and remained below the reference annual air quality levels identified in table 5.3.

Figure 5.8: Rabbit Lake – concentrations of TSP, 2011–15



* Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities is shown. The ambient air quality standards for TSP have been revised under the Saskatchewan *Environmental Management and Protection Regulations* and will be updated when the approval to operate document issued by the Province of Saskatchewan is renewed. Values are calculated as geometric means.

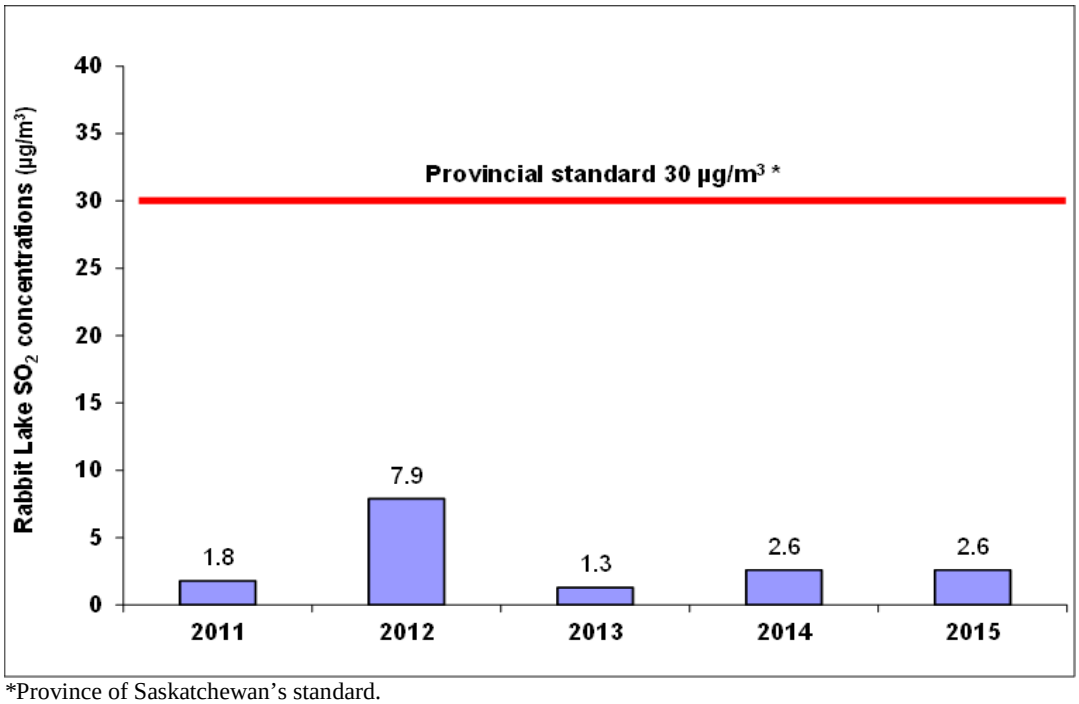
Table 5.3: Rabbit Lake – concentrations of metal and radionuclides in air, 2011–15

Parameter	Reference annual air quality levels*	2011	2012	2013	2014	2015
As (µg/m^3)	0.06 (1)	0.000483	0.000233	0.000175	0.000217	0.000207
Ni (µg/m^3)	0.04 (1)	0.000800	0.000033	0.000007	0.000138	0.000192
Pb^{210} (Bq/m^3)	0.021 (2)	0.000017	0.000012	0.000010	0.000013	0.000015
Ra^{226} (Bq/m^3)	0.013 (2)	0.000002	0.000000	0.000002	0.0000024	0.000001
Th^{230} (Bq/m^3)	0.0085 (2)	0.000003	0.000001	0.000001	0.0000026	0.000001
U (µg/m^3)	0.06 (1)	0.001500	0.000917	0.001033	0.001960	0.002341

1 Reference annual air quality levels derived from *Ontario 24-hour Ambient Air Quality Criteria*.
2 Reference level from ICRP Publication 96.
* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or Province of Saskatchewan limits are currently established.

Daily in-stack monitoring of sulphur dioxide emissions from the mill acid plant showed a 30-percent reduction in terms of the mass released in 2015 from the previous year. A sulphur dioxide sampler located approximately 450 metres southwest of the acid plant monitors releases associated with mill operations. Sulphur dioxide monitoring results (see figure 5.9) show no exceedances of the annual standard of 30 µg/m^3. Ambient sulphur dioxide (SO_2) levels remain at safe concentrations in the nearby environment.

Figure 5.9: Rabbit Lake – concentrations of ambient SO_2, 2011–15



*Province of Saskatchewan's standard.

Soil and terrestrial vegetation may be affected by the atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. A terrestrial monitoring program is in place and includes measurements of metals and radionuclides in soil and on lichen.

Lichen sampling has been conducted for three decades at the Rabbit Lake operation. Most recently, sampling was undertaken in 2013. The next sampling is scheduled for 2019. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers. The lichen sampling sites are located to detect both near-field and far-field influences, with a control station providing information for comparison. CNSC staff concluded that the level of airborne particulate contaminants produced by the Rabbit Lake operation does not pose a risk to lichen consumers, such as caribou.

Environmental risk assessment

The Rabbit Lake environmental performance report 2010 to 2014 was submitted to regulators in 2015. CNSC staff reviewed the submission and concluded the monitoring programs and special studies were adequate, provided required information, and contained sufficient information to complete a review of the environmental performance of the Rabbit Lake operation from 2010 to 2014. This assessment confirms the environment and human health in the vicinity of the Rabbit Lake operation remain protected.

CNSC staff concluded that the environmental protection SCA for the Rabbit Lake operation met performance objectives and all applicable regulatory requirements.

5.4 Conventional health and safety

For 2015, CNSC staff continued to rate the conventional health and safety SCA as satisfactory based on regulatory oversight activities.

Rabbit Lake conventional health and safety ratings

2011	2012	2013	2014	2015
SA	SA	FS	SA	SA

Practices

Cameco's Rabbit Lake operation has implemented a safety and health management program to identify and mitigate risks. The program includes internal inspections, a safety permit system, occupational health committees, training and incident investigations. By way of example, Rabbit Lake operation implemented a continuous method of monitoring miners onsite (see figure 5.10). CNSC staff monitor this program to ensure the protection of workers through compliance activities.

Figure 5.10: Rabbit Lake – electronic tracking of miners' locations in Eagle Point underground mine

The incident reporting system at the Rabbit Lake operation includes reporting and investigating near misses. This originates from a facility-wide recognition that the reporting of incidents offers significant value in reducing future incidents that could cause injury. CNSC compliance verification activities confirmed the Rabbit Lake operation's strong focus on the prevention of accidents and injuries.

Performance

The LTI performance at the Rabbit Lake operation for 2011 to 2015 is shown in table 5.4.

Table 5.4: Rabbit Lake – total number of FTE workers and LTIs, severity rate and frequency rate, 2011–15

Year	2011	2012	2013	2014	2015
Total number of FTE workers[1]	551	719	744	669	610
Number of LTIs[2]	2	1	0	1	2
Severity rate[3]	10.9	22.6	25.8	11.4	55.3
Frequency rate[4]	0.4	0.1	0.0	0.15	0.33

1 **Total number of workers** (employees and contractors) expressed as FTEs.
FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time injury** - an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.

4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/ # of hours worked in last 12 months)] x 200,000.

Appendix H contains a brief description of the two LTIs that occurred in 2015 and corrective actions taken by the licensee. CNSC staff assessed and were satisfied with the follow-up actions taken by the Rabbit Lake operation.

In 2016, an event initial report was provided to the Commission from Cameco's Rabbit Lake operation. As part of care and maintenance preparations, a contract scaffolder was preparing scaffolding for relocation within an open tank. The scaffolder was accompanied by two other personnel: a spotter and an assistant scaffolder. The scaffolder had begun disassembling the scaffolding by removing the upper supports when the scaffolding shifted and began sliding down the slopped tank floor. While descending from the moving scaffolding, the worker's head hit the steel floor after the worker fell approximately two feet. The worker sustained a head injury and bruised leg as a result of the event. The Rabbit Lake Emergency Response Team was dispatched and the worker extricated. The worker was treated by the site nurse and transferred to a Saskatoon hospital for further assessment and treatment. The CNSC confirmed that proper reporting of the event occurred. A thorough investigation and follow-up corrective actions were undertaken by Cameco.

Awareness

CNSC staff observed that the Rabbit Lake operation's conventional health and safety programs continued to provide education, training, tools and support to workers. Safety is the responsibility of all individuals. This notion is promoted by managers, supervisors and workers. Site management emphasizes the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems.

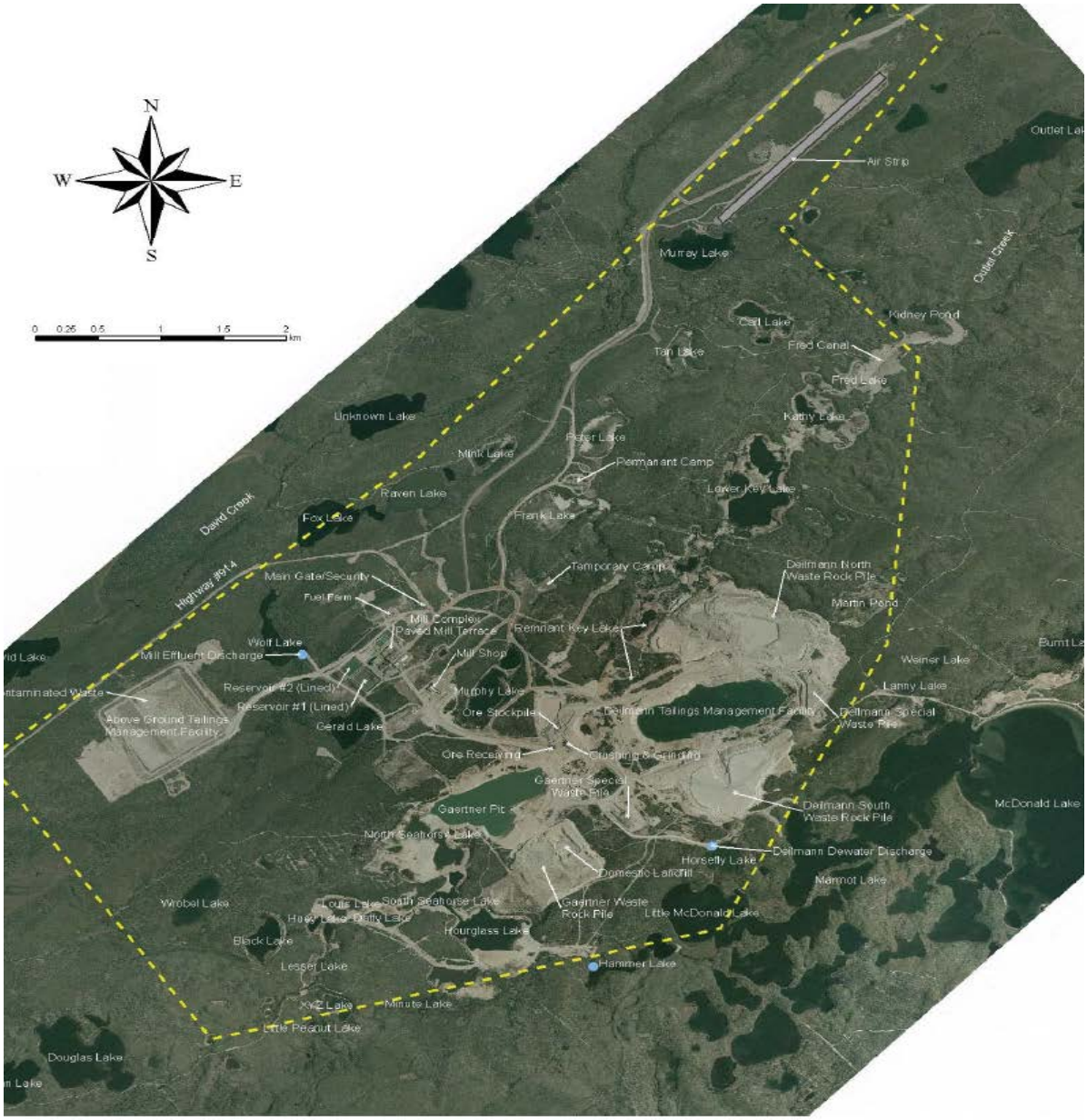
CNSC staff verified that the conventional health and safety program at the Rabbit Lake operation continued to be effective in managing health and safety risks.

6 KEY LAKE OPERATION

Located approximately 570 kilometres north of Saskatoon, Saskatchewan, the Key Lake operation is owned and operated by Cameco Corporation (see figure 6.1). The Key Lake operation began with two open-pit mines and a mill complex. The Gaertner open pit was mined from 1983 to 1987, followed by mining of the Deilmann open pit until 1997.

In October 2013, the Commission issued a 10-year licence following a public hearing in La Ronge, Saskatchewan. The Key Lake operation licence expires on October 31, 2023.

Figure 6.1: Key Lake – site overview



Milling of the Deilmann ore continued until 1999, when the McArthur River operation began supplying ore slurry to the Key Lake mill (see figure 6.2). The Key Lake operation continues today as a mill operation processing McArthur River ore slurry.

Figure 6.2: Ore slurry being transported from McArthur River to the Key Lake mill

After open-pit mining in the eastern pit of the Deilmann orebody was completed in 1995, the pit was converted into the engineered Deilmann tailings management facility. Mill tailings continue to be deposited into this facility today.

Table 6.1 provides the Key Lake milling production data from 2011 to 2015.

Table 6.1: Key Lake milling production data, 2011–15

Milling	2011	2012	2013	2014	2015
Mill ore feed (tonnes/year)	189,821	193,511	184,099	173,007	165,556
Average annual mill feed grade (% U_3O_8)	4.85	4.61	5.03	5.03	5.26
Percentage of uranium recovery	98.7	98.9	99.3	99.4	99.35
Uranium concentrate produced (Mkg U/year)	7.69	7.52	7.75	7.37	7.35
Authorized annual production (Mkg U/year)	7.85	7.85	7.85	9.60	9.60

A new calciner was installed and commissioning carried out in 2015. During commissioning, it was observed that heat generated from the new process was excessive and likely to cause operational issues on component wear and ventilation balance with the scrubber unit. These preliminary observations were made and discussed with CNSC staff during an inspection in March 2016.

In May 2016, CNSC staff were verbally informed that the commissioning process was stopped, and advised that the existing calciner would be operated until further notice. A letter was provided by Cameco on August 2, 2016 as an update on the calciner units confirming that the new horizontal calciner commissioning process has now been halted because of corrosion developing on the internal rotary shell. Cameco outlined the four options that are being investigated for remediation of the calciner unit. Cameco informed the CNSC that the new calciner would not be available for the foreseeable future and the old calciner would be used in the interim.

6.1 Performance

The Key Lake operation SCA ratings for the five-year period of 2011 to 2015 for the 14 SCAs are shown in appendix D. CNSC staff continue to rate all SCAs for 2015 as satisfactory based on regulatory oversight activities. This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs which cover many of the key performance indicators for these facilities.

6.2 Radiation protection

During the reporting period, CNSC staff rated the radiation protection SCA as satisfactory based on regulatory oversight activities.

Key Lake radiation protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Radiological hazard control

The NEWs' average individual effective dose at the Key Lake mill was primarily from gamma radiation (40.4 percent), LLRD (32.5 percent) and radon progeny (27.1 percent). Gamma radiation is controlled through the effective use of time, distance and shielding, LLRD through ventilation and contamination control, and radon progeny through ventilation.

Radiation protection program performance

As discussed in section 2.6, there were two calciner mechanical failure incidents that resulted in LLRD individual dose action level exceedances. The details of these events and the corrective actions taken by the licensee are described in appendix I. CNSC staff conducted follow-up compliance verification inspections at the Key Lake operation and assessed the corrective actions as acceptable.

A third action-level event was the result of a worker failing to properly follow the instructions of a radiation work permit before removing personal protective equipment. A brief description of the action level exceedances and corrective actions implemented are provided in appendix I.

Overall, CNSC staff concluded that an effective radiation protection program and practices exists at the Key Lake operation.

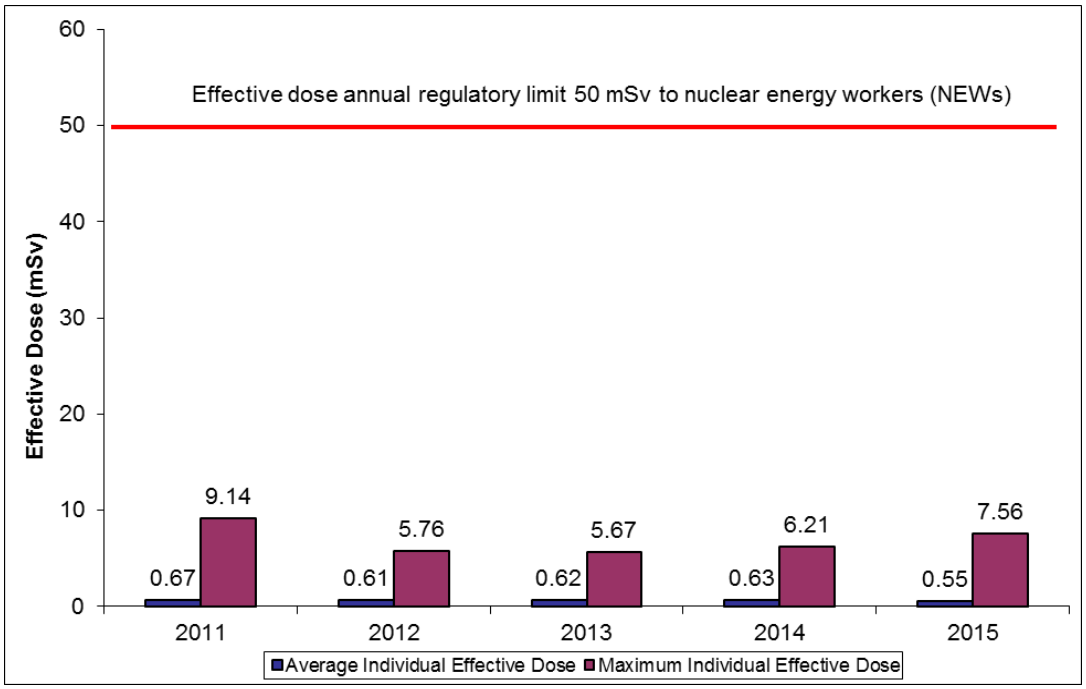
Application of ALARA

Key Lake continued to maintain the ALARA objectives from 2014. This included enhanced quarterly monitoring and review of employees and contractors that receive the highest exposures. In 2015, a new initiative was introduced to focus on reducing radon progeny levels in the lime handling area. It is anticipated that changes to an exhaust fan preventive maintenance schedule will result in improvements. A follow-up review of radon progeny levels in this area is scheduled for 2016.

Worker dose control

As seen in figure 6.3, the effective doses to workers remained well below the annual regulatory limit of 50 mSv. In 2015, the average individual effective dose to NEWs was 0.55 mSv, while the maximum individual effective dose received was 7.56 mSv. The maximum individual effective dose at the Key Lake operation over the last few years, including 2015, has been a result of LLRD exposures from maintenance in the calciner operations.

Figure 6.3: Key Lake, individual effective dose to NEWs, 2011–15



* The effective dose annual limit illustrated applies to the maximum individual effective dose.

CNSC staff concluded that the effective implementation of the radiation protection program maintained worker doses ALARA.

6.3 Environmental protection

For 2015, CNSC staff continued to rate the environmental protection SCA as satisfactory based on regulatory oversight activities. The licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Key Lake environmental protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Environmental management system

The Key Lake operation's environmental management system includes activities such as establishing annual environmental objectives, goals and targets. The Key Lake operation conducts internal audits of its program at least once every year. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Assessment and monitoring

In accordance with the Key Lake operation's environmental protection program, effluent and environmental monitoring, site inspections, environmental awareness training and program implementation audits were performed.

CNSC staff concluded that the Key Lake operation's environmental management system and monitoring programs met regulatory requirements, and all treated effluent discharged to the environment complied with licence requirements.

Protection of the public

In 2015, there was one reportable release of hazardous material to the environment (spill) at the Key Lake operation:

- On January 9, a sample valve on a raise water well head froze and cracked resulting in approximately 1.0 m^3 (1,000 L) of well water being released onto and across the adjacent road towards the Deilmann tailings management facility.

The spill was immediately cleaned up and there was no residual impact to the environment. The corrective actions taken by the Key Lake operation were assessed and found acceptable by CNSC staff. CNSC rated the 2015 spill as low significance. A brief description of the spill and corrective actions implemented are provided in appendix G.

Figure 2.4 shows the number of releases of hazardous material to the environment from the licensed activities at the Key Lake operation from 2011 to 2015.

Effluent and emissions control

Treated effluent released to the environment

At the Key Lake operation, two effluent streams are processed in separate treatment facilities before being released to the environment:

- The mill effluent is processed with a treatment system of chemical precipitation and liquid/solid separation, and released to Wolf Lake in the David Creek system.
- Effluent from dewatering wells of the Gaertner pit and Deilmann pit hydraulic containment systems is treated with a reverse osmosis system before being released to Horsefly Lake in the McDonald Lake system.

The McDonald Lake system receives effluent from the reverse osmosis plant. Monitoring confirms that this effluent poses no environmental concern. The treated effluent quality further discussed in this report refers only to the mill effluent as released to the David Creek system.

Figure 6.4: Key Lake – Deilmann tailings management facility

In 2015, the licensed parameter concentration values in the treated mill effluent were well below the regulatory limits. There were also no exceedances of environmental action levels at the Key Lake operation.

As discussed in section 2.4, constituents of potential concern (COPC) in treated effluent at the uranium mine and mill facilities are molybdenum, selenium and uranium. Molybdenum and selenium concentrations were the primary concerns at the Key Lake facility. The licensee has therefore targeted process changes to reduce concentrations in treated effluent.

Significant reductions of molybdenum and selenium occurred from 2008 to 2009 when additional treatment components were installed and optimized. Figures 2.5 and 2.6 show stable reduced concentrations of molybdenum and selenium in treated effluent have occurred from 2011 to 2015. Figure 2.7 indicates that uranium concentrations in treated effluent released from the Key Lake mill remain low and are effectively controlled.

In addition to the COPC, the Key Lake operation also analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH. As discussed in section 2.4, the Key Lake operation continued to meet the MMER discharge limits.

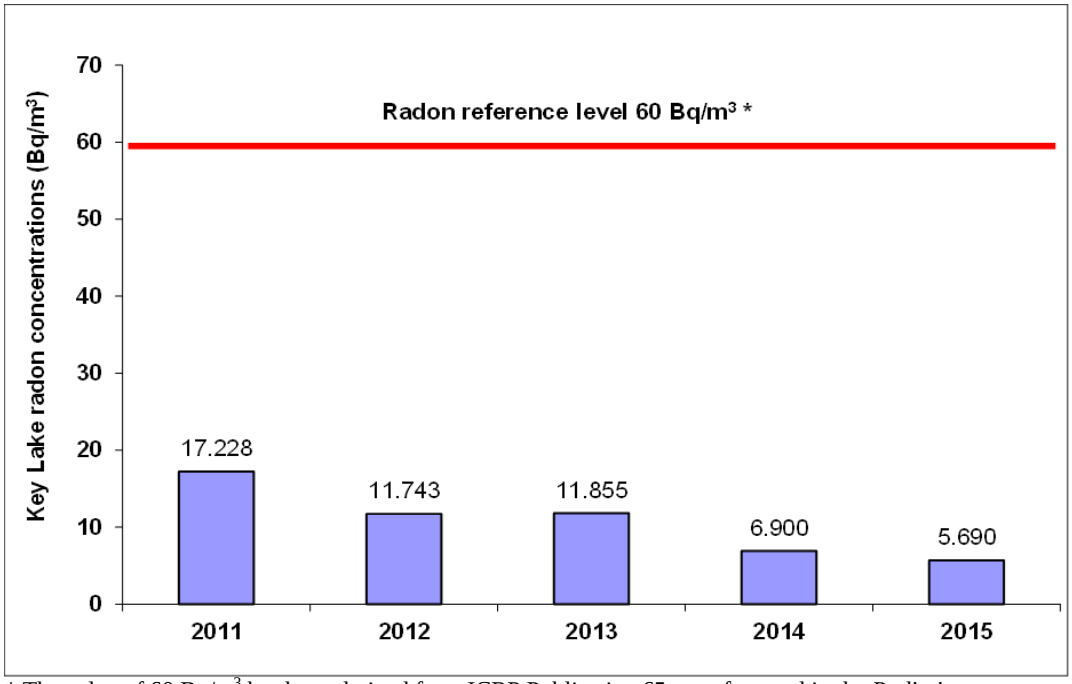
The CNSC will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

Air emissions released to the environment

The atmospheric monitoring program at the Key Lake operation includes ambient monitoring for sulphur dioxide, radon, TSP, soil sampling and lichen sampling to assess air quality. Air emissions from the mill stacks are also included in the air-quality monitoring program.

Five boundary monitoring locations and one boundary reference station are used for the monitoring of ambient radon using passive track-etched cups. Figure 6.5 shows the average concentrations of radon in ambient air for 2011 to 2015 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

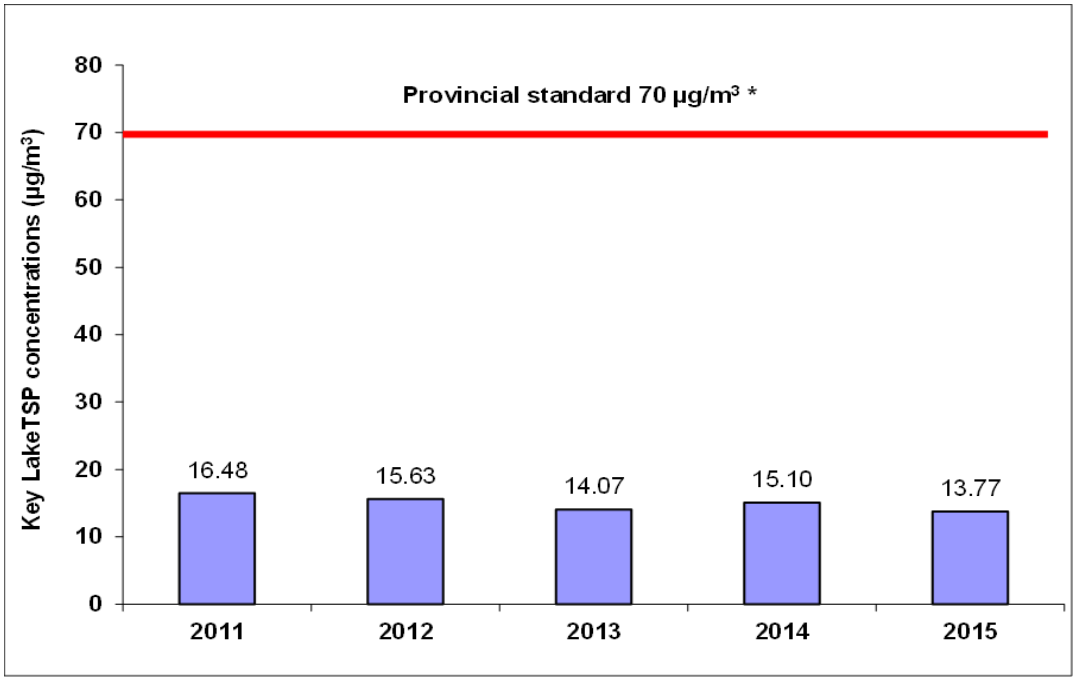
Figure 6.5: Key Lake – concentrations of radon in ambient air, 2011–15



* The value of 60 Bq/m^3 has been derived from ICRP Publication 65, as referenced in the *Radiation Protection Regulations*. The reference level represents an incremental increase above natural dwelling radon levels that could result in a member of the public being exposed to an incremental dose of 1 mSv. Values are calculated as geometric means.

Five HVAS were used to collect and measure TSP. The HVAS units are located downwind of the milling facility, downwind of the crusher, east and west of the above ground tailings management facility, and in the vicinity of the main camp residence. The TSP levels are below the Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities (see figure 6.6). TSP samples are also analyzed for concentrations of metals and radionuclides.
The mean concentrations of metal and radionuclides adsorbed to TSP are low, and below the reference annual air quality levels identified in table 6.2.

Figure 6.6: Key Lake – concentrations of TSP, 2011–15



* The Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities is shown. The ambient air quality standards for TSP have been revised under the *Saskatchewan Environmental Management and Protection Regulations* and will be updated when the approval to operate document issued by the Province of Saskatchewan is renewed. Values are calculated as geometric means.

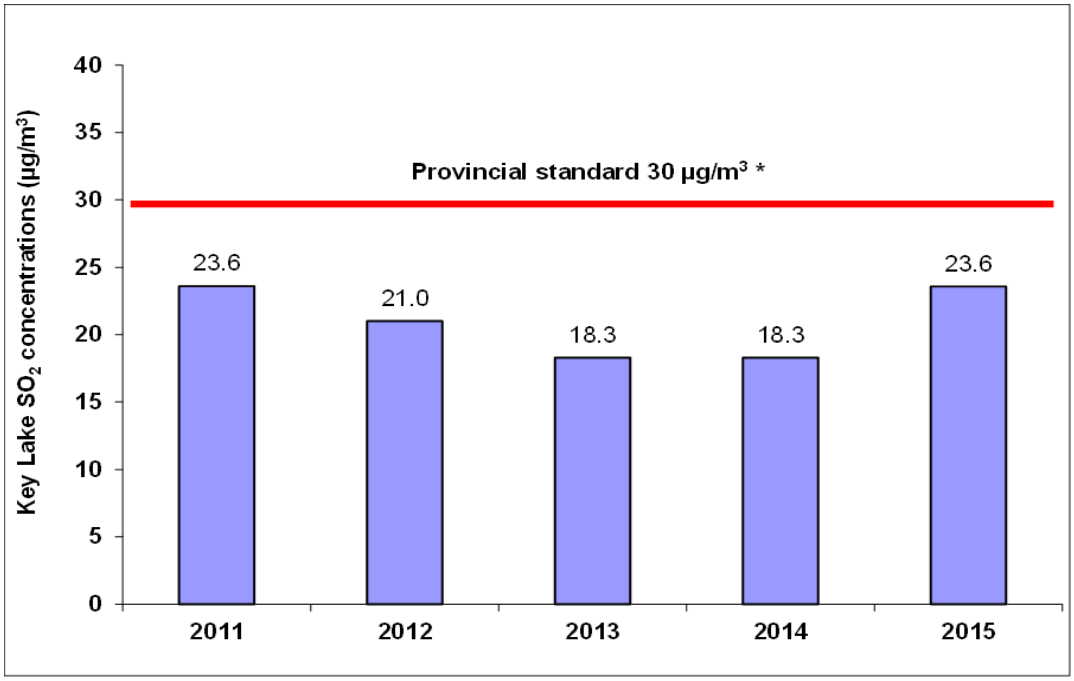
Table 6.2: Key Lake – concentrations of metal and radionuclides in air, 2011–15

Parameter	Reference annual air quality levels*	2011	2012	2013	2014	2015
As (µg/m^3)	0.06 (1)	0.00222	0.00266	0.00166	0.00444	0.0016
Ni (µg/m^3)	0.04 (1)	0.00186	0.00222	0.00118	0.00340	0.0013
Pb^{210} (Bq/m^3)	0.021 (2)	0.00038	0.00034	0.00032	0.00044	0.0003
Ra^{226} (Bq/m^3)	0.013 (2)	0.00010	0.00010	0.00010	0.00022	0.0001
Th^{230} (Bq/m^3)	0.0085 (2)	0.00014	0.00028	0.00010	0.00022	0.0001
U (µg/m^3)	0.06 (1)	0.01286	0.0074	0.00646	0.00794	0.0080

1 Reference annual air quality levels derived from *Ontario 24-hour Ambient Air Quality Criteria* (OMOE 2012).
2 Reference level from ICRP Publication 96.
* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or Province of Saskatchewan limits are currently established.

A sulphur dioxide monitor is used to continuously measure the ambient sulphur dioxide associated with mill emissions. It is located approximately 300 metres downwind of the mill facility. The measured SO_2 monitoring data (see figure 6.7) shows no exceedances of the annual standard of 30 µg/m^3.

Figure 6.7: Key Lake – concentrations of ambient SO_2, 2011–15



* Province of Saskatchewan standard.

In addition to ambient air monitoring for sulphur dioxide, sulfate levels have been monitored in four lakes selected to measure the effects of sulphur dioxide emissions from the operation. The results of the 2015 lake sampling program continued to show that sulfate concentrations remain relatively unchanged compared to historical data. The operations at Key Lake, and resulting sulphur dioxide emissions, do not have an adverse effect on the sulphate levels in nearby lakes.

Soil and terrestrial vegetation may be affected by atmospheric deposition of particulate, adsorbed metals and radionuclides associated with onsite activities. The terrestrial monitoring program in place includes measurements of metals and radionuclides in soil and in lichen.

Lichen samples were collected in 2013. The next sampling is scheduled for 2016, as required by the triennial sampling program. A total of five sites were sampled in 2013, chosen to detect both near-field and far-field influences, including a control station. Lichen samples were analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers. The concentrations of metals and radionuclides in lichen samples collected from exposure stations were similar to reference stations and historical data. CNSC staff assessed and concluded that the level of airborne particulate contaminants produced by the Key Lake operation is acceptable and does not pose a risk to lichen consumers, such as caribou.

Soil samples were taken in the immediate vicinity of the mine. The soil metal parameter concentrations were below the Canadian Environmental Quality Guidelines for industrial and residential/parkland land use. Radionuclide concentrations in soils were low, and near or at background levels and analytical detection limits. CNSC staff concluded that the level of airborne particulate contaminants produced by the Key Lake operation, based on soil sampling results, are acceptable and do not pose a risk to the environment.

The Key Lake calciner stack is monitored annually. The most recent stack test was completed in October 2015. Overall, the stack emissions show better results than past performance and verify that operational controls are working as designed.

Sulphur dioxide concentrations from the acid plant stack are monitored daily. In 2012, a new acid plant was commissioned, resulting in a reduction in sulphur dioxide emissions of more than 90 percent. The new acid plant is operating as designed with stack emissions continuing to provide improved performance.

Environmental risk assessment

In 2015, the Key Lake environmental performance report for the 2010 to 2014 period was submitted to regulators. The CNSC reviewed the report and agreed with its conclusions. The monitoring programs and special studies were sufficiently comprehensive and provided the required information. The models used to predict environmental performance continued to be valid. Therefore, CNSC staff confirm the environment and human health in the vicinity of the Key Lake operation remain protected.

CNSC staff concluded that the environmental protection SCA at the Key Lake operation met performance objectives and all applicable regulatory requirements.

6.4 Conventional health and safety

For 2015, CNSC staff continued to rate the conventional health and safety SCA as satisfactory based on regulatory oversight activities.

Key Lake conventional health and safety ratings

2011	2012	2013	2014	2015
SA	SA	FS	SA	SA

Practices

Throughout 2015, CNSC staff monitored the implementation of the Key Lake operation's operational health and safety program and concluded that this program continues to be effective.

The Key Lake operation's incident reporting system records health and safety-related events and uses several layers of review in investigations. Corrective measures are tracked and assessed for effectiveness prior to closure. The Key Lake operation continued its planned health and safety inspection program in 2015. Any items of concern found during these inspections are included in the licensee's incident reporting system.

Performance

There were four LTIs from 2011 to 2015 at the Key Lake operation (see table 6.3). In 2015, there were no LTIs.

Table 6.3: Key Lake total number of FTE workers and LTIs, severity rate and frequency rate, 2011–15

Year	2011	2012	2013	2014	2015
Total number of FTE workers[1]	886	736	679	499	505
Number of LTIs[2]	3	1	0	0	0
Severity rate[3]	13.1	21.6	8.5	0	0
Frequency rate[4]	0.3	0.1	0.0	0	0

1 **Total number of workers** (employees and contractors) expressed as FTEs.
FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time injury** - an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.

4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/ # of hours worked in last 12 months)] x 200,000.

Awareness

CNSC staff observed that the Key Lake operation's conventional health and safety programs continued to provide education, training, tools and support to workers. Safety is the responsibility of all individuals. This notion is promoted by managers, supervisors and workers. Site management stresses the importance of conventional health and safety through regular communication, management oversight, and continual improvement of safety systems. CNSC staff verified that the Key Lake operation is committed to accident prevention, safety awareness and an increased focus on safety culture.

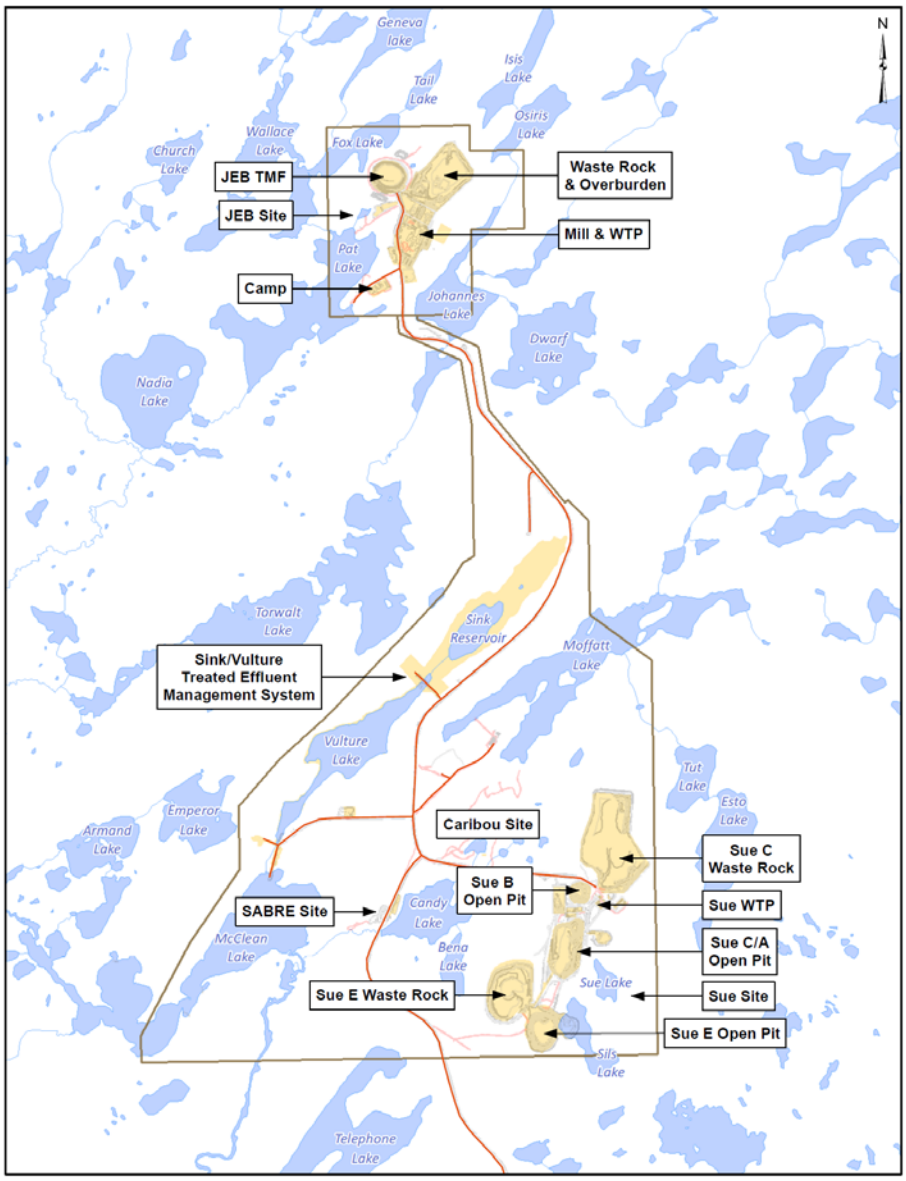
7 MCCLEAN LAKE OPERATION

The McClean Lake operation is located about 750 kilometres northeast of Saskatoon, Saskatchewan and is operated by AREVA Resources Canada Inc. (AREVA). An aerial view of the McClean Lake Operation is shown in figure 7.1 and the site layout is shown in figure 7.2

Construction of the McClean Lake operation began in 1994. A licence was issued in July 2009 for an eight-year term and was amended on December 19, 2012. The licence expires on June 30, 2017.

Figure 7.1: Aerial view of McClean Lake

Figure 7.2: McClean Lake site layout



The mining and milling of uranium ore from five open-pit mines was completed in 2008. Since then, conventional mining of ore for the purpose of production and sale has not been carried out at the McClean Lake operation. No ore was mined in 2015 through the Surface Access Borehole Resource Extraction (SABRE) project. The CNSC was informed during the first quarter of 2014 that the SABRE project had been placed into care and maintenance.

Mill tailings resulting from the processing of ore were deposited within the McClean Lake operation tailings management facility (TMF), which is constructed in the mined-out JEB open pit. The JEB water treatment plant and the TMF operated throughout 2015.

Restart of production at the McClean Lake mill began in September 2014 and ramp-up continued throughout 2015. Due to restart and commissioning of some new and modified circuits, the McClean Lake operation was requested to submit a commissioning report on operational performance and safety analysis with respect to health and safety of workers, radiation protection and environmental protection at higher production rates and ore grades. AREVA submitted its report in December 2015. The document summarizes the results of commissioning of new and modified circuits and the restart of existing circuits from September 2014 until September 2015. The ore feed grades were gradually increased from initial grades of approximately 2.5 percent uranium to up to 25 percent uranium. The McClean Lake operation has demonstrated that the processing circuits have operated at production rates equivalent to, or exceeding, 8.2 million kilograms uranium concentrate while meeting objectives of the licensing basis including protection of the environment and the safety of workers.

Tables 7.1 and 7.2 display the production data for mining and milling from 2011 to 2015.

Table 7.1: McClean Lake mining production data, 2011-–15

Mining*	2011	2012	2013	2014	2015
Ore tonnage (tonnes/year)	No mining	1,022	No mining	No mining	No mining
Average ore grade mined (% U_3O_8)	No mining	4.76	No mining	No mining	No mining
U mined (Mkg U/year)	No mining	0.04	No mining	No mining	No mining

* The last ore from the Sue E pit was mined on March 15, 2008, and Sue B pit's last ore was mined on November 26, 2008. Mine production since then is from the SABRE project.

Table 7.2: McClean Lake milling production data, 2011–15

Milling	2011	2012	2013	2014	2015
Mill ore feed (tonnes/year)	No milling*	No milling*	No milling*	7,832	25,517
Average annual mill feed grade (% U_3O_8)	No milling*	No milling*	No milling*	3	17.56
Percentage of uranium recovery (%)	No milling*	No milling*	No milling*	97.54	98.99
Uranium concentrate produced (Mkg U)	No milling*	No milling*	No milling*	0.200	4.3
Authorized annual production (Mkg U/year)	3.08	5.00	5.00	5.00	5.00

* The McClean Lake operation mill temporarily stopped producing uranium concentrate in July 2010.

During 2015, the main ore source for the mill was Cigar Lake ore slurry with some stockpiled Sue B low-grade ore feed. The McClean Lake mill upgrade project, which is scheduled to be completed in 2016, continued to progress throughout 2015.

Four projects at the McClean Lake operation began in 2015 and are ongoing.

1) Mill upgrade project

The McClean Lake mill upgrade project includes modifications, alterations and additions to some of the uranium production circuits, mill utilities and supporting facilities. The upgrade is expected to be completed in late 2016. The modifications will enable the mill to acquire approval to produce 24 million pounds of uranium concentrate per year. Production ramp-up was coordinated with the Cigar Lake mine plan and ore slurry delivery schedule.

2) Slurry receiving ventilation

The McClean Lake mill is uniquely designed and constructed to process undiluted high-grade ore. Radiation protection features and engineered controls have been incorporated. During the commissioning of the slurry receiving circuit, ventilation systems were put into service and high-grade ore introduced to the process.

A review of current monitoring and prevention practices as well as ventilation design was undertaken to identify opportunities for improvement in maintaining doses ALARA. Several items implemented in 2015, such as ventilation changes to slurry storage vaults and the truck bay, have been effective.

3) Cigar Lake tailings production

Preliminary results indicate that selenium concentrations in Cigar Lake ore are greater than the selenium concentrations in the ore previously processed at the mill. During initial commissioning and subsequent milling of Cigar Lake ore, an increasing trend has been identified for selenium, though effluent concentrations remain within historical ranges and below administrative levels described in the licensee's environment code of practice (ECOP). The McClean Lake operation has implemented process improvements in the various mill circuits. These changes have improved control of selenium oxidation and speciation. Additional options are being investigated by the McClean Lake operation to further continual improvement in selenium treatment options. As required, AREVA submitted a selenium management plan, which CNSC staff have reviewed. As an outcome of the review, the McClean Lake operation will establish a single interim administrative level and action level in the ECOP. This interim administrative and action level will be reviewed annually to determine whether it remains adequate, or whether it should be revised to reflect actual performance while taking into consideration predicted performance for the following year.

4) Sulfur dioxide mitigation project

During mill restart and commissioning, the McClean Lake operation encountered a safety issue not identified prior to restart, which was the impact of sulphates in the mill circuits and subsequent release of sulphur dioxide gas. Upon recognition of this challenge, process improvements have been undertaken and emissions of sulphur dioxide from the calciner stack have been brought under control through adjustments to operational parameters. Control of sulphur dioxide has been achieved through maintaining key process variables. The McClean Lake operation is evaluating further defence-in-depth strategies for potential system design improvements. As required, a sulphur dioxide mitigation plan was recently submitted by the McClean Lake operation to the CNSC. The plan is currently under staff review.

In November 2014, CNSC staff received a revised preliminary decommissioning plan and financial assurance for the McClean Lake operation following a five-year cycle requirement. The preliminary decommissioning plan has been updated to include decommissioning of the expanded McClean Lake mill, current labour and equipment rates, and future water treatment requirements. AREVA has proposed an increase of $64.146 million in the financial guarantee, from $43.095 million to $107.241 million, to reflect inflated costs for decommissioning. CNSC staff reviewed the preliminary decommission plan and sent comments to AREVA. Currently, CNSC staff comments are being addressed by AREVA.

7.1 Performance

Ratings for all 14 SCAs for the five-year period, 2011 to 2015, are shown in appendix D. For 2015, CNSC staff continue to rate all SCAs as satisfactory based on regulatory oversight activities. This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs that cover many of the key performance indicators for these facilities.

7.2 Radiation protection

For this reporting period, CNSC staff continued to rate the radiation protection SCA as satisfactory at the McClean Lake operation based on regulatory oversight activities.

McClean Lake radiation protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Radiological hazard control

The effective dose contributors to workers at the McClean Lake facility were gamma radiation (49.1 percent), radon progeny (29.6 percent) and LLRD (21.3 percent). Gamma radiation exposure is controlled through the application of time, distance and shielding. The effective dose to NEWs from exposures to radon progeny and LLRD are controlled through the effective use of ventilation.

Radiation protection program performance

The action levels for effective dose are 1 mSv per week and 5 mSv per quarter of a year. There were two exceedances of the weekly action level, and no exceedances of the quarterly action level during 2015.

- The first event took place in May 2015 and was attributed to work in the calciner enclosure. After applying the respirator protection factor for the use of a powered air purifying respirator, an employee received a LLRD dose of 1.6 mSv.
- The second event took place in June 2015 and was attributed to work in the slurry receiving circuit. The employee's personal alpha dosimeter recorded a radon progeny exposure of 0.89 mSv and an LLRD exposure of 1.93 mSv.

These action level events are summarized in appendix I. CNSC staff are satisfied with the actions taken by the McClean Lake operation to address these action level exceedances.

Overall, the radiation protection program and practices continued to effectively maintain worker doses ALARA.

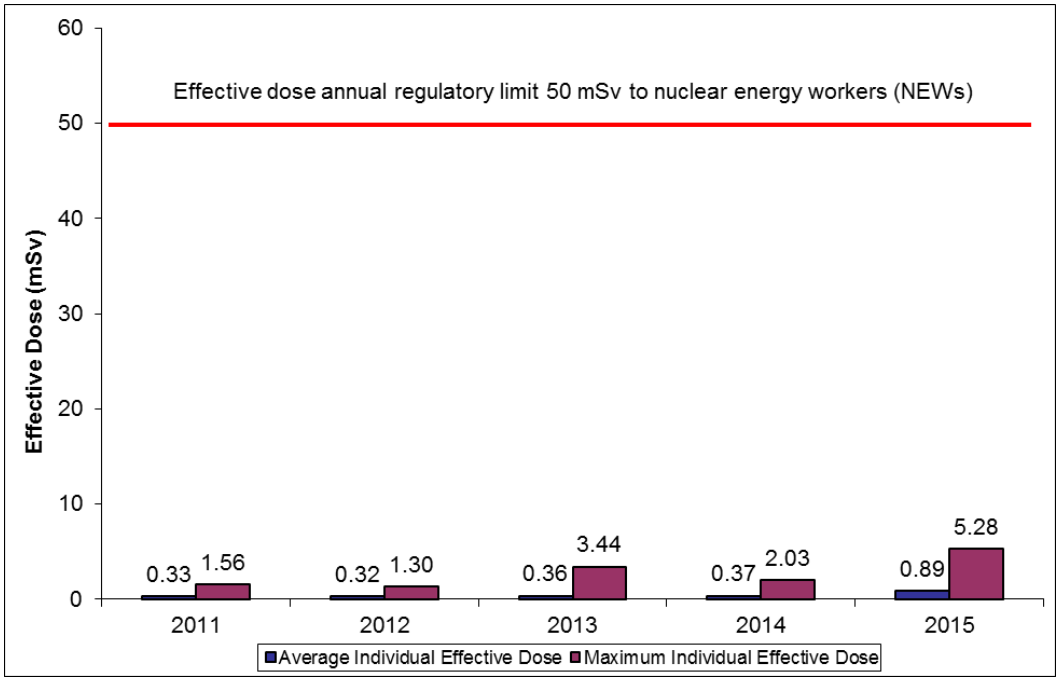
Application of ALARA

CNSC staff have verified through regulatory oversight activities that the McClean Lake operation continues to maintain worker exposures ALARA. Radiation protection initiatives and projects to optimize worker exposures (e.g., application of shielding and ventilation improvements) continued in 2015. During production increases, the McClean Lake facility continued to monitor radiological hazard levels in accordance with a radiation performance confirmation plan. Data collection for increasing ore grades (constituting several hundred samples at each step of ore grade) continued throughout 2015.

Worker dose control

Figure 7.3 displays the average individual effective dose and the maximum individual effective dose for 2011 to 2015. The cessation of mining in 2008 and the temporary shutdown of milling operations in 2010 resulted in lower average and maximum individual effective doses. The average individual effective dose for NEWs in 2015 was 0.89 mSv, while the maximum individual effective dose received was 5.28 mSv. Annual effective doses to all NEWs at the McClean Lake operation from 2011 to 2015 remained well below the annual regulatory dose limit of 50 mSv.

Figure 7.3: McClean Lake individual effective doses to NEWs, 2011–15



* The effective dose annual limit illustrated applies to the maximum individual effective dose.

CNSC staff concluded the effective implementation of the radiation protection program maintained worker doses ALARA.

7.3 Environmental protection

For 2015, CNSC staff continued to rate the environmental protection SCA as satisfactory based on regulatory oversight activities. The licensee's environmental protection program was effectively implemented and met all regulatory requirements.

McClean Lake environmental protection ratings

2011	2012	2013	2014	2015
SA	SA	SA	SA	SA

Environmental management system

McClean Lake's environmental management system is described in its approved internal quality management system and includes activities such as establishing annual environmental objectives, goals and targets. The McClean Lake operation conducts internal audits of its program at least once every year. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities.

Assessment and monitoring

In accordance with the McClean Lake operation's environmental protection program, CNSC staff noted that AREVA has continued with routine site inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to ensure continual improvement and to confirm that the controls put into place to protect the environment are effective. CNSC staff assessed the environmental protection program and concluded that it met regulatory requirements during 2015.

CNSC staff verified that the McClean Lake operation's environmental management systems and monitoring programs met regulatory requirements during 2015 and treated effluent discharged to the environment complied with licence requirements.

Protection of the public

In 2015, six events were classified as releases of hazardous material to the environment (spills):

- 1,000 kg of isodecanol
- 1.3 m^3 (1,249 L) of isodecanol
- 5 kg of radiologically contaminated foam
- 0.5 kg of non-calcined yellowcake
- 0.003 m^3 (3 L) of ammonia liquid
- 0.050 m^3 (50 L) of slurry rinse water

Appendix G further describes the spills and corrective actions taken. Due to the timely responses and effective actions applied by the McClean Lake operation, there were no residual impacts to the environment by the spills. CNSC staff were satisfied with the reporting of releases of hazardous materials to the environment and the corrective actions taken. CNSC staff rated all the 2015 spills as being of low significance.

Figure 2.4 displays the number of environmental reportable spills that occurred at the McClean Lake operation from 2011 to 2015.

Effluent and emissions control

Treated effluent released to the environment

At the McClean Lake operation, two effluent streams are processed in separate treatment facilities before being released to the environment:

- The mill effluent is processed at the JEB water treatment plant with a treatment system of chemical precipitation and liquid/solid separation. Treated water is released to the Sink/Vulture Treated Effluent Management System.
- Effluent from the mined-out open pits to maintain hydraulic containment of groundwater is treated in the Sue water treatment plant using a chemical precipitation and settling pond clarification process before being released to the Sink/Vulture Treated Effluent Management System.

The blended treated effluent is released in a controlled manner and monitoring has verified that this effluent poses no environmental concern. The McClean Lake operation's treated effluent quality further discussed in this report refers only to the JEB mill effluent. All treated mill effluent discharged to the environment was well below regulatory limits.

Contaminated wastewater from the McClean Lake JEB mill is treated in the JEB water treatment plant to remove dissolved metals and suspended solids. The quality of the final treated effluent is monitored, and if acceptable, discharged to the environment through the Sink/Vulture Treated Effluent Management System. There were no treated effluent regulatory limit discharge exceedances during the 2015 reporting period.

The McClean Lake operation temporarily ceased milling operations in July 2010 with a restart in September 2014. Effluent treatment of the JEB TMF pond water continued while the mill was not in operation. The concentrations of molybdenum, selenium and uranium in treated effluent remained low while not in operation. The concentrations increased with the restart and commissioning of operations, as expected. Since the operation was optimized, concentrations have dropped for all dissolved metals other than selenium (see figures 2.5 to 2.7).

During initial commissioning and subsequent milling of Cigar Lake ore, it has been observed that selenium in the raffinate stream that feeds the tailings preparation circuit has been elevated above concentrations previously observed during JEB and Sue milling activities. This has resulted in higher selenium concentrations in the tailings thickener overflow solution. As the uranium grade processed through the mill increases, the amount of selenium loading to the tailings preparation circuit, JEB TMF reclaim pond and JEB water treatment plant has increased. Effluent concentrations remain within historical ranges and below administrative levels described in the environmental code of practice.

The McClean Lake operation has implemented process improvements in various mill circuits. These changes have resulted in improved control of selenium oxidation and speciation. Additionally, a series of activities has been initiated to control selenium releases: investigating treatment technologies, conducting field studies and evaluating selenium risks. CNSC staff acknowledge the McClean Lake operation's proactive approach to implementing a selenium management strategy that incorporates short-term continuous improvement initiatives and a long-term adaptive management approach to commission an advanced selenium treatment technology. As a result of CNSC staff's review, AREVA's McClean Lake operation submitted a selenium management plan. Based on CNSC staff review and comments, AREVA has established a single interim administrative level and action level in the ECOP. This interim administrative and action level will be reviewed annually to determine whether it remains adequate, or whether it should be revised to reflect actual performance while taking into consideration predicted performance for the following year. The reduced concentrations of uranium in treated effluent from 2011 to 2015 are well below the CNSC's interim objective of 0.1 mg/L (shown in figure 2.7).

In addition to the COPC, the McClean Lake operation also analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids and pH. As shown in section 2.4, the McClean Lake operation continues to meet the MMER discharge limits.

CNSC staff will continue to review effluent quality results to ensure that effluent treatment performance remains effective.

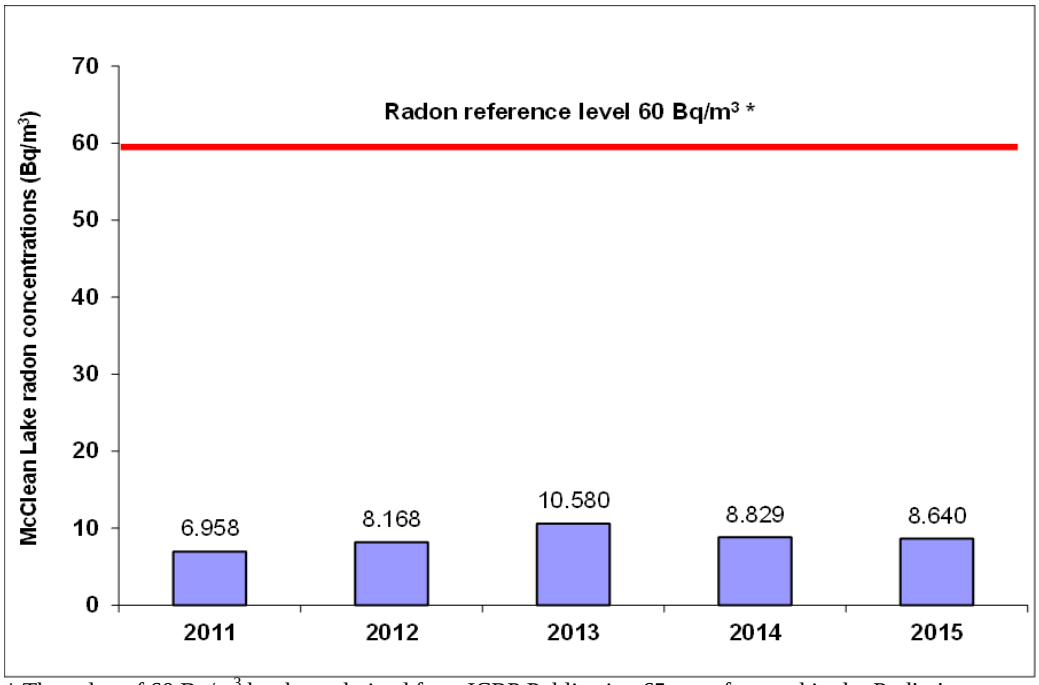
Air emissions released to the environment

Air quality at the McClean Lake operation is monitored through direct measurement of emissions from the mill, ambient air quality near the operation, and indirectly through measurements of metal accumulations in the terrestrial environment.

Air quality monitoring at the McClean Lake operation includes programs for ambient radon, TSP, sulphur dioxide and exhaust stack monitoring. Ambient sulphur dioxide and exhaust stack monitoring restarted in September 2014 with the mill restart and commissioning activities.

Environmental monitoring for radon concentrations is conducted using the passive method of track-etched cups. There are 23 monitoring stations in various locations around the site-lease boundary. Figure 7.4 shows the average concentrations of radon in ambient air for 2011 to 2015 were below the reference level for radon. The radon concentrations were also typical of the northern Saskatchewan regional baseline of < 7.4 Bq/m^3 to 25 Bq/m^3.

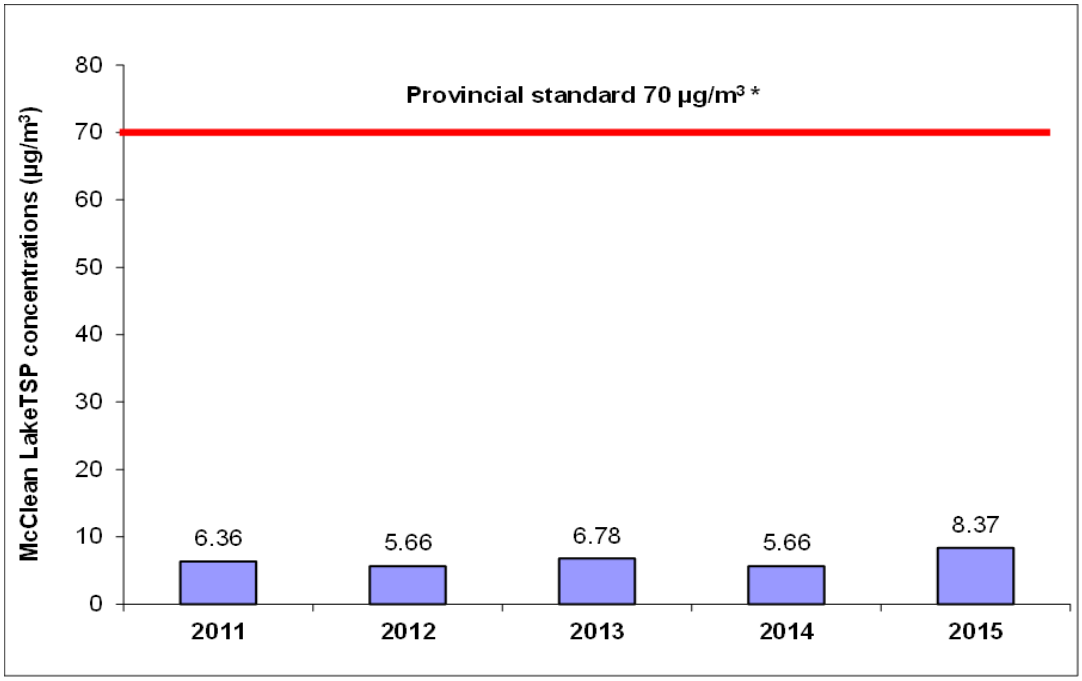
Figure 7.4: McClean Lake concentrations of radon in ambient air, 2011–15



* The value of 60 Bq/m^3 has been derived from ICRP Publication 65, as referenced in the *Radiation Protection Regulations*. The reference level represents an incremental increase above natural dwelling radon levels that could result in a member of the public being exposed to an incremental dose of 1 mSv. Values are calculated as geometric means.

Five high-volume sampling units are strategically located at various locations around the McClean Lake operation to monitor dust, particulates and associated contaminants. TSP values remained low in 2015 and well below the provincial standard of 70 µg/m^3 as shown in figure 7.5.

Figure 7.5: McClean Lake concentrations of TSP, 2011–15



* The Province of Saskatchewan's authorized concentration of contaminants monitored for ambient air quality as listed in the facility's approval to operate pollutant control facilities is shown. The ambient air quality standards for TSP have been revised under the Saskatchewan *Environmental Management and Protection Regulations* and will be updated when the approval to operate document issued by the Province of Saskatchewan is renewed. Values are calculated as geometric means.

TSP samples are also analyzed for concentrations of metals and radionuclides. The mean concentrations of metal and radionuclides adsorbed to TSP are low, and below reference annual air quality levels identified in table 7.3.

Table 7.3: McClean Lake concentrations of metal and radionuclides in air, 2011–15

Parameter	Reference annual air quality levels*	2011	2012	2013	2014	2015
As (µg/m^3)	**0.06** (1)	0.000565	0.000350	0.000226	0.000420	0.003070
Cu (µg/m^3)	**9.6** (1)	0.000025	0.016789	0.036192	0.013888	0.019630
Mo (µg/m^3)	**23** (1)	0.000000	0.000061	0.000657	0.000721	0.000892
Ni (µg/m^3)	**0.04** (1)	0.000000	0.000259	0.000258	0.000420	0.000247
Pb (µg/m^3)	**0.10** (1)	0.000001	0.000453	0.000422	0.000501	0.000368
Zn (µg/m^3)	**23** (1)	0.000002	0.006790	0.005896	0.005939	0.005452
Pb^{210} (Bq/m^3)	**0.021** (2)	0.000588	0.000388	0.000763	0.000277	0.000271
Po^{210} (Bq/m^3)	**0.028** (2)	0.000194	0.000130	0.000159	0.000088	0.000083
Ra^{226} (Bq/m^3)	**0.013** (2)	0.000010	0.000008	0.000013	0.000010	0.000008
Th^{230} (Bq/m^3)	**0.0085** (2)	0.000003	0.000004	0.000000	0.000005	0.000005
U (µg/m^3)	**0.06** (1)	0.000657	0.000444	0.000328	0.000576	0.001319

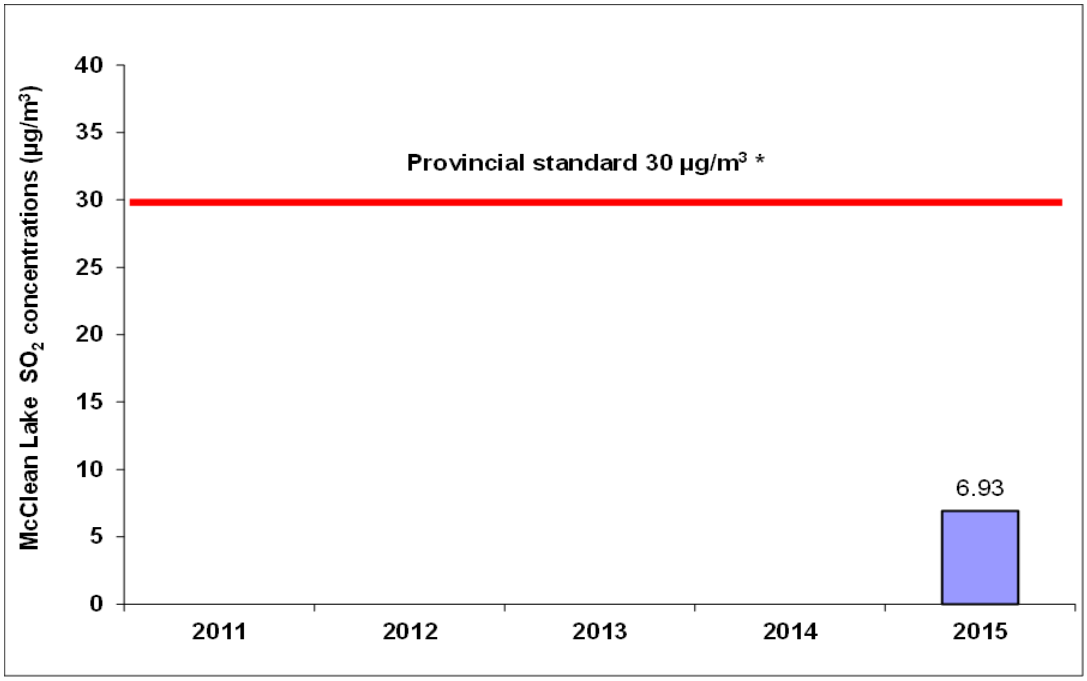
1 Reference annual air quality levels have been derived from *Ontario 24-hour Ambient Air Quality Criteria* (OMOE 2012).

2 Reference level has been derived from ICRP Publication 96.

* Province of Ontario and ICRP reference annual air quality levels are shown for reference only. No federal or provincial limits are currently established.

An SO_2 monitor is used during operations to continuously measure ambient sulphur dioxide concentrations associated with mill emissions. The monitor is located approximately 200 metres downwind of the sulphuric acid plant stack. The measured SO_2 monitoring data (see figure 7.6) shows no exceedances of the annual standard of 30 µg/m^3 in 2015.

Figure 7.6: McClean Lake concentrations of ambient SO_2, 2011–15



* Province of Saskatchewan's standard is shown.

** Ambient SO_2 was not monitored during the temporary shutdown of the mill. Therefore ambient SO_2 concentrations were not measured for the years 2011 to 2013. In 2014, measurement of ambient SO_2 concentrations began again on December 29, 2014 when the acid plant restarted.

The sulphuric acid plant at the McClean Lake facility was not in operation from July 2010 until the end of December 2014 due to the temporary shutdown of the mill.

AREVA's terrestrial monitoring program determines if there is influence on the environment from aerial deposition. Soil and terrestrial vegetation may be affected by the atmospheric deposition of particulate and adsorbed metals and radionuclides associated with onsite activities. This program includes measurements of metals and radionuclides in soil and vegetation.

Results from soil samples collected are presented in the 2016 environmental performance report. These show that the soil metal parameter concentrations were below the Canadian Environmental Quality Guidelines for industrial and residential/parkland land use. Three metal parameters (arsenic, nickel and uranium) measured in soil samples at the McClean Lake operation were below the levels described in the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health. Radionuclide concentrations in soils were also low, and near or at background levels and analytical detection limits. CNSC staff concluded that the level of airborne particulate contaminants produced by the McClean Lake operation was acceptable and did not pose a risk to the environment.

Vegetation sampling was also presented in the 2016 environmental performance report and shows most parameters are within the range of concentrations previously measured in lichen, Labrador tea and blueberry twig samples. Blueberry twigs are monitored to determine if soil-born contaminants (when present) are being absorbed through the roots into the growing plant parts. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of ensuring that a significant level of contamination is not entering lichen consumers, such as caribou. The concentrations of metals and radionuclides in lichen, Labrador tea and blueberry twigs have higher than background concentrations for some samples located in the immediate vicinity of mining activity, although the concentrations decrease within a short distance. Overall, the results indicated that the McClean Lake operation has had a localized effect on vegetation in areas of activity.

CNSC staff concluded that the level of airborne particulate contaminants produced by the McClean Lake operation is acceptable and does not pose a risk to lichen consumers.

Environmental risk assessment

The McClean Lake technical information document was submitted to regulators in 2016 and is currently being reviewed by CNSC staff. Environmental effect monitoring studies generally confirm the environmental assessment predictions. CNSC staff confirm that the aquatic environment is protected downstream of the McClean Lake operation.

Based on a preliminary assessment, CNSC staff are confident that the environmental protection SCA at the McClean Lake operation meets performance objectives and all applicable regulatory requirements.

7.4 Conventional health and safety

For 2015, CNSC staff continued to rate the conventional health and safety SCA as satisfactory based on regulatory oversight activities.

McClean Lake conventional health and safety ratings

2011	2012	2013	2014	2015
SA	SA	FS	SA	SA

Practices

AREVA continues to improve performance and maintain health and safety programs at the McClean Lake operation to minimize occupational health and safety risks. CNSC staff confirmed that the McClean Lake operation has an effective occupational health and safety committee and completes regular reviews of its safety program.

AREVA's McClean Lake operation investigates safety concerns and incidents, including near-miss events. In 2015, several investigations were completed using the cause mapping process to determine the cause of incidents, near misses, injuries or property damage. This methodology employs a collaborative group effort to identify a problem, analyze its causes and determine the best solutions.

Performance

Table 7.4 shows that from 2011 to 2015, AREVA's McClean Lake operation reported seven LTIs, including three in 2015.

Table 7.4: McClean Lake total number of FTE workers, LTIs, severity rate and frequency rate, 2011–15

Year	2011	2012	2013	2014	2015
Total number of FTE workers[1]	163	249	348	739	793
Number of LTIs[2]	0	1	0	3	3
Severity rate[3]	0.0	1.2	0.0	4.3	27.7
Frequency rate[4]	0.0	0.4	0.0	0.4	0.4

1 **Total number of workers** (employees and contractors) expressed as FTEs.
FTE = total person-hours / 2,000 hours worked per employee per year.

2 **Lost-time injury** - an injury that takes place at work and results in the worker being unable to return to work for a period of time.

3 **Severity rate** - the accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity = [(# of days lost in last 12 months)/# of hours worked in last 12 months)] x 200,000.

4 **Frequency rate** - the accident frequency rate measuring the number of LTIs for every 200,000 person-hours worked at the site. Frequency = [(# of injuries in last 12 months)/ # of hours worked in last 12 months)] x 200,000.

Additional details on the 2015 LTIs and corrective actions taken are provided in appendix H. The severity rate has increased significantly in 2015 due to three LTIs in 2015 and a carry-over of lost days from 2014.

Corrective actions were implemented with the effectiveness verified and documented by management. CNSC staff observed that the McClean Lake operation strives to involve all levels of its organization in the health and safety program. Employees are encouraged and trained to continuously identify and assess risks, and propose solutions.

Awareness

CNSC staff observed that McClean Lake's conventional health and safety programs provide education, training, tools and support to ensure worker protection (see figure 7.6). An active onsite occupational health and safety committee completes regular reviews of its safety program. Through inspections, reviews of incidents and discussions with McClean Lake staff, CNSC staff verified that the McClean Lake operation is committed to accident prevention and safety awareness.

Figure 7.7: McClean Lake emergency response vehicles ~~on site~~ onsite

SECTION II: HISTORIC (REMEDIATING) AND DECOMMISSIONED URANIUM MINES AND MILLS

8 OVERVIEW

Section II of this report provides information on the three active remediation projects and 10 decommissioned uranium mine and mill sites, which are shown in figure 8.1. The objective of active remediation projects is to establish long-term, stable conditions that ensure the safe use of each site by current and future generations. Wherever possible, the remediation plans aim to return historic uranium mines and mills to previously existing environmental conditions or to land uses that will be sustainable in the long term. Active remediation projects consist of ongoing clean-up activities, full-time staff, contractor management in different areas as well as frequent monitoring and reporting.

There are three sites currently undergoing remediation:

- Gunnar legacy uranium mine site
- Lorado uranium mill site
- Deloro mine site

The remaining 10 sites have been decommissioned for several years and are currently in the long-term monitoring and maintenance phase:

- Beaverlodge mine and mill site
- Cluff Lake uranium mine and mill site
- Rayrock mine site
- Port Radium mine site
- Agnew Lake uranium mine site
- Madawaska legacy uranium mine site
- Bicroft tailings storage facility
- Dyno idle mine site
- Elliot Lake sites (managed by Rio Algom)
- Elliot Lake sites (managed by Denison Mines Inc.)

Figure 8.1: Location of remediating and decommissioned sites in Canada

8.1 CNSC regulatory efforts

CNSC staff provide risk-informed regulatory oversight of licensed activities at the active remediation projects and decommissioned sites. According to CNSC staff's risk-informed baseline inspection plan, all but two remediation projects and decommissioned sites are required to have a minimum of one inspection per year. The Rayrock and Port Radium mine site are inspected once every three years. Inspections for these two sites were last performed in 2013, therefore no inspections were conducted in 2015. Inspections for these two sites were completed in June 2016, as per CNSC staff's baseline compliance verification plan. Findings from these inspections will be reported in the 2016 regulatory oversight report.

Table 8.1 presents CNSC staff's licensing and compliance efforts for the remediation projects and decommissioned sites in 2015. CNSC staff performed 14 compliance inspections at these sites. Findings resulting from these inspections were provided to the licensees in detailed inspection reports. All enforcement actions arising from the findings were recorded in the CNSC regulatory information bank to ensure they are tracked to completion. CNSC staff reviewed and verified that the licensee's corrective actions taken were appropriate and acceptable. All non-compliances or enforcement actions issued in 2015 are considered closed by CNSC staff. Details of enforcement actions are provided in the following sections.

Table 8.1: CNSC regulatory oversight licensing and compliance activities for remediating and decommissioned sites, 2015

Site	Number of inspections	Compliance activities effort (person days)	Licensing activities effort (person days)
Gunnar	0*	86	79
Lorado	1	31	4
Deloro	5**	199	25
Beaverlodge	1	69	15
Cluff Lake	1	68	21
Agnew Lake	1	18	0
Madawaska	1	9	0
Bicroft	1	12	0
Dyno	1	10	1
Elliot Lake	1	21	5
Denison and Stanrock	1	32	0

* In 2015, CNSC staff were unable to conduct an inspection at the Gunnar legacy uranium mine site due to weather conditions. An inspection was completed in August 2016.
** Unplanned releases to environment resulted in frequent inspections at Deloro (refer to section 11.1).

Licensing information for each site is found in appendix A.

The CNSC requires licensees to develop decommissioning plans for each site. Each plan, which is reviewed and approved by CNSC staff, is accompanied by a financial guarantee that provides the funding necessary to complete all decommissioning work. For sites that have been decommissioned, financial guarantees are still required to support monitoring, care and maintenance of the site.

These values of the financial guarantees for the historic and decommissioned sites are listed in appendix E.

8.2 Performance

The CNSC requires each licensee, as per their CNSC licence, to submit an annual compliance report. These reports contain licensees' performances in the applicable safety and control areas (SCAs). CNSC staff review these reports to verify that licensees are complying with their regulatory requirements and are operating safely. The full versions of these reports are available on licensees' websites as applicable, and the associated references are found in appendix K of this report.

CNSC staff used licensee compliance reports, revisions to licensee programs, responses to events and incidents by licensees, as well as CNSC staff inspections to compile the performance ratings for the active remediation projects and decommissioned sites.

The availability and presence of workers and licensee staff onsite determines the applicability of each SCA. The following SCAs are not rated for any of the remediation projects and decommissioned sites:

- Human performance management is not applicable due to the routine monitoring and maintenance activities carried out at decommissioned mine and mill sites.
- Safety analysis has been completed at the licensing stage and is used throughout the lifecycle of each site. Due to the static nature of the sites, new safety analyses are not required.
- Fitness for service is not applicable as these sites are currently in stable states.
- Waste management is not applicable as the authorized license activities are all related to the management of wastes for the decommissioned sites.
- Safeguards and non-proliferation is not applicable because each site has been decommissioned and the risk for intervention is very low. Licensees are required to provide reasonable services and assistance to the International Atomic Energy Agency (IAEA) inspectors to carry out their duties and functions. During the 2015 calendar year, there were no requests by IAEA inspectors to inspect any of these sites.
- Packaging and transport is not applicable to these sites because they do not ship radioactive materials.

The remaining applicable SCAs are presented in tables 8.2 and 8.3 along with the rating for each site.

For 2015, CNSC staff rated all applicable SCAs as satisfactory for all but one remediation project and decommissioned site. The Deloro mine site's management system SCA was rated below expectations. (See section 11 for more information.)

This report focuses on radiation protection, environmental protection and conventional health and safety, the three SCAs that cover many of the key performance indicators for these sites.

Table 8.2: Applicable SCA performance ratings for active remediation sites, 2015

Safety and control area	Gunnar*	Lorado	Deloro
Management system	N/A	SA	BE**
Operating performance	N/A	SA	SA
Physical design	N/A	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	SA	SA
Security	SA	SA	SA

Note: BE = Below expectations, SA = Satisfactory, N/A = Not Applicable

* The management systems, physical design, and emergency management and fire protection SCAs were not rated for 2015 because remediation work had not yet begun and there were no workers onsite.

** See section 11.

Table 8.3: Applicable SCA performance ratings for decommissioned sites, 2015

Safety and control area	Beaverlodge	Cluff Lake	Rayrock	Port Radium	Agnew Lake	Madawaska	Bicroft	Dyno	Elliot Lake	Denison and Stanrock
Radiation protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Conventional health and safety	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

Note: BE= Below expectations, SA = Satisfactory, N/A = Not Applicable

8.3 Radiation protection

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

For 2015, CNSC staff rated the radiation protection SCA at all remediation projects and decommissioned sites as satisfactory.

Radiological hazard control

Sources of radiation exposure at remediated and decommissioned sites include:

- gamma radiation
- long-lived radioactive dust (LLRD)
- radon progeny
- radon gas

Based on their oversight, CNSC staff found that the licensees control these hazards through the effective use of time, distance and shielding, contamination control and personal protective equipment.

Radiation protection performance

CNSC staff conducted regulatory oversight activities in the area of radiation protection at all remediation projects and decommissioned sites during 2015 in order to verify compliance of the licensees' performances against regulatory requirements.

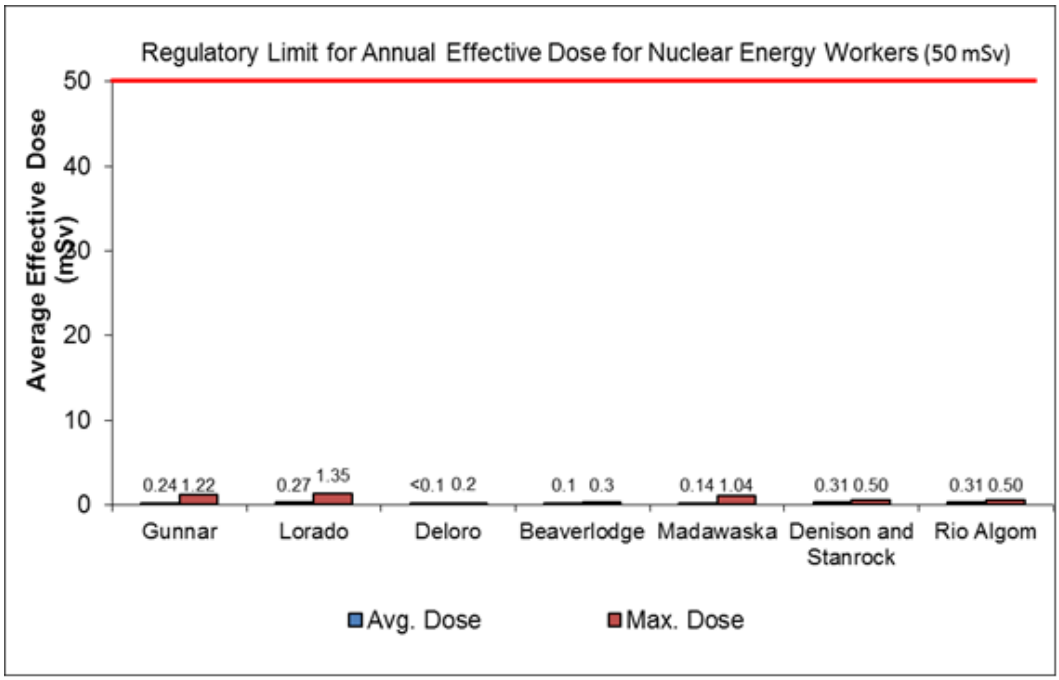
CNSC staff concluded the active remediation projects and decommissioned site licensees had adequate radiation protection practices identified for the work activities being conducted in 2015, and for ensuring the protection of health and safety of persons working at their sites.

Worker dose control

The 2015 maximum and average effective doses for nuclear energy workers (NEWs) at historic and decommissioned sites are provided in figure 8.2. There were no workers designated as NEWs at the Cluff Lake, Rayrock, Port Radium, Agnew Lake, Bicroft and Dyno sites. In 2015, the maximum exposure of NEWs ranged from <0.2 mSv to 1.35 mSv, all well below the regulatory dose limit of 50 mSv per year.

Annual effective doses for NEWs are based on different work conditions and environments. Therefore, direct comparisons of effective doses among sites do not necessarily provide appropriate measures of the effectiveness of radiation protection programs.

Figure 8.2: Remediating and decommissioned uranium mine and mill sites – comparisons of average and maximum effective doses to NEWs, 2015



Appendix F shows the number of NEWs with the corresponding effective doses and maximum individual effective doses at each site.

Application of ALARA

The CNSC requirement to apply the ALARA principle has consistently resulted in doses well below regulatory dose limits. Based on the review of the dose data provided above and the work activities conducted at remediation projects and decommissioned sites, CNSC staff are satisfied that all licensees are controlling radiation doses below regulatory dose limits for NEWs, and in accordance with the ALARA principle.

Estimated dose to the public

The maximum dose to the public from licensed activities at each of the remediation projects and decommissioned sites is based on a human health risk assessment and supported with monitoring data. Estimated doses to the public from all sites continue to be well below the regulatory annual public dose limit of 1 mSv.

8.4 Environmental protection

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

CNSC staff rated the 2015 performance of all remediation projects and decommissioned sites for the environmental protection SCA as satisfactory.

In 2015, environmental protection programs were effectively implemented and met regulatory requirements for all remediation projects and decommissioned sites. There were no exceedances of effluent discharge limits. Therefore, CNSC staff confirmed that the environment is protected at all sites.

Water quality objectives

Water quality is typically compared to the Canadian Water Quality Guidelines for the Protection of Aquatic Life, and/or to provincial levels where applicable. For example, for sites in Saskatchewan, water quality is compared to the province's Surface Water Quality Objectives. In some cases, there are site-specific objectives that are based on risk assessments at the time of licensing. These objectives are further described in sections 9 to 21.

8.5 Conventional health and safety

The conventional health and safety SCA covers the implementation of programs to manage workplace safety hazards and to protect workers and equipment.

For 2015, CNSC staff rated the conventional health and safety SCA at sites undergoing remediation and decommissioned sites as satisfactory.

Practices

Each licensee is responsible for developing and implementing a conventional health and safety program for the protection of its staff and contract workers, which must comply with Part II of the Canada Labour Code. CNSC staff reviewed licensee annual reports and conducted site inspections, where safety practices were observed. CNSC staff concluded that licensees implemented their conventional health and safety programs satisfactorily during 2015, and their programs were effective in protecting the health and safety of persons working in their facilities.

Performance

A key performance measure for conventional health and safety is the number of lost-time injuries (LTIs) that occur per facility. A LTI is a workplace injury that results in the worker being unable to return to work for a period of time. There were no LTIs at the remediation projects and decommissioned sites during 2015.

SECTION II-A: HISTORIC (REMEDIATING) URANIUM MINES AND MILLS

This section provides information on CNSC's oversight of three active remediation projects of historic uranium mine and mill sites in Saskatchewan and Ontario.

9 GUNNAR

The Gunnar legacy uranium mine site is located approximately 600 kilometres north of Saskatoon, on the north shore of Lake Athabasca in northwest Saskatchewan (see figure 9.1).

The Gunnar site consists of a former uranium mine and mill that is being remediated by the Saskatchewan Research Council (SRC). In January 2015, the Commission issued SRC a waste nuclear substance licence for the Gunnar Remediation Project following a public hearing. SRC's licence is valid until November 30, 2024.

Figure 9.1: Aerial view of Gunnar site, 2015

The remediation project consists of the clean-up of mine tailings, waste rock piles (see figure 9.2), an open pit, a mine shaft and demolition debris. The remediation work is being carried out in three phases. Phase 1, which is now complete, involved characterizing and monitoring the onsite waste and developing remediation plans. Phase 2 consists of implementing the remediation plans. Phase 3 will be the long-term monitoring and maintenance to ensure the site remains stable and safe.

When issued by the Commission, the Gunnar Remediation Project licence included a regulatory hold point for phase 2. This required SRC to develop plans for remediation of the different site components and to present those plans at a public hearing with written interventions. Following a public hearing in September 2015, the Commission removed part of the Gunnar Remediation Project phase 2 hold point to allow for the remediation of the site's tailings area. A subsequent public Commission hearing was held on September 22, 2016 at SRC's request to remove the remainder of the hold point and authorize the remediation of the waste rock piles, open pit, mine shaft and demolition debris.

According to SRC's plan, the remediation activities will have been completed by the time the current site licence expires in 2024. SRC is required to request the Commission's approval prior to moving to phase 3 of the project, which consists of maintenance and monitoring, and preparation for transfer of the site to institutional control. Currently, SRC plans for the maintenance and monitoring phase to last 10 years, with the site entering the institutional control program in 2035.

Figure 9.2: Surface of waste rock pile at Gunnar site

9.1 Performance

For 2015, CNSC staff were satisfied with SRC's performance at the Gunnar site in the radiation protection, conventional health and safety, environmental protection, emergency management and fire protection, and security SCAs.

The CNSC's risk-informed baseline inspection plan for 2015 required CNSC staff to conduct one site inspection at the Gunnar site. However, due to severe weather, the inspection was cancelled. Because remediation activities at the site had not yet begun, the 2015 inspection was not rescheduled. CNSC staff reviewed the 2015 inspection report completed by the Saskatchewan Ministry of Environment. In it, ministry staff indicated they observed good management of the site by SRC and discussed upcoming site remediation activities. CNSC staff visited the site in 2013 and 2014 and conducted an inspection in August 2016. All findings are in line with the 2015 Saskatchewan Ministry of Environment report.

9.2 Radiation protection

For 2015, CNSC staff rated the radiation protection SCA as satisfactory.

2015
SA

Radiation protection program performance

CNSC staff reviewed and are satisfied with SRC's implementation of its radiation protection program at the Gunnar site in 2015.

Worker dose control

In 2015, workers onsite for total periods exceeding four weeks were classified as NEWs and assigned appropriate dosimetry. The average individual effective dose was 0.24 mSv and the maximum individual effective dose was 1.22 mSv. All reported doses were below SRC's action levels, as well as below the CNSC's regulatory dose limit of 50 mSv per year for workers designated as NEWs.

CNSC staff concluded that the Gunnar site is adequately controlling radiological dose to individuals and maintained ALARA.

9.3 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory.

2015
SA

Assessment and monitoring

CNSC staff verified that SRC has maintained an environmental protection program that ensures the protection of the public, and an environmental monitoring program that measures existing conditions at the site.

SRC performed semi-monthly surface water and groundwater monitoring and analyses over the 2015 field season (May through October). CNSC staff reviewed the results of these analyses and found they were consistent with previous years and with the 2014 Gunnar Environmental Impact Statement. This data is being used as baseline in order to monitor and verify impacts and improvements for upcoming remediation activities.

There is no liquid effluent at the Gunnar site; however there is overland flow and seepage from the site into local water bodies.

Passive radon emissions are monitored in the air. The radon monitored at the perimeter of the Gunnar site for 2015 was within natural background levels. CNSC staff reviewed the results and confirmed that adequate radon monitoring is conducted to verify the public is protected.

CNSC staff are satisfied that SRC has maintained an environmental protection program to ensure the protection of the public and establish baseline conditions for the site prior to remediation.

9.4 Conventional health and safety

For 2015, CNSC staff rated the conventional health and safety SCA as satisfactory.

2015
SA

Health and safety program performance

CNSC staff confirmed that SRC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting.

This site has an active monitoring and reporting program for LTIs. There have been no LTIs at the Gunnar site in the reporting period of 2015.

CNSC staff are satisfied with SRC's performance in the area of conventional health and safety for the Gunnar site.

10 LORADO

The Lorado tailings management site is located eight kilometres south of Uranium City, Saskatchewan (see figure 10.1).

The Lorado uranium mill operated from 1957 to 1960 and was abandoned in the 1960s without any decommissioning or remedial work. The Province of Saskatchewan now has ownership of the site under the Saskatchewan Ministry of the Economy. The ministry has subsequently appointed SRC as the project manager to oversee the ongoing management and remediation of the Lorado site. SRC's waste nuclear substance licence for Lorado is valid until April 30, 2023.

Figure 10.1: Lorado – soil cover on tailings area before final grading, 2015

At the end of 2015, SRC completed remediation of the Lorado site. The remediation work consisted of:

- covering the mine tailings with an engineered cover
- treating the water of Nero Lake to neutralize acidity and reduce contaminant concentrations
- monitoring the environment

During remediation work, SRC found that the footprint of tailings was about 10 percent larger than anticipated. CNSC staff have confirmed that the additional tailings can be accommodated within the approved decommissioning plans.

The next step for the site is to transition to the long-term monitoring phase which is planned for 2017. CNSC staff are currently reviewing SRC's long-term monitoring and maintenance plans. The long-term objective is to transfer the remediated safe and stable site into the Saskatchewan Institutional Control Program after a period of 10 to 15 years post remediation.

10.1 Performance

CNSC staff are satisfied with SRC's performance in 2015 at the Lorado tailings management site in the applicable SCAs of management systems, operating performance, physical design, radiation protection, conventional health and safety, environmental protection, emergency management and fire protection, and security.

10.2 Radiation protection

For 2015, CNSC staff rated the radiation protection SCA as satisfactory.

2015
SA

Radiation protection program performance

CNSC staff verified that SRC had a radiation protection program in place that met the requirements of the *Radiation Protection Regulations* and ensured that radiation doses were monitored, controlled and maintained ALARA.

Worker dose control

All personnel at the Lorado site, including the main contractor, its subcontractors and all SRC personnel are classified as NEWs and follow an approved dosimetry program. In addition to the yearly exposure limits, those working around the tailings area also monitor their daily gamma doses with electronic personal dosimeters.

The average individual effective dose for workers at the site was divided into general contractors and land surveyors. The average dose for contractors was 0 mSv and the average dose for land surveyors and SRC staff was 0.27 mSv. The maximum individual effective dose received was 1.35 mSv, well below the regulatory dose limit of 50 mSv per year for NEWs. Nonetheless, SRC looked into the maximum individual effective dose and found that this individual spent a lot of time working on the tailings area including carrying out gamma survey activities of the tailings. The cover on the tailings area was completed in 2016, and CNSC staff confirmed that gamma radiation was low and within background values.

CNSC staff reviewed the worker dose data for the reporting period and concluded that radiation doses are being adequately controlled.

10.3 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory.

2015
SA

Assessment and monitoring

SRC's environmental program ensures the health and safety of persons and the environment are protected by identifying, controlling and monitoring all potential releases from remediation activities.

There is no liquid effluent at the Lorado site. SRC's environmental sampling program includes measurement of surface water concentrations for metals, radionuclides and general water quality parameters in local lakes and groundwater. CNSC staff verified that SRC conducted surface water monitoring at several locations to verify the impact of recent remediation activities in Nero Lake and Hanson Bay. As a result of liming of Nero Lake in 2014, the pH in Nero Lake was brought back to neutral and the overall water quality has improved from baseline conditions. As more data is collected over time at the site, the effectiveness of the remediation works can be verified.

Air monitoring at the Lorado site consists of radon and monitoring of dust generation from tailings. CNSC staff confirmed the radon and dustfall monitoring were within the range of natural background in 2015.

In addition to water quality and air monitoring, SRC hired an independent contractor whose job was to walk the site every day and identify potential impacts to the environment (e.g., survey area for animal tracks and relay information to SRC). CNSC staff met with the contractor and confirmed the daily monitoring activities during the 2015 inspection.

Environmental risk assessment

SRC completed Lorado's environmental risk assessment in 2014. As a follow up, an aquatic macrophyte chemistry program was carried out and submitted to the CNSC. CNSC staff were satisfied that these new results did not change the predictions concerning low risk to moose and other wildlife.

CNSC staff are satisfied that SRC has adequate measures in place to protect the public and the environment from releases from the Lorado site.

10.4 Conventional health and safety

For 2015, CNSC staff rated the conventional health and safety SCA as satisfactory.

2015
SA

Health and safety program performance

CNSC staff confirmed during an inspection that SRC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting.

This site has an active monitoring and reporting program for LTIs. There were no LTIs at the Lorado site during 2015.

For 2015, CNSC staff were satisfied with SRC's performance in the area of conventional health and safety for the Lorado site.

11 DELORO

The Deloro mine site is located approximately 65 kilometres east of Peterborough, Ontario. This site was an abandoned gold mine where metallurgical and refining processes related to the production of cobalt oxides and metal, and the extraction of silver, nickel and arsenic took place (see figure 11.1).

In 2009, the CNSC issued the Ontario Ministry of Environment, now known as the Ontario Ministry of Environment and Climate Change (MOECC), a waste nuclear substance licence to remediate the Deloro site. The licence is valid until December 30, 2016.

Figure 11.1: Deloro mine site, 2015

The remediation of the Deloro mine site has been organized into three separate clean-up projects: the tailings area, the industrial and mine area, and the Young's Creek area. Remediation of the tailings area is complete, remediation of the industrial mine area is about 80 percent complete, and remediation of the Young's Creek area is approximately 20 percent complete. In July 2016, the MOECC applied for the conditional release of the Deloro site from the CNSC's regulatory oversight. Public Commission proceedings are planned for 2017.

11.1 Performance

For 2015, CNSC staff were satisfied with the MOECC's performance for the SCAs of operating performance, physical design, radiation protection, environmental protection, conventional health and safety, emergency management and fire protection, and security. However, they rated the management systems SCA as below expectations.

In May 2015, CNSC staff received notice that an unplanned release of non-radioactive construction wastewater occurred at the Young's Creek area in April 2015. This release resulted in no significant impact to the environment. However, upon subsequently visiting the site, CNSC staff determined that the licensee did not have any:

- contingency plans in place to deal with any failures of the temporary aqua barriers
- action plans for dealing with results from their monitoring program to ensure the stability of the temporary aqua barriers
- systems or programs to ensure that every contractor working at the site complied with the licence

In June 2015, a CNSC designated officer issued an order to MOECC relating to discharges of non-radioactive construction wastewater from the Young's Creek area. In the order, the CNSC required the MOECC to immediately cease any remediation activities that may have increased environmental risk from clean-up work at the Young's Creek area project. The order also required MOECC to develop and implement a contingency plan for the current exigent circumstances and ensure plans were in place to prevent any future releases. The licensee did not request the opportunity to be heard. In public proceedings, CNSC staff provided updates to the Commission regarding this event in June 2015 (CMD 15-M26) and January 2016 (CMD 16-M6).

After issuing the order, CNSC staff increased the planned number of inspections in 2015. During these inspections, they identified problems with some aspects of the site such as: poor water management practices in the Young's Creek area, poor communication between site contractors and MOECC staff, and a remediation barrier (i.e., the landfill cover) in the industrial mine area that did not meet technical specifications. MOECC put in place corrective actions and CNSC staff confirmed that the situation at the site has since improved significantly. CNSC staff determined that MOECC met all of the conditions of the order and that remediation work could resume at the site. Subsequently, in March 2016, the order was closed. CNSC staff will continue to closely monitor this area to ensure that the licensee continues to meet regulatory expectations.

11.2 Radiation protection

For 2015, CNSC staff rated the radiation protection SCA as satisfactory.

2015
SA

Radiation protection program performance

In 2015, MOECC satisfactorily maintained a radiation protection program that ensured the protection of the workers and the public. Each contractor also has a specific radiation protection program for each clean-up project. All contractors and visitors attended radiation protection training prior to going onsite. In 2015, CNSC staff verified that the licensee ensured that radiation protection training and records were up to date and maintained according to an approved dosimetry program.

Worker dose control

Contractors who are designated NEWs onsite either wore thermos luminescent dosimeters or electronic personal dosimeters, depending on the tasks assigned to them. The average individual effective dose to Deloro mine site NEWs was less than 0.1 mSv; the maximum individual effective dose was 0.2 mSv.

The reported doses were below licensees' action levels and below the CNSC's regulatory dose limit.

For 2015, CNSC staff were satisfied with the MOECC's radiation protection program for the Deloro site.

11.3 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. CNSC staff were satisfied that the MOECC maintained an environmental protection program that ensured the protection of the environment.

2015
SA

Assessment and monitoring

The environmental monitoring program at the Deloro site includes monitoring of surface water, groundwater and radiological contaminants. Since 2011, the licensee has been responsible for enhanced environmental monitoring including air quality, noise, archaeological and biological monitoring. The licensee also ensures healthy habitat and suitable conditions for all resident fish and wildlife.

The results of the 2015 radon monitoring by the MOECC of its three indoor locations (i.e., arsenic treatment plant and garage) showed that concentrations ranged from 37 Bq/m^3 to 126 Bq/m^3. All of the results remained below the Health Canada guideline for radon of 200 Bq/m^3. CNSC staff reviewed the results and were satisfied that all measurements were below background radon levels.

MOECC's surface water monitoring program consists of the collection and analysis from 19 sampling locations in and near the site. CNSC staff reviewed the 2015 surface water results for radionuclides, which showed all samples were well below the Ontario Drinking Water Quality Standards (ODWQS). The main contaminant of concern at the site is arsenic, concentrations of which exceeded ODWQS in Young's Creek in 2015. This finding is consistent with those in previous years. The concentration of arsenic is expected to decrease following completion of all remediation activities.

The site has a number of groundwater monitoring wells throughout the property. All radionuclides in groundwater were well below the ODWQS.

Protection of the public

CNSC staff are satisfied that the MOECC has adequate measures in place at the Deloro site to protect the public and the environment from releases from its facility.

11.4 Conventional health and safety

For 2015, CNSC staff rated the conventional health and safety SCA as satisfactory.

2015
SA

Health and safety program performance

CNSC staff confirmed during inspection that the MOECC's health and safety program is implemented effectively and employs the good practices of awareness, training, communication and reporting.

This site has an active monitoring and reporting program for LTIs. There were no LTIs at the Deloro site in 2015.

For 2015, CNSC staff were satisfied with the MOECC's performance in the area of conventional health and safety for the Deloro site.

SECTION II-B: DECOMMISSIONED URANIUM MINES AND MILLS

Section II-B describes uranium mine and mill sites that have been decommissioned and are in the long-term maintenance and monitoring phase. In general, given the limited nature of onsite work, outdoor setting and low radiation levels following remediation activities, the potential for radiation exposure to workers and the public is very low. In addition, CNSC staff have reviewed the risk assessments and CNSC monitoring data for all decommissioned sites and concluded that levels of exposure are much lower than regulatory radiation limits. The doses for all NEWs performing monitoring, maintenance or visits to site were well below regulatory dose limits. The SCA rating for radiation protection for all decommissioned sites was satisfactory in 2015.

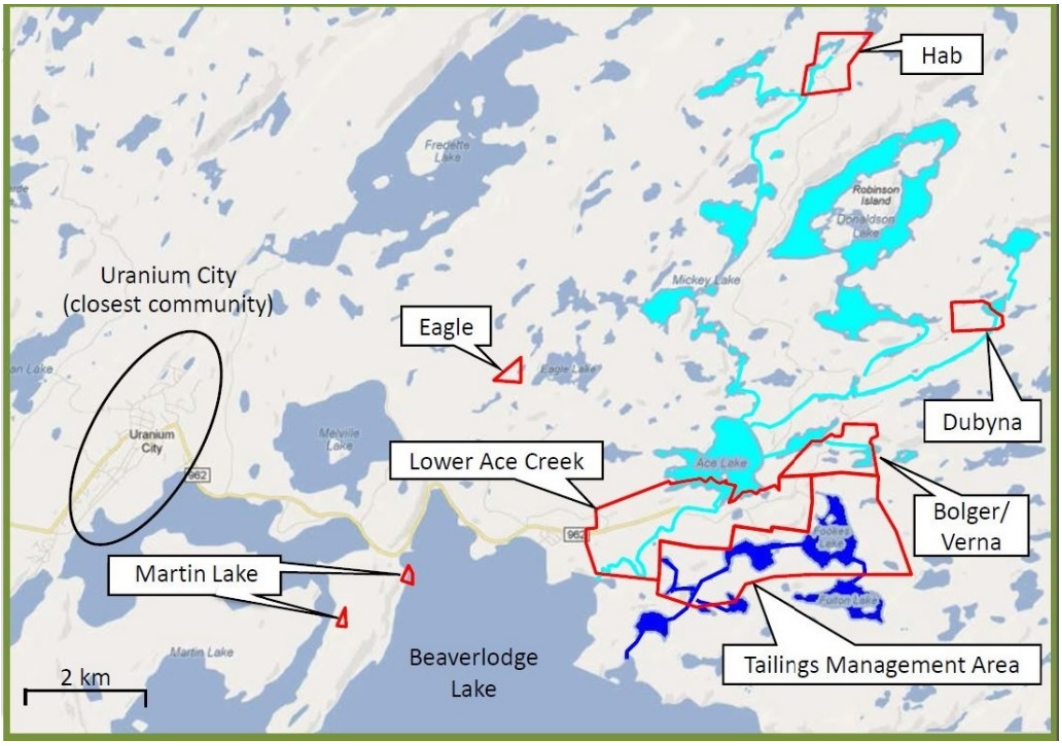
Activities at decommissioned sites involve routine monitoring and maintenance work. In most cases, there are no permanent staff onsite. All sites maintain effective occupational health and safety programs that protect workers, contractors and visitors. The rating for conventional health and safety at all sites was satisfactory in 2015.

The environmental protection SCA is a key indicator for the effectiveness of past remediation measures at the site and is highlighted for each site in this report. All decommissioned sites have environmental monitoring programs to ensure the continued protection of the environment and ongoing performance of remediation works. Once long-term environmental objectives for the site have been met, these sites are released into institutional control (or conditionally released from regulatory oversight). The rating for environmental protection at all sites was satisfactory in 2015. The following sections provide information about each decommissioned site, including any changes that occurred to the site in 2015.

12 BEAVERLODGE

The decommissioned Beaverlodge uranium mine and mill site is located near Uranium City in northwest Saskatchewan (see figure 12.1).

Figure 12.1 Overview of Beaverlodge site



Mining and milling activities began at the Beaverlodge site in 1950. The mine closed in 1982. The Beaverlodge site consisted of a central mill, underground mine and an above ground tailings management area. The tailings management area is located on Fulton Creek watershed (shown in dark blue in figure 12.1 and shown again in figure 12.2). There are also several smaller satellite mines that provided ore during the three decades of operation. Decommissioning commenced shortly after operations ended and was completed to the standards in place at the time of decommissioning (i.e., in 1985). Beaverlodge was the first uranium site in Canada to be decommissioned under an Atomic Energy Control Board licence. On behalf of the federal government, Cameco Corporation manages the site conducting routine environmental monitoring, environmental investigations and maintenance work, to ensure the site remains safe and secure.

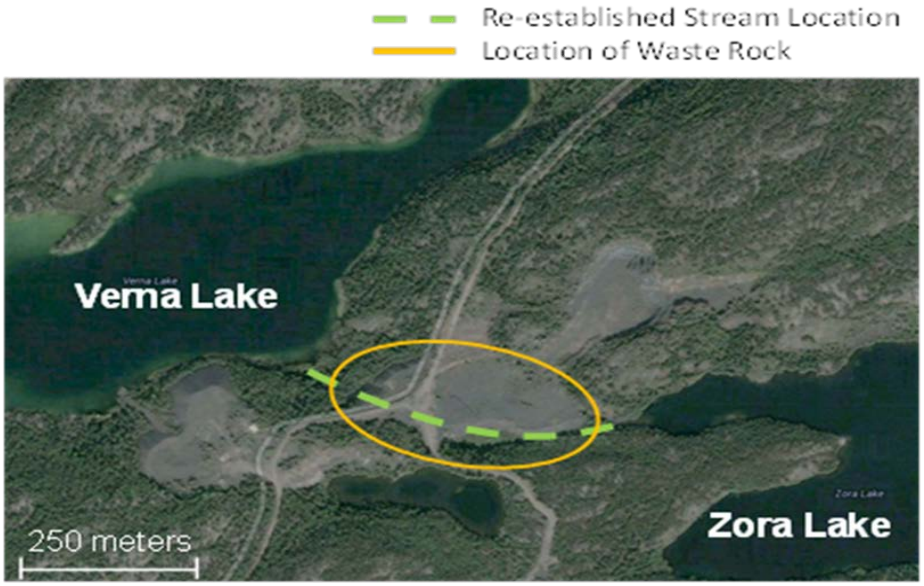
At the time of decommissioning, the site consisted of 73 separate properties that covered approximately 744 hectares including 17 different mining areas. Saskatchewan's *Reclaimed Industrial Sites Act* later came into effect and created an institutional control framework for the long-term provincial management of post-decommissioning properties. As a result, five Beaverlodge properties were released from CNSC licensing and entered into institutional control (IC) registry in 2009. This information was presented at a public hearing in February 2009 and authorized by the Commission.

Figure 12.2: Beaverlodge tailings cover, 2015

On May 27, 2013 the Commission issued a 10-year licence for the Beaverlodge site. As part of its application, Cameco provided reasonable options to support a natural recovery of the site and a timetable for final decommissioning of the site's various licensed areas. Since issuance of that licence, Cameco has completed studies and additional remediation work to support an application to release additional portions of the Beaverlodge site into the Province of Saskatchewan's IC program. After comprehensive review and verification by the province and the CNSC in 2015 and 2016, Cameco is expected to request a licence amendment to release the confirmed low-risk areas of Martin Lake, Eagle, and portions of the Lower Ace Creek, Hab and Bolger/Verna from the current CNSC licence. Once released from the current licence, the properties will be administered under the Saskatchewan IC program. The remaining portions of the Beaverlodge site under the CNSC licence continue to progress following the decommissioning timeline. CNSC staff expect that at the next licence renewal in 2023, the entire site could be released to the IC program.

In addition to continued monitoring and maintenance activities in 2015, Cameco completed the stream diversion at the Bolger/Verna area (see figure 12.3). The purpose of the stream diversion was to relocate a stream around a waste rock pile, and thereby reducing a source of contamination to the downstream watershed. The stream diversion site was inspected by CNSC staff in June 2015. They verified that stream diversion activities were implemented in accordance with the licence. No issues were identified during the inspection and CNSC staff concluded that Cameco's Beaverlodge site is meeting regulatory requirements. CNSC staff will continue to conduct inspections on the Beaverlodge site to verify regulatory compliance.

Figure 12.3: Beaverlodge – Bolger/Verna Stream diversion



12.1 Performance

In 2015 CNSC staff rated Beaverlodge site performance as satisfactory for all applicable SCAs. The following sections contain addition information on the performance rating of the SCAs of radiation protection, environmental protection and conventional health and safety.

12.2 Radiation protection

For 2015, CNSC staff rated the radiation protection SCA as satisfactory.

2015
SA

There are no year-round workers at the Beaverlodge site. During 2015, Cameco staff and contractors were onsite for limited periods of time for monitoring, mitigation activities and inspections. The average individual effective dose and maximum individual effective dose to workers in 2015 was 0.1 mSv and 0.3 mSv, respectively; well below the annual regulatory limit of 1 mSv for the public. Gamma dose, measured through the use of optically stimulated luminescence dosimeters badges, was negligible.

Based on the outcome of CNSC staff inspections and reviews of the radiation protection program, work practices and effective doses measured in 2015, CNSC staff concluded the Beaverlodge project is adequately controlling radiation doses to workers and the public.

12.3 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory.

2015
SA

CNSC staff reviewed the water quality results from the 2015 monitoring programs and found that the levels are generally stable or decreasing with time, and are within the predictions made by Cameco. There is a precautionary fish consumption advisory in effect, which in 2016 was renamed and is now referred to as a healthy fish consumption guideline. The public has been advised of the lakes and creeks in the area from which no fish should be consumed. The public has also been advised of those water bodies where fish consumption should be limited due to elevated selenium levels as a result of past mining and milling activities at Beaverlodge site and milling at the nearby Lorado site.

CNSC staff reviewed reported radon concentrations and concluded the concentrations are within the historical range of values or similar to background values.

For 2015, CNSC staff were satisfied that Cameco had adequate measures in place to protect the public and the environment.

12.4 Conventional health and safety

For 2015, CNSC staff rated the conventional health and safety SCA as satisfactory.

2015
SA

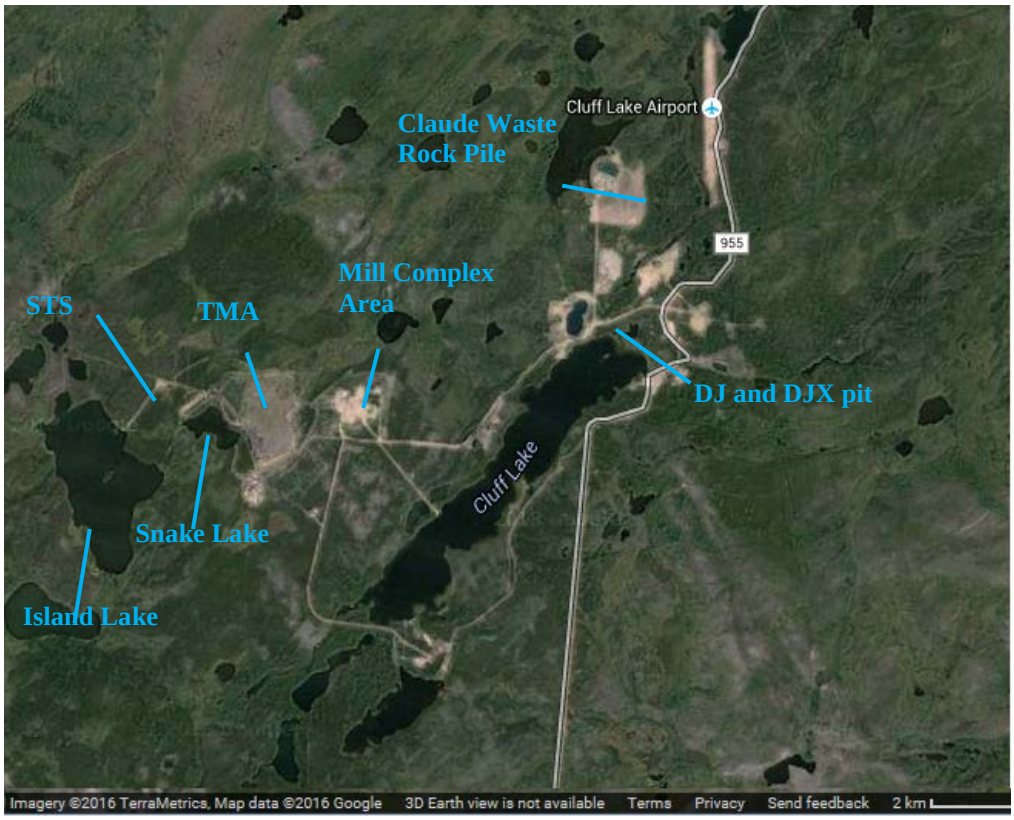
The health and safety risks at the Beaverlodge site are very low for this unoccupied site. The risks are associated with the management of contractors undertaking surveillance, maintenance and any remediation work. As required by the CNSC licence, a contractor management program is in place to mitigate this risk. For example, during the Bolger/Verna stream diversion work, the workers held daily safety meetings prior to commencement of the work. These meetings included discussions regarding task details for that day, potential hazards and personal protective equipment.

CNSC staff concluded Beaverlodge satisfactorily maintained a health and safety program that protected the health and safety of workers.

13 CLUFF LAKE

The decommissioned Cluff Lake uranium mine and mill is located in northern Saskatchewan, approximately 75 kilometres south of Lake Athabasca and 30 kilometres east of the provincial border with Alberta. Owned and operated by AREVA Resources Canada Inc. (AREVA), Cluff Lake operated from 1981 to 2002. Following closure, the major decommissioning activities commenced and were largely completed within five years. In September 2013, the Cluff Lake project reached a major milestone when AREVA decommissioned the remaining camp residence and airstrip. Site occupancy was ceased, and access to the site is no longer controlled. Figure 13.1 provides an aerial view of Cluff Lake showing the key components of the operation.

Figure 13.1: Cluff Lake – area map



The former Cluff Lake operation consisted of a central mill and above ground tailings management area (TMA), three open-pit and two underground mines, associated waste rock piles, and site infrastructure including an airstrip and camp (see figure 13.2).

Figure 13.2: Cluff Lake – pre-decommissioning view, 2009

As part of decommissioning activities, the Claude pit was completely filled in. The DJ/DJX and D pits were flooded and remain isolated from adjacent natural water bodies. Potentially problematic portions of the surface waste rock piles were placed into the pits, while the remainder of the surface waste rock was contoured, covered and revegetated. The portals and vents to the underground mines were closed. The TMA was contoured, covered and revegetated. All structures were dismantled and disposed of. Figure 13.3 shows the DJ and DJX pits with the Claude waste rock pile in the background.

Figure 13.3: Cluff Lake – DJ and DJX pits and Claude waste rock pile, 2014

In 2009, the CNSC issued AREVA a 10-year uranium mine decommissioning licence for Cluff Lake. The licence is valid until July 31, 2019. During relicensing, the Commission requested CNSC staff to provide a midterm update. This report fulfils those midterm requirements. Additional information about the decommissioning work is provided in appendix J. CNSC staff understand that AREVA may request to transfer the Cluff Lake site to the Saskatchewan's Institutional Control Program at the end of the current licence period. Once the application is submitted, CNSC staff, in consultation with the province, will determine if the transfer is acceptable. Once the province is satisfied and is ready to accept the site into the IC program, CNSC staff will present to the Commission a request to release the site from CNSC licensing. This request will be granted only if the Commission is satisfied.

In 2015, AREVA completed the second year of campaign monitoring in compliance with its licence. There were no issues or concerns identified. It appears that the recovery of the site is proceeding as anticipated.

13.1 Performance

For 2015, CNSC staff were satisfied with Cluff Lake's performance in all relevant SCAs. Cluff Lake's performance over the reporting period of 2015 was rated as satisfactory and the site continues to be stable, safe and well managed.

13.2 Radiation protection

For 2015, CNSC staff rated the radiation protection SCA as satisfactory.

2015
SA

AREVA's radiation protection program is reflective of the low risk of radiation exposure at the site. Due to the nature of the site activities and mitigation measures in place, radiation doses to the workers and the public are well below the public dose limit of 1 mSv.

CNSC staff were satisfied with AREVA's radiation protection program at Cluff Lake and will continue to monitor the effectiveness of the program in future inspections.

13.3 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory.

2015
SA

The environmental monitoring program at Cluff Lake measures the quality of groundwater, surface water and air. Groundwater monitoring confirmed predicted quality values and verified that aquatic life in nearby lakes is protected. Water quality in Island Lake, which received treated effluent from the tailings impoundment area during operations, is generally stable or improving as predicted. AREVA monitors radon gas in remediated areas. CNSC staff reviewed the results and concluded that the radon concentrations are consistent with values measured in previous years and generally reflective of concentrations naturally occurring in northern Saskatchewan. In 2015, CNSC staff were satisfied with the environmental monitoring at Cluff Lake and will continue to assess results to ensure that mitigation measures remain effective and stable.

In 2015, CNSC staff reviewed the environmental performance and environmental risk assessment update for Cluff Lake. CNSC staff concluded that the air, surface water and sediment quality were similar to that predicted in the Cluff Lake Decommissioning Project Comprehensive Study Report and are satisfied with the results.

For 2015, CNSC staff were satisfied that AREVA had adequate measures in place to protect the public and the environment from residual releases from the Cluff Lake site.

13.4 Conventional health and safety

For 2015, CNSC staff rated the conventional health and safety SCA as satisfactory.

2015
SA

AREVA maintained a conventional health and safety program to protect the health and safety of workers at the Cluff Lake site. This program is reflective of the low risk and unique challenges of the isolated location of the work. Prior to each sampling campaign, safety meetings were held between AREVA and consultants.

For 2015, CNSC staff were satisfied with Cluff Lake's conventional health and safety program and will continue to monitor the program's effectiveness.

14 RAYROCK

The Rayrock idle mine site was formerly a uranium mine and mill. It is located in the Northwest Territories, 74 kilometres northwest from the community of Behchoko (formerly community of Rae) and 156 kilometres northwest of Yellowknife (see figure 14.1).

The uranium mine and mill operated from 1957 until 1959 when the site was abandoned. The site was then decommissioned and rehabilitated in 1996 by Indigenous and Northern Affairs Canada (INAC). On July 4, 2011, the CNSC issued INAC a waste nuclear substance licence for Rayrock. The licence is valid until June 30, 2017. INAC has indicated its intent to apply for renewal the licence to allow for an additional 10 years of maintenance and monitoring activities.

Figure 14.1: Rayrock idle mine site

14.1 Performance

For 2015, CNSC staff were satisfied with INAC's performance in the areas of radiation protection, environmental protection and conventional health and safety. INAC's performance over the reporting period of 2015 has been stable and met the requirements of the NSCA and its associated regulations.

According to the CNSC risk-informed baseline inspection plan, Rayrock is subject to a minimum of one compliance inspection every three years. As a result, CNSC staff did not conduct an inspection in 2015. The last inspection conducted by CNSC staff was in June 2013.

14.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. INAC's environmental protection program ensured the protection of the environment.

2015
SA

Assessment and monitoring

The Rayrock site follows a long-term post-remediation monitoring program. Surface water quality monitoring is carried out every three years and radon and gamma monitoring is carried out every five years. CNSC staff reviewed the monitoring results and found the contaminant concentrations in water bodies in and around the site were typically below the Canadian Water Quality Guidelines for the Protection of Aquatic Life, however, there were some exceedances for aluminum, copper, iron and selenium at some locations in onsite lakes. There was one exceedance of the water quality guidelines for uranium in Mill Lake, because there are historic uranium mine tailings at the bottom of the lake.

Environmental risk assessment

Previous risk assessments and modelling have shown that localized elevated concentrations would not impact downgradient water bodies. However, the measurement of elevated concentrations in recent years has prompted INAC to undertake an updated site risk assessment to ensure that remedial measures are still meeting remediation objectives identified in 2009. CNSC staff are currently reviewing the site assessment submitted by INAC in August 2016, which proposes a path forward for a new risk assessment and any additional maintenance activities that may be required.

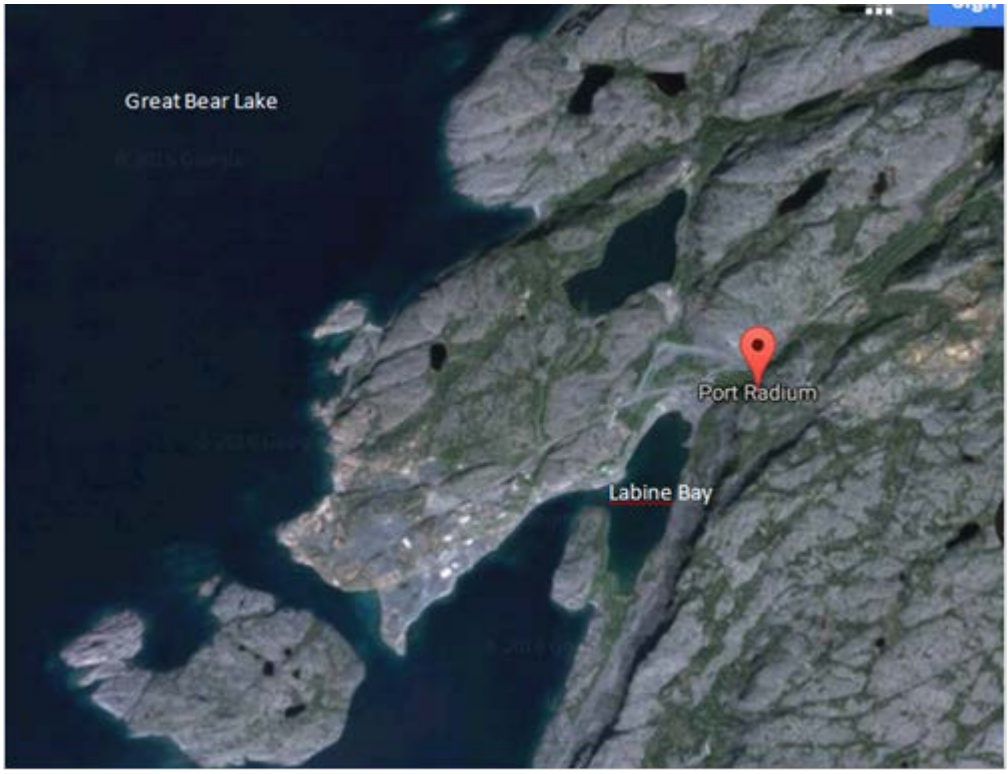
For 2015, CNSC staff concluded that INAC had adequate measures in place to protect the public and the environment from releases from the Rayrock site.

15 PORT RADIUM

The Port Radium idle mine site is located in the Northwest Territories at Echo Bay on the eastern shores of Great Bear Lake, about 265 kilometres east of the Déné community of Déline at the edge of the Arctic Circle (see figure 15.1).

The mine was in operation for 50 years, from 1932 to 1982. The site covers approximately 12 hectares and is estimated to contain 1.7 million tons of uranium and silver tailings. The site was partially decommissioned in 1984, according to the standards at that time. In 2006, the Government of Canada reached an agreement with the local community and completed the remediation of the site in 2007 under a CNSC licence. The CNSC issued INAC a waste nuclear substance licence for Port Radium on November 1, 2006. The licence is valid until December 31, 2016. INAC has submitted an application to the CNSC for the renewal of its licence for another 10 years.

Figure 15.1: Port Radium idle mine site



15.1 Performance

For 2015, CNSC staff are satisfied with INAC's performance at the Port Radium site in the SCAs of radiation protection, environmental protection and conventional health and safety. INAC's performance over the 2015 reporting period has been stable and met the requirements of the NSCA and its associated regulations.

According to CNSC's risk-informed baseline inspection plan, Port Radium is subject to a minimum of one compliance inspection every three years. As a result, CNSC staff did not conduct an inspection in 2015.

15.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. INAC's environmental protection program ensured the protection of the environment.

2015
SA

There was no water quality sampling conducted in 2015. Measurements from 2014 therefore form the basis of the CNSC's environmental rating for this site. There were some elevated concentrations of several contaminants including arsenic, uranium, copper and zinc in onsite water bodies. Concentrations of contaminants in nearby Great Bear Lake and Labine Bay were all below the Canadian Water Quality Guidelines for the Protection of Aquatic Life.

Environmental risk assessment

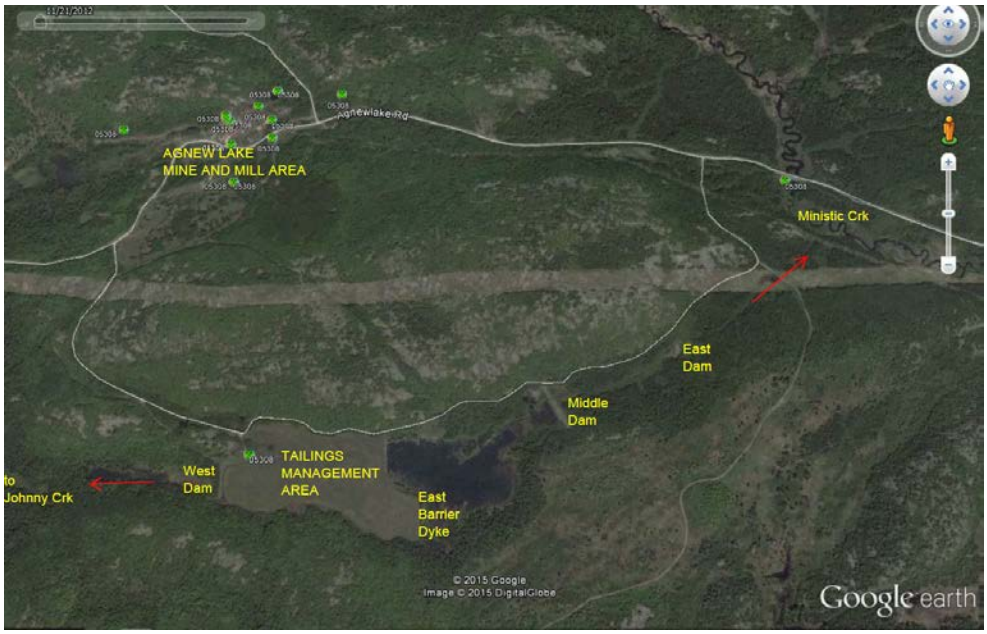
The 2007 risk assessment showed that risks to human health associated with being present at the Port Radium site prior to remediation were low. With completion of remedial activities, these risks have been further reduced. Likewise, risks of adverse effects to ecological species were assessed as being low. INAC is conducting environmental sampling to verify that the conclusions in the 2007 risk assessment are still valid. The CNSC is currently reviewing the monitoring plan and associated results.

For 2015, CNSC staff were satisfied that INAC had adequate measures in place to protect the public and the environment from releases from the Port Radium site.

16 AGNEW LAKE

The Agnew Lake mine is located about 25 kilometres northwest of Nairn Centre, Ontario (see figure 16.1). The uranium mine site was decommissioned and monitored by Kerr Addison Mines from 1983 until 1988. The site was then turned over to the Province of Ontario in the early 1990s. The CNSC issued Ontario's Ministry of Northern Development and Mines (MNDM) a waste nuclear substance licence for Agnew Lake on January 20, 2011. The licence is valid until January 31, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

Figure 16.1: Agnew Lake remediation spillway



16.1 Performance

For 2015, CNSC staff were satisfied with MNDM's performance in the radiation protection, environmental protection and conventional health and safety SCAs. MNDM's performance over the reporting period of 2015 has been stable and met the requirements of the NSCA and its associated regulations.

16.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. MNDM's environmental protection program protected of the environment.

2015
SA

Assessment and monitoring

MNDM measures surface water concentrations at several locations around the site every two years. The last reported measurements were submitted to the CNSC in 2014. CNSC staff reviewed the results and found that contaminant concentrations in water bodies in and around the site were below Ontario surface water quality objectives. The licensee performed maintenance work on two of the dams. This work has not changed the site's overall design.

For 2015, CNSC staff were satisfied that MNDM had adequate measures in place at Agnew Lake to protect the public and the environment from releases from the site.

17 MADAWASKA

Madawaska is a legacy uranium mine located near Bancroft, Ontario that operated between 1957 to 1982 and was decommissioned in the 1980s. EWL Management Ltd. is the licensee of the Madawaska mine site, under the CNSC waste nuclear substance licence. The licence was issued on July 4, 2011 and is valid until July 31, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

The site includes the footprint of the mining operation, a number of capped and sealed openings, underground workings and two tailings dams. Site discharge is through Bentley Creek to Bow Lake or directly to Bow Lake (see figure 17.1).

Figure 17.1: Madawaska – Bentley Creek Dam

In 2015, EWL Management Ltd. undertook maintenance work to improve the cover and surface water management on the tailings management areas. At the time of the CNSC's inspection, contractors were clearing vegetation in order to add an extra layer of soil material to the cover. This work was conducted to limit radiation from the tailings, improve surface water quality and reduce future maintenance.

17.1 Performance

For 2015, CNSC staff were satisfied with EWL Management Ltd.'s performance at Madawaska in the radiation protection, environmental protection, and conventional health and safety SCAs. EWL Management Ltd.'s performance over the reporting period of 2015 has been stable and met NSCA requirements and its associated regulations.

For the maintenance activities on the tailings, CNSC staff verified that EWL Management Ltd. had an effective radiation protection program in place and that all NEWs at the Madawaska site followed appropriate dosimetry programs. The reported doses were below the licensee's investigation levels and action levels, as well as below the regulatory limit of 50 mSv per year. CNSC staff also verified that EWL Management Ltd. had a robust health and safety program and that all contractors and visitors were required to complete the site-specific occupational health and safety training.

In 2015, CNSC staff found the site was well managed and had no compliance issues. No enforcement actions were issued as a result of the inspection.

17.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. EWL Management Ltd. satisfactorily maintained an environmental protection program to ensure the protection of the environment at the Madawaska site.

2015
SA

Concentrations in some water bodies adjacent to the site exceeded the Canadian Water Quality Guidelines for the Protection of Aquatic Life for uranium in 2015. These measurements are consistent with those from previous years (i.e., the highest value measured was 50 µg/L in Bow Lake compared to water quality objective of 15 µg/L). Risk assessments conducted in 2012 concluded that those values would not result in adverse effects on any species of aquatic life from exposure to those concentrations in surface water, sediment and groundwater associated with the Madawaska decommissioned site. However, improvements to water flow and the cover system are currently underway at the site to further limit the migration of contaminants into the surrounding environment.

CNSC staff have reviewed and are satisfied that EWL Management Ltd. has adequate measures in place to protect the public and the environment from releases from the Madawaska site.

18 BICROFT

Bicroft is located on the south side of Highway 118, about 2 kilometres west of Cardiff, Ontario. Barrick Gold Corporation is the owner and licensee of the Bicroft tailings storage facility. On December 14, 2010, the CNSC issued Barrick Gold a waste nuclear substance licence for Bicroft. The licence is valid until February 28, 2021. For the foreseeable future, the site will remain under long-term monitoring and maintenance (see figure 18.1).

Figure 18.1: Bicroft spillway, 2016

The Bicroft facility was constructed to contain tailings from mining operations that were carried out at the nearby Bicroft mine, which operated from 1956 to 1962. The uranium tailings stored in the Bicroft tailings storage site resulted from processing low-grade uranium ore at the Bicroft mine. Remediation work has included vegetation of exposed tailings in 1980 and upgrading of dams in 1990 and 1997. Areas of the site are now used for occasional recreational use by the local snowmobile club.

18.1 Performance

For 2015, CNSC staff were satisfied with Barrick Gold Corporation's performance in the SCAs of radiation protection, environmental protection and conventional health and safety at the Bicroft site. The licensee's performance over the 2015 reporting period has been stable and met the requirements of the NSCA and its associated regulations.

In 2015, CNSC staff found the site was well managed and maintained and that there were satisfactory environmental protection measures and procedures in place. CNSC staff made recommendations to the licensee that maintenance improvements could be made to the site by removing larger trees on certain dams and beaver cuttings more regularly to ensure the overall integrity of the dams.

18.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. Bicroft satisfactorily maintained an environmental protection program that ensured the protection of the environment.

2015
SA

The Bicroft site has an environmental sampling program and provided the results to the CNSC in its 2015 annual report. Water quality sampling is carried out every five years at the site. Sampling last occurred during the 2015 field season. CNSC staff reviewed the results and concluded that all except one onsite location for uranium surface water samples met the provincial water quality objectives. However concentrations of all contaminants in the receiving environment were below provincial objectives.

For 2015, CNSC staff were satisfied that Barrick Gold Corporation has adequate measures in place to protect the public and the environment from releases from the Bicroft site.

19 DYNO

The Dyno idle mine property is located at Farrel Lake, about 30 kilometres southwest of Bancroft, Ontario (see figure 19.1). The mill circuit at Dyno operated between 1958 and 1960. The property consists of an abandoned, sealed underground uranium mine; a mill, which has been demolished; capped openings; a tailings area; one dam with a toe berm; and various roadways. The site is managed and monitored by EWL Management Ltd., which holds a CNSC waste nuclear substance licence for Dyno. The licence was issued on September 23, 2009 and is valid until January 31, 2019. For the foreseeable future, the site will remain under long-term monitoring and maintenance.

Figure 19.1: Dyno idle mine site

19.1 Performance

For 2015, CNSC staff were satisfied with EWL Management Ltd.'s performance in the SCAs of radiation protection, environmental protection and conventional health and safety. Performance over the reporting period of 2015 at the Dyno site has been stable and met the NSCA requirements and its associated regulations.

In 2015, CNSC staff found the site was well managed and maintained. There were satisfactory environmental protection measures and procedures in place. CNSC staff requested that the licensee perform some maintenance work around the concrete caps to the former mine openings to prevent animals from burrowing in the area and possibly affecting the integrity of the concrete covers. During the 2016 inspection, CNSC staff verified this work was completed.

19.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. EWL Management Ltd. satisfactorily maintained an environmental protection program to ensure the protection of the environment.

2015
SA

The Dyno site has an environmental sampling program. EWL Management Ltd. provided the results of that sampling to CNSC in its 2015 annual report. Water quality sampling is carried out every five years at the site. It last occurred during the 2015 field season. CNSC staff reviewed the results and concluded that all locations for uranium surface water samples met the provincial water quality objectives.

CNSC staff confirmed that since the Dyno site has been remediated, atmospheric emissions monitoring is not required. The site is closed and the remediation work including the covering of radioactive tailings has reduced the effects of contamination.

For 2015, CNSC staff were satisfied that EWL Management Ltd. has adequate measures in place to protect the public and the environment from releases from the Dyno site.

20 ELLIOT LAKE

Rio Algom Limited is the owner and licensee of nine decommissioned uranium mines in the Elliot Lake area of northeastern Ontario: Stanleigh, Quirke, Panel, Spanish, American, Milliken, Lacnor, Buckles and Pronto and some peripheral areas (see figure 20.1).

The mine sites and associated TMAs are being managed under one CNSC waste facility operation licence. The licence is of indefinite term. The sites have all been decommissioned and the TMAs are in the long-term care and maintenance phase. Rio Algom Limited conducts site-specific and regional environmental monitoring programs, operates the effluent treatment plants, and inspects and maintains the sites in the Elliot Lake area. The long-term plan for the site is to reach a state where water treatment is no longer required and reliance on physical works can be reduced.

Rio Algom Limited requested to amend its Class I licence to be consistent with the updated CNSC licence format. CNSC staff have prepared a licence conditions handbook to accompany the licence. It is anticipated that the proposed amended licence will be before the Commission before the end of 2016.

A status update to the Commission for the decommissioned Elliot Lake sites is due coincident with the five-year status of environment (SOE) report. The Elliot Lake area SOE was submitted to CNSC staff in January 2016 and CNSC staff are currently reviewing the document. A status update for the Elliot Lake sites will be part of the 2016 edition of this report.

Figure 20.1: Elliot Lake historic sites, 2015

20.1 Performance

According to CNSC staff's risk-based inspection planning, Rio Algom Limited is required to have a minimum annual compliance inspection annually and one geotechnical inspection every two years. CNSC staff conducted the annual compliance inspection in 2015 and found the sites were in good condition and well managed by the licensee. No enforcement actions were issued during this period as a result of the inspection.

For 2015, CNSC staff are satisfied with Rio Algom Limited's performance in the radiation protection, environmental protection and conventional health and safety SCAs. Performance at the Elliot Lake historic sites over the reporting period of 2015 has been stable and has met the NSCA requirements and its associated regulations.

There were no gamma doses detected for NEWs at the Rio Algom Limited properties using either the thermos luminescent dosimeter or optically stimulated luminescence dosimeter gamma badges, and there were no radon progeny action level exceedances in 2015.

20.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. Rio Algom Limited satisfactorily maintained an environmental protection program to ensure the protection of the environment.

2015
SA

Assessment and monitoring

CNSC staff reviewed the licensee's liquid effluent monitoring results for 2015 and confirmed that all results are below the CNSC licence limits.

CNSC staff reviewed the monitoring results for indoor radon concentrations for 2015 and confirm that all results are below Health Canada guidelines.

For 2015, CNSC staff were satisfied that Rio Algom Limited had adequate measures in place to protect the public and the environment from releases from its facilities.

21 DENISON AND STANROCK

Denison Mines Inc. is the licensee for the two closed uranium mines of Denison and Stanrock in the Elliot Lake area of northeastern Ontario (see figure 21.1). The Denison site is licensed under UMDL-MINEMILL-Denison-01/indf while the Stanrock site is licensed under UMDL-MINEMILL-Stanrock.02/indf. Both licenses have indefinite licence periods. Denison Mines Inc. has applied to have both licenses merged under one licence.

A status update to the Commission for all the decommissioned Elliot Lake sites (including Denison and Stanrock) is due coincident with the five-year SOE report. The Elliot Lake area SOE was submitted to CNSC staff in January 2016 and CNSC staff are currently reviewing the document. A status update for the Elliot Lake sites will be part of the 2016 edition of this report.

Figure 21.1: Denison mine shaft cap

The mine sites have been decommissioned and there are no mining or milling structures remaining. The TMAs are in the long-term care and maintenance phase which includes water treatment, source and watershed monitoring. The Denison mine site contains two TMAs that are covered by water and contain a total of 63 million tonnes of uranium mine tailings. The Stanrock site is a dry TMA with 6 million tonnes of uranium mine tailings.

The licence covers the physical works associated with the decommissioned mine and mill tailings such as dam structures, effluent treatment plants and fencing. The licensee conducts onsite inspection programs and ensures local and area-wide environmental monitoring programs are in place.

21.1 Performance

For 2015, CNSC staff were satisfied with the licensee's performance for the SCAs of radiation protection, environmental protection and conventional health and safety. The performance at the Denison and Stanrock sites over the reporting period of 2015 has been stable, and has met the NSCA requirements and its associated regulations.

In 2015, CNSC staff inspected the sites and found that they were well managed and had no compliance issues. CNSC staff confirmed that the dams and associated structures were found to be in good operating condition and appeared well maintained. Effluent water quality at all discharge locations was in compliance with licence limits.

CNSC staff verified that there were no gamma doses measured for NEWs at the Denison property using either the thermos luminescent dosimeter or optically stimulated luminescence dosimeter gamma badges in 2015.

21.2 Environmental protection

For 2015, CNSC staff rated the environmental protection SCA as satisfactory. An environmental protection program was satisfactorily maintained at the Denison and Stanrock facilities to ensure the protection of the environment.

2015
SA

Effluent and emissions

CNSC staff reviewed air emissions monitoring results for radon annual averages for 2015 and are satisfied with the results at the Denison and Stanrock facilities.

CNSC staff verified that the effluent water quality for constituents of potential concern consistently achieved discharge criteria at all TMAs.

The Serpent River Watershed Monitoring Program monitors and assesses the aquatic environmental conditions in the watershed downstream of the facilities. Every five years, Denison Environmental and Rio Algom submit a joint SOE report on releases from tailings facilities and their impacts on the receiving Serpent River Watershed. The latest report was submitted in January 2016 and is currently under CNSC staff review.

For 2015, CNSC staff were satisfied that adequate measures are in place to protect the public and the environment from releases from the site.

GLOSSARY

action notice

A written request that the licensee take action to correct a non-compliance that is not a direct contravention of governing regulations, licence conditions, codes or standards, but that can compromise safety, security or the environment. Such non-compliances include:

- failure to satisfy one of the compliance criteria if the criteria are not directly referenced in the governing regulations or licence conditions
- a significant but non-systemic failure to comply with the licensee's own policies, procedures or instructions that it has established to meet licensing requirements (including programs and internal processes submitted in support of a licence application)

chemocline

A boundary in a body of water that separates the upper layer from a deeper layer containing higher concentrations of dissolved solids and gases.

Commission

A corporate body of not more than seven members, established under the *Nuclear Safety and Control Act* and appointed by the Governor in Council, to perform the following functions:

- regulate the development, production and use of nuclear energy and the production, possession, use and transport of nuclear substances
- regulate the production, possession and use of prescribed equipment and prescribed information
- implement measures respecting international control of the development, production, transport and use of nuclear energy and nuclear substances, including those respecting the non-proliferation of nuclear weapons and nuclear explosive devices
- disseminate scientific, technical and regulatory information concerning the activities of the CNSC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and uses referred to above

Commission member document (CMD)

A document prepared for Commission hearings and meetings by CNSC staff, proponents and interveners. Each CMD is assigned a specific identification number.

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 one of an item of schedule one of the *Radiation Protection Regulations*, by the weighting factor set out in column two of that item.

equivalent dose

The product, in Sieverts, obtained by multiplying the absorbed dose of radiation of the type set out in column one of an item of schedule two of the *Radiation Protection Regulations*, by the weighting factor set out in column two of that item.

frequency rate

The accident frequency rate measuring the number of lost-time injuries (LTIs) for every 200,000 person-hours worked at the site. The frequency rate is calculated as follows:

Frequency = [(# of injuries in last 12 months) / # of hours worked in last 12 months)] x 200,000.

full-time equivalent (FTE)

Total person-hours divided by 2,000 hours worked per employee per year.

geometric mean

An average that indicates the central tendency or typical value of a set of numbers according to the product of their values (as opposed to the arithmetic mean, which uses their sum);

The geometric mean of a data set (a1, a2, … an) is given by:

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 a_2 \cdots a_n}.$$

The geometric mean is a useful summary when we expect that changes in the data occur in a relative fashion. An example is when filters trap dusts in an amount relative to the amount of air flowing through the filters.

International Atomic Energy Agency (IAEA)

An independent international organization related to the United Nations (UN) system. The IAEA, located in Vienna, works with its member states and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA reports annually to the UN General Assembly and, when appropriate, to the Security Council regarding non-compliance by states with their safeguards obligations, as well as on matters relating to international peace and security.

lost-time injury (LTI)

An injury that takes place at work and results in the worker being unable to return to work for a period of time.

root-cause analysis

An objective, structured, systematic and comprehensive analysis designed to determine the underlying reasons for a situation or event, which is conducted with a level of effort consistent with the safety significance of the event.

severity rate

The accident severity rate measures the total number of days lost to injury for every 200,000 person-hours worked at the site. Severity rate is calculated as follows:

Severity = [(# of days lost in last 12 months) / # of hours worked in last 12 months)] x 200,000.

total number of workers

The total number of workers includes employees and contractors and is expressed as full-time equivalents.

triennial

Recurring every three years.

uranium concentrate (yellowcake)

Uranium concentrate, commonly referred to as U_3O_8, is the product created when uranium ore has been mined and milled.

APPENDIX A: LICENCE AND LICENCE CONDITIONS HANDBOOK

Table A-1 outlines licensing information for the five uranium mine and mill facilities. Table A-2 provides information related to the historic and decommissioned sites.

Table A-1: Uranium mines and mills – licensing information

Licensee/licence #	Licence effective	Last licence amendment	Licence expiration
AREVA Resources Canada Inc. McClean Lake Operation Uranium Mine and Mill Operating Licence UMOL-MINEMILL-McCLEAN.01/2017	July 1, 2009	December 19, 2012	June 30, 2017
Cameco Corporation Cigar Lake Operation Uranium Mine Operating Licence UML-MINE-CIGAR.00/2021	July 1, 2013		June 30, 2021
Cameco Corporation Key Lake Operation Uranium Mill Operating Licence UMLOL-MILL-KEY.00/2023	November 1, 2013		October 31, 2023
Cameco Corporation Rabbit Lake Operation Uranium Mine and Mill Operating Licence UMOL-MINEMILL-RABBIT.00/2023	November 1, 2013		October 31, 2023
Cameco Corporation McArthur River Operation Uranium Mine Operating Licence UMOL-MINE-McARTHUR.00/2023	November 1, 2013		October 31, 2023

Table A-2: Historic and decommissioned sites – licensing information

Licensee/licence #	Licence effective	Last licence amendment	Licence expiration
Saskatchewan Research Council Gunnar Legacy Uranium Mine Site WNSL-W5-3151.00/2024	January 14, 2015	-	November 30, 2024
Saskatchewan Research Council Lorado Tailings Management Site WNSL-W5-3150.00/2023	April 29, 2014	-	April 30, 2023
Ontario Ministry of Environment Deloro Mine Site WNSL-W1-3301.0/2016	December 22, 2009	-	December 30, 2016
Cameco Corporation Beaverlodge Mine and Mill WFOL-W5-2120.0/2023	June 1, 2013	-	May 31, 2023
AREVA Resources Canada Inc. Cluff Lake Mine and Mill UMDL-MINEMILL-CLUFF.00/2019	August 1, 2009	-	July 31, 2019
Indigenous and Northern Affairs Canada Rayrock Idle Mine Site WNSL-W5-3208.2/2017	June 28, 2007	November 26, 2012	June 30, 2017
Indigenous and Northern Affairs Canada Port Radium Idle Mine Site WNSL-W5-3207.1/2016	November 1, 2006	November 26, 2012	December 31, 2016
Ontario Ministry of Northern Development and Mines Agnew Lake Tailings Management Area WNSL-W1-3102.3/2021	January 20, 2011	December 18, 2012	January 31, 2021
EWL Management Ltd. Madawaska Decommissioned Mines and Tailings Management Site WNSL-W5-3100.1/2021	July 4, 2011	December 18, 2012	July 31, 2021
Barrick Gold Corporation Bicroft Tailings Storage Facility WNSL-W5-3103.1/2021	December 14, 2010	February 24, 2011	February 28, 2021
EWL Management Ltd. Dyno Idle Mine Site WNSL-W5-3101.4	September 23, 2009	July 31, 2013	January 31, 2019

Licensee/licence #	Licence effective	Last licence amendment	Licence expiration
Rio Algom Limited Elliot Lake Historic Sites Facility WFOL-W5-3101.01/2005	January 1, 2006	June 7, 2007	Indefinite
Denison Mines Inc. Denison Mining Facility UMDL-MINEMILL-DENISON-.01/indf	October 16, 2002	December 15, 2004	Indefinite
Denison Mines Inc. Stanrock Mining Facility UMDL-MINEMILL-STANROCK-.02/indf	October 16, 2002	December 15, 2004	Indefinite

The following table outlines the licence conditions handbook changes as of December 31, 2015 for the five uranium mine and mill facilities. There were no changes to the licence conditions handbooks for historic and decommissioned sites.

Table A-3: Uranium mines and mills – licence conditions handbook changes, 2015

Record of the issuance of licence conditions handbook			
Licensee/licence #	**Licence conditions handbook revision**	**Summary of changes**	**Effective date**
Cameco Corporation McArthur River Operation Uranium Mine Operating Licence UMOL-MINE-McARTHUR.00/2023	2	Revised wording in Part 1 section 2.4 to allow an annual production of up to 9.6 Mkg U/yr.	April 2. 2015
Cameco Corporation Key Lake Operation Uranium Mill Operating Licence UMLOL-MILL-KEY.00/2023	2	Minor wording changes to Part II, added regulatory guide G-218 to section 8.1, updated financial guarantee in section 12.3.	June 23, 2015

APPENDIX B: SAFETY AND CONTROL AREA FRAMEWORK FOR URANIUM MINES AND MILLS

The CNSC evaluates how well licensees meet regulatory requirements and CNSC performance expectations for programs in 14 safety and control areas (SCAs). The SCAs are grouped according to in three functional areas: management, facility and equipment, and core control processes.

Table B-1: Safety and control area framework

Functional area	Safety and control area	Definition	Specific areas
Management	**Management system**	Covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.	▪ management system ▪ organization ▪ performance assessment, improvement and management review ▪ operating experience (OPEX) ▪ change management ▪ safety culture ▪ configuration management ▪ records management ▪ management of contractors ▪ business continuity
	Human performance management	Covers activities that enable effective human performance through the development and implementation of processes that ensure a sufficient number of licensee personnel are in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.	▪ human performance program ▪ personnel training ▪ personnel certification ▪ initial certification examinations and requalification tests ▪ work organization and job design ▪ fitness for duty
	Operating performance	Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.	▪ conduct of licensed activity ▪ procedures ▪ reporting and trending ▪ outage management performance ▪ safe operating envelope ▪ severe accident management and recovery ▪ accident management and recovery
Facility and equipment	**Safety analysis**	Covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.	▪ deterministic safety analysis ▪ hazard analysis ▪ probabilistic safety analysis ▪ criticality safety ▪ severe accident analysis ▪ management of safety issues (including research and development programs)

Functional area	Safety and control area	Definition	Specific areas
	Physical design	Relates to activities that impact the ability of structures, systems and components to meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.	▪ design governance ▪ site characterization ▪ facility design ▪ structure design ▪ system design ▪ component design
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function.	▪ equipment fitness for service/equipment performance ▪ maintenance ▪ structural integrity ▪ aging management ▪ chemistry control ▪ periodic inspection and testing
Core control processes	**Radiation protection**	Covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA).	▪ application of ALARA ▪ worker dose control ▪ radiation protection program performance ▪ radiological hazard control ▪ estimated dose to public
	Conventional health and safety	Covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.	▪ performance ▪ practices ▪ awareness
	Environmental protection	Covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.	▪ effluent and emissions control (releases) ▪ environmental management system ▪ assessment and monitoring ▪ protection of the public ▪ environmental risk assessment
	Emergency management and fire protection	Covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions. This area also includes any results of participation in exercises.	▪ conventional emergency preparedness and response ▪ nuclear emergency preparedness and response ▪ fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	▪ waste characterization ▪ waste minimization ▪ waste management practices ▪ decommissioning plans
	Security	Covers programs required to meet security requirements stipulated in the regulations, the licence, orders or expectations for the facility or activity.	▪ facilities and equipment ▪ response arrangements ▪ security practices ▪ drills and exercises

Functional area	Safety and control area	Definition	Specific areas
	Safeguards and non-proliferation	Covers programs and activities required to meet obligations of the Canada/International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons*.	▪ nuclear material accountancy and control ▪ access and assistance to the IAEA ▪ operational and design information ▪ safeguards equipment, containment and surveillance ▪ import and export
	Packaging and transport	Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.	▪ package design and maintenance ▪ packaging and transport ▪ registration for use
Other matters of regulatory interest			
▪ environmental assessments ▪ CNSC consultation – Indigenous communities ▪ CNSC consultation – other ▪ cost recovery ▪ financial guarantees ▪ improvement plans and significant future activities ▪ licensee public information program ▪ nuclear liability insurance			

APPENDIX C: RATING METHODOLOGY AND DEFINITIONS

Performance ratings used in this report are defined as follows:

Fully satisfactory (FS)

Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory, and compliance within the safety and control area or specific area exceeds requirements and Canadian Nuclear Safety Commission (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 safety control area or specific area meets requirements and CNSC expectations. Any deviation is only minor, and any issues are considered to pose a low risk to the achievement of regulatory objectives and the CNSC's 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 safety and control area or specific area deviates from requirements or CNSC expectations, to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee or applicant is taking appropriate corrective action.

Unacceptable (UA)

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

APPENDIX D: SAFETY AND CONTROL AREA RATINGS (2011–15)

Table D-1: Cigar Lake operation – safety and control area summary

Safety and control areas	2011	2012	2013	2014	2015
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	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 D-2: McArthur River operation – safety and control area summary

Safety and control areas	2011	2012	2013	2014	2015
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 D-3: Rabbit Lake operation – safety and control area summary

Safety and control areas	2011	2012	2013	2014	2015
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 D-4: Key Lake operation – safety and control area summary

Safety and control areas	2011	2012	2013	2014	2015
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 D-5: McClean Lake operation – safety and control area summary

Safety and control areas	2011	2012	2013	2014	2015
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

APPENDIX E: FINANCIAL GUARANTEES

The following table outlines the financial guarantees as of December 31, 2015 for the five uranium mine and mill facilities.

Table E-1: Uranium mines and mills – financial guarantees

Facility	Canadian dollar amount
Cigar Lake	$49,200,000
McArthur River	$48,400,000
Rabbit Lake	$202,700,000
Key Lake	$218,300,000
McClean Lake	$43,094,900
Total	$560,894,900

The following table outlines the financial guarantees as of December 31, 2015 for the historic and decommissioned sites.

Table E-2: Historic and decommissioned sites – financial guarantees

Facility	Canadian dollar amount
Gunnar	Responsibility of provincial government
Lorado	Responsibility of provincial government
Deloro	Responsibility of provincial government
Beaverlodge	Responsibility of Government of Canada
Cluff Lake	$33,600,000
Rayrock	Responsibility of Government of Canada
Port Radium	Responsibility of Government of Canada
Agnew Lake	Responsibility of Government of Canada
Madawaska	$4,041,472
Bicroft	$1,837,000
Dyno	$1,871,543
Denison and Stanrock	$2,480,000
Elliot Lake	$32,749,000

APPENDIX F: WORKER DOSE DATA[1]

Table F-1 shows the total number of nuclear energy workers (NEWs) monitored at each of the five operating mines for 2015. An individual who is required to work with a nuclear substance or in a nuclear industry is designated as a NEW if he or she has a reasonable probability of receiving an individual effective dose greater than the prescribed effective dose limit for a member of the public (i.e., 1 mSv in a calendar year).

Table F-1: Total number of NEWs at each of the five operating facilities, 2015

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Total NEWs	1,222	1,360	958	1,191	508

The following table compares the average and maximum individual effective dose for all five operating uranium mines and mills.

Table F-2: Radiation dose data to NEWs at uranium mines and mills (mSv/yr), 2015

Facility	Average individual effective dose	Maximum individual effective dose	Regulatory limit
Cigar Lake operation	0.45	5.99	**50 mSv/yr**
McArthur River operation	1.00	7.40	
Rabbit Lake operation	1.36	9.14	
Key Lake operation	0.55	7.56	
McClean Lake operation	0.89	5.28	

The following tables provide a five-year trend (2011 to 2015) of the average and maximum effective annual doses received at the various operating uranium mines and mills.

Each table also identifies the maximum five-year dose for a worker at each operating uranium mine and mill. In 2015, no radiation dose at any operating uranium mine or mill exceeded a regulatory effective dose limit.

[1] Worker dose data is obtained from licensees' annual reports.

Table F-3: Cigar Lake operation – worker effective dose

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Total NEWs	1,932	2,420	3,039	1,458	1,222	**N/A**
Average individual effective dose (mSv)	0.13	0.14	0.27	0.16	0.45	**50 mSv/yr**
Maximum individual effective dose (mSv)	1.30	2.87	2.21	2.04	5.99	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	33.60*					**100 mSv/ 5 yrs**

* The five-year dose data includes exposure received at the Cigar Lake facility, other Cameco facilities and non-Cameco facilities since January 1, 2011 by an individual.

Table F-4: McArthur River operation – worker effective dose

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Total NEWs	1,253	1,276	1,302	1,149	1,360	**N/A**
Average individual effective dose (mSv)	1.32	0.97	0.89	1.03	1.0	**50 mSv/yr**
Maximum individual effective dose (mSv)	10.07	9.26	7.58	7.91	7.40	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	33.48					**100 mSv/ 5 yrs**

Table F-5: Rabbit Lake operation – worker effective dose

Dose data	2011	2012*	2013**	2014	2015	Regulatory limit
Total NEWs	1,066	1,257	1,178	964	958	**N/A**
Average individual effective dose (mSv)	1.36	1.22	1.30	1.32	1.36	**50 mSv/yr**
Maximum individual effective dose (mSv)	11.66*	18.8**	11.67	8.64	9.14	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	49.33					**100 mSv/ 5 yrs**

* In 2012, the maximum individual effective doses for 2010 and 2011 were modified from the CNSC Staff Report on the Performance of Canadian Uranium Fuel Cycle and Processing Facilities: 2011. These changes occurred as a result of dose changes approved through the National Dose Registry. The new values resulted from previously rejected personal alpha dosimeter results, which were accepted in early 2012 (i.e., 2010 changed from 10.7 mSv to 11.15 mSv and 2011 changed from 11.4 mSv to 11.66 mSv).

** In 2013, the 2012 maximum individual effective dose was modified from 14.37 mSv (as stated in the *previous CNSC Staff Report on the Performance of Canadian Uranium Fuel Cycle and Processing Facilities: 2012*), as a result of approved dose changes following an injury to an underground worker (for further information see section 5.2 of the 2013 report).

Table F-6: Key Lake operation – worker effective dose

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Total NEWs	1,314	1,345	1,380	1170	1191	**N/A**
Average individual effective dose (mSv)	0.67	0.61	0.62	0.63	0.55	**50 mSv/yr**
Maximum individual effective dose (mSv)	9.14	5.76	5.67	6.21	7.56	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	22.2					**100 mSv/ 5 yrs**

Table F-7: McClean Lake operation – worker effective dose

Dose data	2011	2012	2013	2014	2015	Regulatory limit
Total NEWs	120	174	308	894	508	**N/A**
Average individual effective dose (mSv)	0.33	0.32	0.36	0.37	0.89	**50 mSv/yr**
Maximum individual effective dose (mSv)	1.56	1.30	3.44	2.03	5.28	**50 mSv/yr**
Maximum five-year dose for an individual (mSv) 2011–2015	6.74					**100 mSv/ 5 yrs**

Historic and decommissioned sites

The following table compares the maximum and average individual effective doses in 2015 for historic and decommissioned sites where there are workers designated as NEWs. Cluff Lake, Rayrock, Port Radium, Agnew Lake, Bicroft and Dyno do not have NEWs.

Table F-8: Radiation dose data for NEWs at the historic and decommissioned sites (mSv/yr), 2015

Facility	Maximum individual effective dose	Average individual effective dose	Regulatory limit
Gunnar	1.22	0.24	**50 mSv/yr**
Lorado	1.35	0.27	
Deloro	0.2	<0.1	
Beaverlodge	0.3	0.1	
Madawaska	0.14	1.04	
Denison and Stanrock	0.31	0.50	
Elliot Lake	0.31	0.50	

APPENDIX G: REPORTABLE RELEASES TO THE ENVIRONMENT (SPILLS) AND CNSC RATING DEFINITIONS

CNSC staff were satisfied with the remedial actions taken by the licensees for the spills presented in table G-1, and concluded that these spills resulted in no residual impacts to the environment. Table G-2 lists the spill rating definitions.

Table G-1: Uranium mines and mills reportable releases to the environment, 2015

Facility	Details	Corrective actions	Significance rating
Cigar Lake operation	On January 6, a weld on the condenser coil header failed, causing anhydrous ammonia to leak from the system into the atmosphere and onto the secondary containment outside the modular freeze plant. It is estimated that approximately 57 kg of anhydrous ammonia was released from the system (both in gas and liquid state).	This module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed. The condenser coils have been re-welded and tested.	Low
Cigar Lake operation	On January 15, a weld on the condenser coil header failed, causing anhydrous ammonia to leak from the system into the atmosphere and onto the secondary containment outside the modular freeze plant. It is estimated that approximately 1 L of liquid anhydrous ammonia and less than 45 kg (both in gas and liquid state) was released from the system.	This module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed. To prevent similar releases the condenser coils have been re-welded and tested.	Low
Cigar Lake operation	On January 16, a loose packing nut on the condenser allowed anhydrous ammonia to leak from the system into the atmosphere and onto the secondary containment outside the modular freeze plant. It is estimated that approximately 1 L of liquid anhydrous ammonia and less than 45 kg (both in gas and liquid state) was released from the system.	This specific module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed on the loose nut and the units brought back into safe operation.	Low

Facility	Details	Corrective actions	Significance rating
Cigar Lake operation	On January 30, a weld on the condenser coil header failed, causing anhydrous ammonia to leak from the system into the atmosphere and onto the secondary containment outside the modular freeze plant. It is estimated that approximately 2 L of liquid anhydrous ammonia and approximately 453 kg (both in gas and liquid state) was released from the system.	This specific module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed on the failed weld. The condenser coils have been re-welded and tested.	Low
Cigar Lake operation	On February 26, two welds on the condenser coil header failed, causing anhydrous ammonia to leak from the system onto the secondary containment outside the modular freeze plant. It is estimated that approximately 4 L of liquid anhydrous ammonia and approximately 45 kg (both in gas and liquid state) was released from the system.	This module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed on the failed weld. The condenser coils have been re-welded and tested.	Low
Cigar Lake operation	On March 6, one of the condenser tubes failed, causing anhydrous ammonia to leak from the system onto the secondary containment outside the modular freeze plant. It is estimated that approximately 10 L of liquid anhydrous ammonia was released from the system.	This module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed on the failed condenser tubes and the units brought back into safe operation.	Low

Facility	Details	Corrective actions	Significance rating
Cigar Lake operation	On June 2, while testing the contingency water treatment pipeline, the pipeline and its associated secondary containment leaked, allowing approximately 3 m^3 of water to report to the ground near the freeze plant conditions. The pipeline and containment were repaired to prevent recurrence.	The pipeline test was stopped immediately. The liquid released was collected with the use of a vacuum truck. Affected surface soil was collected and placed in an approved storage facility. Samples of the released liquid and affected soil were collected for analysis. A gamma scan of the area was also performed with all results meeting the 0.5 µSv/hr criteria as defined in PO12-090. The results from the post-clean-up confirmatory soil samples confirmed that the clean-up activities were adequate in remediating the areas to pre-discharge site.	Low
Cigar Lake operation	On July 17, during routine monitoring of water levels in effluent Monitoring Pond D, it was determined that the pond had lost approximately 8% (730 m^3) of water. Once the loss was identified, the pond was emptied and pond valves locked out so that an inspection could be completed. Two large tears were identified.	The pond was emptied for inspection and repaired on July 21. Pond liner inspections are completed annually. The CNSC completed a follow-up inspection in September. Preventative maintenance and monitoring of ponds were reviewed and deemed satisfactory.	Low
Cigar Lake operation	On July 31, a packer failure in a surface freeze hole allowed 19 m^3 of brine to report to the ground via a vacuum test fitting that had been left connected to the freeze hole. This fitting was not properly capped. A very slow leak occurred over a period of approximately 24 hours.	Approximately 2 m^3 of material was collected for disposal. Site staff checked other freeze holes for the possibility of a similar issue to ensure that the hoses on those wells were properly capped. The vacuum test fitting equipment was taken out of service.	Low

Facility	Details	Corrective actions	Significance rating
Cigar Lake operation	On November 20, a weld on the condenser coil header failed, causing anhydrous ammonia to leak from the system into the atmosphere and onto the secondary containment outside the modular freeze plant. It is estimated that approximately 0.5 L of liquid anhydrous ammonia was released from the system.	This specific module of the freeze plant was shut down and isolated to ensure no further release of material. The area was then roped off and access restricted until maintenance could be completed. The condenser coils have been re-welded and tested.	Low
McArthur River operation	No spills.		
Rabbit Lake operation	On January 24, a line patrol operator identified a leak on the treated effluent line in the ditch shortly before the #6 Retention Pond. Approximately 23 m^3 of treated effluent was released to the ditch in the immediate vicinity of the leak. A small amount (<0.1 m^3) escaped the ditch and onto the adjacent roadway.	Upon discovery, the line was immediately shut down. The majority of the released water was contained within the ditch. Frozen ground conditions prevented infiltration into the soil. A small amount of water ran onto the adjacent roadway but froze quickly over a relatively small area. All water recovered from the ditch area was transferred to the mine water pond. The ice scraped from the roadway was deposited at the above ground tailings management facility. A gamma grid survey of the spill area was completed following clean-up. Results confirm clean-up of the area to specified criteria of <0.5 μSv/hr as listed in Approval No. PO13-123.	Low

Facility	Details	Corrective actions	Significance rating
Rabbit Lake operation	On May 5, 2015, while completing piping work on the high pH pre-mix tank, a mix of high pH underflow and process water was unexpectedly released during disconnection of the premix tank feed line. Water from the line sprayed against the interior wall of the building, with most of the water contained by the travelway and high pH basement containment located below. An estimated 10 L of water escaped from the closed overhead access door and ran onto the ground.	Upon discovery, the water was removed from the line. The majority of the 50 L of released water was contained within the building and the basement sump for recovery. Spill pads, socks and absorbent were used to absorb water that had run onto the ground. Affected aggregate material was removed using heavy equipment and placed on the mill ore pad. Absorbent pads and socks were sent to the contaminated landfill at the above ground tailings management facility for disposal. A gamma grid survey of the area was completed following clean -up and the average reading recorded from within the spill areas was 0.07 μSv/hr.	Low
Key Lake operation	January 9, a sample valve on well head D-33 froze and cracked resulting in well water being released onto and across the adjacent road towards the Deilmann tailings management facility. During thawing of the valve, the housing cracked and began to leak as a result of residual pressure.	The well head was isolated. A water sample was collected for analysis. Approximately 60 m^3 of sand, snow and ice was removed to ensure effective clean-up. Confirmation radiation scanning was completed in the affected area confirming effective clean-up. The work instruction for dewatering well valves was updated to include procedures for operation during irregular circumstances and normal circumstances.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake operation	March 5, approximately 1,000 kg of isodecanol was released to the ground. An employee was transporting a tote of isodecanol with a forklift. The operator encountered uneven ground due to a build-up of snow. The tote slipped off the forks and onto the ground and the tote cracked and the contents spilled onto the ground.	The free-standing product was cleaned up and the affected area was scraped with a loader. Material was placed at the hydrocarbon landfarm for disposal. The snow that caused the uneven ground was removed. The associated work instruction was updated to ensure that totes are strapped to the forklift.	Low
McClean Lake operation	March 27, a tote containing approximately 1,200 L of isodecanol fell off a forklift during transportation and broke open releasing all of the contents onto the mill terrace.	The free-standing product was cleaned collected and the affected area was scraped with a loader. Material was placed on the hydrocarbon landfarm for disposal. The current work instruction (for handling reagent, lube or oil tote containers) will be revised.	Low
McClean Lake operation	April 12, a strong gust of wind picked up an estimated 5 kg of foam from the surface of the tailings thickener tank and deposited the material over an area of approximately 400 m^2.	Approximately 12 m^3 of affected soil and snow was scraped up and disposed of into the temporary contaminated landfill. A grid gamma survey was conducted post clean-up with no readings exceeding 0.5 μSv/hr above background levels. Operational controls were implemented to prevent the generation of foam on top of the tailings thickener. A long-term engineering solution is being pursued in 2016.	Low

Facility	Details	Corrective actions	Significance rating
McClean Lake operation	On May 8, less than 0.5 kg of noncalcined yellowcake was released when a contaminated pipe spool was removed from the precipitation circuit and relocated outside the solvent extraction building. Non-calcined yellowcake fell from the spool onto the ground during unloading.	The affected ground was scraped up and brought to the mill for disposal. A visual inspection of the ground followed and a radiation gamma survey was performed confirming that there were no values above background radiation levels	Low
McClean Lake operation	On October 28, approximately 3 L of anhydrous ammonia was released. An operator noticed a slow drip from the sight glass of a flow metre between the anhydrous ammonia tank and the vaporizer. The operator did not notice any unusual odours.	The operator placed a pail under the flow meter to prevent further release to the ground. The seal on the flow metre sight glass was replaced. The affected ground was cleaned up and placed into the hydrocarbon landfarm. Soil samples were collected. Further clean-up was to be completed in summer 2016.	Low
McClean Lake operation	On December 8, approximately 50 L of slurry rinse water was released when a plugged line caused a flow switch to malfunction. Subsequently this caused a step in the slurry offload sequence to fail resulting in slurry rinse water exhausting from the vacuum pump exhaust. In addition, a high-level alarm did not function as intended.	The line blockage was removed and the flow switch was changed out. The affected area was cleaned up and disposed of on the JEB ore pad. A grid gamma survey was completed post clean-up with no readings exceeding 0.5 µSv/hr above background levels. The high-level alarm (nuclear gauge) was changed out.	Low

Table G-2: CNSC spill rating definitions

Functional area	Radiation protection		Environmental protection	
SCA/safety significance	**Definition**	**Directorate-specific examples**	**Definition**	**Directorate-specific examples**
High	Exposures to multiple workers in excess of regulatory limits. Widespread contamination to several persons or to a place.	Incident that results in, or has reasonable potential for, a worker to exceed regulatory limits. Example: ▪ NEW exceeding 20 mSv/year or 100 mSv/5 years ▪ Non-NEW exceeding 1 mSv	Nuclear or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or that results in significant impact to the environment.	Incident that results in, or has reasonable potential to have, a significant or moderate impacts or extensive future remediation. Example: ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish bearing water ▪ fish kill
Medium	Exposure to a worker in excess of regulatory limits. An incident that would result in a licensee exceeding action level. Limited contamination that could affect a few persons or limited area.	Incident that results in or has reasonable potential to exceed an action level. Example: doses to workers of 1 mSv/week or 5 mSv/quarter	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that results in impact to the environment outside the licensing basis.	Incident that results in, or has reasonable potential to have, a minor impact or requiring some future remediation. Example: ▪ effluent action level exceedance ▪ spills to environment (including atmosphere) with short-term or seasonal impacts

Functional area	Radiation protection		Environmental protection	
SCA/safety significance	**Definition**	**Directorate-specific examples**	**Definition**	**Directorate-specific examples**
Low	Increased dose below reportable limits. Contamination that could affect a worker.	Incident that results in, or has reasonable potential to exceed, the highest administrative level.	Release of hazardous or nuclear substances to the environment below regulatory limits.	Incident that results in, or has reasonable potential to have, a negligible impact. Example: ▪ effluent administrative level exceedance ▪ spills to environment (including atmosphere) with no future impacts

APPENDIX H: LOST-TIME INJURIES

Table H-1: Uranium mines and mills – lost-time injuries (LTIs), 2015

Facility	Incident	Corrective action
Cigar Lake operation	On January 20, while a contractor was loading a tank onto the flat deck area of a truck, the contractor was checking the cable tension used to hold the tank in place. Simultaneously, the operator of the truck activated the hydraulic travel locking mechanism that holds the base of the tank in place during transport. While standing on the flat deck, the operator's foot was in the path of the travel lock, resulting in the lock closing on the foot, inflicting a crush injury to the worker.	The subsequent investigation resulted in the modification of the procedure used by the contractor for this activity to require visual confirmation by the operator of the controls that there are no obstructions to the path of the travel lock prior to activating its hydraulics. This became an internal requirement for the organization as a result of this injury.
Cigar Lake operation	On February 26, two contractor workers were attempting to disassemble a reamer head using two large pipe wrenches. One individual was applying force to the wrenches to break the joint, and the other was providing support to the reamer itself. While applying force to the wrenches, one of the wrenches broke loose, striking one of the individuals in the jaw.	As a result of this injury, a new hydraulic tool complete with protective guards was designed, tested and found to perform the task in a much safer manner. The use of this new tool became mandatory for this task throughout the contractor company.
Cigar Lake operation	On November 23, Cameco was notified that a claim of injury was accepted by the Saskatchewan Workers' Compensation Board for carpal tunnel syndrome. The employee required surgery to correct this medical condition. Even though no issues were ever raised by the worker at the site health clinic, and no history of injury was present, the claim was accepted based on the type of long-term activities the worker was involved in as part of their duties.	As this was an unusual circumstance not normally seen by individuals performing the type of work the individual conducted at Cigar Lake, there were no corrective actions implemented as a result of this LTI.

Facility	Incident	Corrective action
Cigar Lake operation	On August 3, an employee sustained an injury when a metal lid on a storage bin closed on the worker's wrist. Initially, this injury was treated with first aid injury only. Further medical assessment a month later resulted in the injury being elevated to a restricted work injury. Due to continued issues related to the injury, the individual participated in a multidisciplinary assessment. This external assessment was completed on May 25 and 26, 2016. This assessment resulted in the recommendation that the worker participate in a four-week secondary program, which requires physical rehabilitation for four weeks, five days a week, four hours per day. Due to this recommendation the worker lost time due to the injury, starting June 20, 2016. The secondary program is expected to allow the worker to return to full, non-restricted duties by mid-July 2016.	Extensive work was completed with this employee to ensure that all restricted work activities were in line with recommendations from external medical assessments to help rehabilitation of the injury. Also, once results of the multidisciplinary assessment were known, work was conducted to determine if any viable options were available for the secondary assessment to be completed within the routine work schedule. No viable options were available. Therefore, arrangements were made for the worker to attend the physical rehabilitation as recommended.
McArthur River operation	There were no LTIs at McArthur River in 2015.	Not applicable.

Facility	Incident	Corrective action
Rabbit Lake operation	On March 23, a driller was struck by a core tube while drilling on 400 L. While preparing to pull the core tube, the driller removed one drill rod with the water swivel attached, and at that time, the next core tube slid out of the open hole and struck the driller's upper left thigh, temporarily pinning the driller to the ground. The injury required offsite treatment and surgery. Results of the investigation found two causal factors: 1) A mid-run miss-latch of the inner core tube head assembly from locking coupling occurred. A miss-latch is not a frequent occurrence, but latch failures do occur and may occur several times a year in a drill program. While the specific mechanism of failure could not be fully confirmed through the investigation, the miss-latch was a causal factor to the injury. 2) The driller did not follow the written work procedure. Although the worker was experienced, the worker did not follow procedures in the event of a miss-latch occurrence.	The driller managed to move the rod off their leg and called for assistance from the vehicle's radio. The medical response team was dispatched. It stabilized and transported the driller to surface into the care of the site nurse until medical evacuation was possible. Cameco has undertaken two corrective actions related to this event: 1. A review of the proper inspection procedures for inner core tube head assemblies with all drill crews, and will reinforce the pre-use inspection requirements. 2. A review of the procedures for up-hole drilling and core retrieval with all drill crews in the context of the event, with emphasis on the hazards and procedural controls.
Rabbit Lake operation	On February 14, a mill operator slipped on a newly painted area in the mill. The worker's shoulder became dislocated as a result of reaching out to break the fall. The investigation determined that the paint used was unsafe on this surface area due to its smooth finish. A change in the work area, present hazards and situational awareness was not recognized.	Based on the causal factors identified, Cameco undertook two corrective actions related to this event: 1. The area was barricaded to limit further access to the painted area until a non-slip paint/surface finish was applied. 2. The incident investigation was reviewed with the workers to share the importance of identifying changes to the work area and potential hazards associated with improvements or changes to the work site.
Key Lake operation	There were no LTIs at Key Lake in 2015.	Not applicable

Facility	Incident	Corrective action
McClean Lake operation	On July 16, a worker was engaged in normal duties, breaking excess material away from the doors to the calciner hearth. Some of the material fell out of the hearth, and into the worker's boot. This resulted in first, second and third degree burns to the foot, as well as a uranium in urine administrative level exceedance. The worker has subsequently returned to work resulting in 27.5 lost work days.	During the investigation into the event, operating parameters for the calciner centrifuges were examined to ensure optimal operating effectiveness eliminating the build up and thereby eliminating the risk at the source. Additional preventive actions included a revision to the work instruction for performing the hearth checks task with training for all workers performing this task. Workers in this area are now required to wear specialized heat protective clothing when opening the calciner hearth doors.
McClean Lake operation	On July 30, a contract worker was engaged in the non-routine duty of preparing a disabled truck for transport offsite. The truck had been loaded onto the trailer of another truck for transport. While standing on the step of the truck, which was then on the trailer, the driver slipped and fell approximately 10 feet to the ground, landing on their ribs and elbow. The worker returned to work following 17 lost work days.	During the investigation, the following corrective actions were identified and implemented: minimize the height differential for drivers when they tarp or secure loads. Depending on the situation, this will be accomplished in one of the following ways: • pull up beside another flat deck trailer to create a stage • utilize wheeled stairs with handrails • utilize an aerial work platform • utilize fall protection when a minimized height differential is not possible. As well, drivers will be trained in the job-specific expectations of McClean Lake's Integrated Quality Management System, as well as educated on whom to contact to retrieve equipment they require to do the job safely.

Facility	Incident	Corrective action
McClean Lake operation	On November 23, an AREVA worker was transporting an inoperable Points North Bus to the McClean Lake operation to be repaired. The bus had no heat and an inoperable radio. The employee was not dressed appropriately for the weather. The trip back to the McClean Lake operation took 80 minutes. The employee suffered frostbite to the feet. The employee completed the remainder of the work shift but was not able to return to work after seeking further medical attention during the week off. The employee lost 14.5 days of work in 2015 and returned to work on March 10, 2016. There was a total of 34.5 lost work days.	An investigation into this injury resulted in the following preventive actions: • emergency winter kits have been placed in the buses that travel offsite • work winter gear has been ordered for each bus driver to have available while operating the buses • the existing work instruction for vehicle towing was reviewed with employees, emphasizing the requirement for a proper radio check prior to commencement of towing

APPENDIX I: RADIOLOGICAL ACTION LEVEL EXCEEDANCES

Table I-1: Uranium mines and mills – radiological action level exceedances in 2015

Facility	Action level exceedance	Corrective action
Cigar Lake operation	None in 2015	Not applicable
McArthur River operation	Weekly and Quarterly Action Level: January 6, a raise bore operator received 4.725 mSv radon progeny and long-lived radioactive dust on their January personal alpha dosimeter and a total of 5.5 mSv for the quarter, which exceeds the quarterly action level of 5.0 mSv.	The worker was assigned low-dose work for the remainder of 2015. A daily radiation safety topic was created to address the placement of Prisms (continuous air monitors). Work instructions were updated to include "pigging" the hole to prevent upcasting from open raises.
McArthur River operation	Weekly Action Level: On September 30, five workers received doses on their September personal alpha dosimeters that were in excess of the weekly action level. The total dose for the year for impacted workers ranged between 5 and 7.4 mSv. The dose received to each worker as a result of the incident ranged between 1.9 to 3.7 mSv. A review indicated the workers received their exposure while backfilling a sloughing raise on the 500 level.	The workers were placed on a work plan for the remainder of 2015. The remaining back filling was completed under SCBA. A TapRoot investigation was carried out by Cameco's corporate offices in addition to the site investigation. Work management plans for impacted employees were implemented. Radiological sampling in affected areas was increased from one to four times daily. Two safety stand downs were scheduled and carried out.
Rabbit Lake operation	None in 2015	Not applicable
Key Lake operation	Weekly Action Level: On January 14, a hole in the main calciner shaft allowed uranium ore concentrate to enter and pass through the crystallization circuit and enter the work space. Uranium analysis indicated 13 workers had a uranium uptake, and five of those were assigned an effective dose of greater than 1 mSv, with results ranging from 1 to 1.89 mSv/week.	A safe start-up plan was developed and reviewed by CNSC staff. Site management committed to monitor the uranium concentration of the ammonia sulfate crystals once every 12 hours. Radiation monitoring was amended to include five personal air samples for the yellowcake calciner operator each month, a weekly contamination swipe in the control room and an additional monthly area sample in the yellowcake calciner/crystallization building. This incident was combined with the February 19, 2015 incident. A TapRoot investigation was performed.

Facility	Action level exceedance	Corrective action
Key Lake operation	Weekly Action Level: On February 19, calcined uranium ore concentrate was found on the floor of the fourth floor of the yellowcake building. It was determined that the material came from a leak in the calciner exhaust duct. Enhanced urine bioassay sampling confirmed that one worker received a weekly total effective dose of 1.16 mSv exceeding Key Lake's radiation code of practice action level exceedance reporting of 1 mSv/week effective dose.	A safe shutdown was initiated. A multi-point repair plan was put in place to repair the damaged ducting and expansion joints as well as to address the causes of the break. An inspection port was added to the ducting to allow annual internal examination. A safe start-up plan was developed and included operator care round inspections, area airborne uranium ore concetrate sampling and surface contamination swipe monitoring for a period of three days. This incident was combined with the January 14 incident and a TapRoot investigation was performed.
Key Lake operation	Weekly Action Level: On April 15, a worker was performing tasks to obtain target weights on packaged calcined uranium ore concentrate drums. The worker failed to complete all work instruction steps and radiation work permit before removing their personal protective equipment. A potential uptake of uranium was detected in the post-work urine sample. The worker was assigned a dose for the event of 1.94 mSv, and dose for the quarter of 2.64 mSv.	The worker was restricted from performing tasks requiring a radiation work permit for the remainder of the week of the event. A review of the on-boarding process will be completed to ensure that new tasks are reviewed with the supervisor prior to the worker initiating the task.
McClean Lake operation	Weekly Action Level: In May, while clearing material from the calciner, a worker wearing a personal powered air purifier was exposed to a high level of uranium concentrate dust. Following analysis of the worker's personal alpha dosimeter, and application of the approved respirator protection factor, the worker was assigned a dose of 1.6 mSv for the non-routine work conducted in the calciner over a one week period.	An interlock system was installed in the calciner to prevent product feed when the lump disintegrator is inoperable. An industrial vacuum system MegaVac, was installed in the area, and applicable work instructions were reviewed and updated.

Facility	Action level exceedance	Corrective action
McClean Lake operation	Weekly Action Level: In June, an operator in the slurry receiving circuit recorded a radon progeny and long-lived radioactive dust result on their personal alpha dosimeter of 2.86 mSv. Improper performance of routine tasks, as well as inadequate work instructions were identified as causes.	The operator was provided additional coaching, and work instructions were updated to provide clear instructions on the slurry line transfer job.

APPENDIX J: CLUFF LAKE MID-TERM UPDATE, 2009–15

Operations at Cluff Lake ceased in 2002. The CNSC provided approval for decommissioning in 2004 and the majority of physical decommissioning was completed between 2004 and 2006. This report focuses on decommissioning advances over the licence period from 2009 to present. The CNSC's continued oversight is to evaluate and prevent unreasonable risk to the environment in a manner that is consistent with Canadian environmental policies, acts and regulations and with Canada's international obligations. The report is heavily informed by four technical documents (i.e., the Environmental Performance Technical Information Document volumes 1 and 2, the Hydrogeology and Groundwater Modelling Technical Information Document, and the Follow-up Program Report) that were submitted by AREVA in 2015. The documents outline advancement or resolution of uncertainties and the current and future predicted environmental performance of the site.

From 2009 to 2013, activities onsite were largely limited to environmental monitoring with minor care and maintenance activities (e.g., erosion repairs and revegetation). In 2013, much of the remaining infrastructure at Cluff Lake was decommissioned, including the secondary treatment system (STS). During this timeframe, environmental monitoring transitioned to quarterly campaigns and the continuous site presence was discontinued.

The following work activities occurred at the STS location:

- demolition of the STS plant
- demolition of a small storage shack near the STS plant
- covering debris placed in the former B1 pond
- decommissioning of the A1 and A2 ponds

Prior to decommissioning the STS plant, AREVA removed the remaining reagents and disposed of them offsite. The STS plant and small storage shed were demolished and the concrete floor slab was perforated with a hydraulic hammer. The debris from the demolition of the STS plant and small storage shack was placed in the former B1 pond. AREVA placed a minimum of 1 metre thick glacial till cover over the former B1 pond and the concrete foundations of the STS plant. The area was then revegetated using a seed mix previously used in tailings management area (TMA) reclamation activities.

At the end of 2013, AREVA discontinued a full-time presence at the Cluff Lake site and transitioned to campaign monitoring. The first monitoring campaign took place in December 2013. Subsequent campaigns are conducted in March, June, September and December annually.

Environmental risk assessment

In 2015, CNSC staff reviewed the Cluff Lake Project Environmental Performance and Environmental Risk Assessment Update technical information documents to determine whether the environmental performance is consistent with that predicted in the Cluff Lake Project Decommissioning Comprehensive Study Report completed in 2003, and the 2009 Environmental Risk Assessment update predictions of no unreasonable risk to the environment or human health.

CNSC staff reviewed AREVA's monitoring results to verify that air, surface water and sediment quality measurements were within predictions made in the comprehensive study report and the environmental risk assessment. The environmental risk assessment was updated using monitoring data collected from 2009 to 2014. Results continue to show that the environment is recovering from historical impacts and no unreasonable risk to the environment or human health is predicted to occur in the future.

The main findings of the CNSC staff review are that:

- Radon concentrations are at background levels and are consistent with the model predictions that were presented in the Cluff Lake Decommissioning Comprehensive Study Report.
- Terrestrial contaminant levels are similar to background contaminant levels. Some indicators of a mining/milling footprint surrounding Island and Snake lakes can be observed, although contaminant levels remain well below the Canadian Environmental Quality Guidelines for soil for residential/parkland land use.
- Vegetation has established on the Claude waste rock pile and the TMA. The vegetation cover is currently preventing erosion and reducing infiltration.
- Measured concentrations of contaminants in surface water and sediments of lakes downstream of the decommissioned site are generally within the peak predictions made in the comprehensive study report (2003).
- Updated conservative modelling using improved modelling tools predicts surface water and sediment activity of radium-226 in the Snake Lake/Island Lake receiving environments and the concentration or activity of several contaminants in the Claude Lake/Claude Creek/Peter River receiving environments to be higher than earlier predictions.
- Concentrations of radiological and hazardous substances in surface waters are below the decommissioning objectives. Human health risks therefore remain low.

CNSC staff conclude that the current environmental performance of the former Cluff Lake operation is within predictions made in the Cluff Lake Decommissioning Project Comprehensive Study Report. CNSC staff concluded that the environment and the human health are adequately protected.

Tailings management area dam

The Cluff Lake TMA has been decommissioned. The tailings are consolidated, dewatered and covered with an engineered dry cover. AREVA revegetated the cover to reduce water infiltration and shaped the surface to direct runoff water to purpose-built channels. The main dam was buttressed and the exterior slope was reduced to increase the erosional stability of the slope. The dam no longer retains a surface pond as it did during operations and only retains clay-like material.

CNSC staff verified and confirmed that the TMA dam at Cluff Lake followed the best available technologies as recommended by the Mount Polley expert panel.

Follow-up program

A follow-up program was created in 2003 to address uncertainties with the environmental assessment program. The follow-up program results are to inform of the potential need for any contingency measures to ensure that the environmental effects remain acceptable and to validate other monitoring and modelling results. AREVA submitted its final follow-up program report in 2015.

Claude waste rock pile cover performance

AREVA built a cover over the Claude waste rock pile to reduce water infiltration, thus lowering the transport of contaminants to the groundwater and surface water. The follow-up program identified the need to validate the infiltration rate used in the modelling once the cover was in place. AREVA installed instrumentation in 2006 and has monitored the cover continuously since. The area was seeded and vegetation established. The cover performance data collected since 2006 was used to update the groundwater flow and contaminant transport models. The cover is performing as designed and vegetation is preventing erosion.

Claude Lake sediments

Claude Lake, a shallow, non-fish bearing lake with an average depth of 1.2 metres, is slowly filling up with sediments and progressing into a wetland. The lake is characterized by submerged and emergent aquatic vegetation and contains a significant layer of organic sediments as thick as 2 metres. AREVA postulated that the organic carbon content of the sediments as modeled was sufficient to mitigate the potential constituents of potential concern released from the Claude waste rock pile flowing through Claude pit and into Claude Lake.

CNSC staff verified the results from field programs conducted to date and from the column testing studies. They confirmed that attenuation by the sediments is occurring along the flowpath from Claude pit to Claude Lake.

Peat trenches

The initial aim of this component of the follow-up program was to test a permeable reactive barrier as a potential supplementary structure to remove the groundwater contaminants before they reached aquatic environments. AREVA constructed two different barrier designs southwest of the Claude waste rock pile. Based on the data, AREVA concluded that the first trench design was not trapping contaminants (e.g., nickel) as expected. The second trench design displayed limited success. The barrier was effective in the short-term, but is not considered effective at sequestering contaminants in the long-term. As these trenches were installed to study the usefulness of the structure in cold climate, the contaminant transport model does not consider any removal resulting from the installation of these barriers. Although this project has limited success, the knowledge gathered during this study will improve any future implementation of this form of technology.

DJX pit water quality

When the DJX pit was flooded, it was assumed that a chemocline would form, as it did in other previously flooded open pit mines in western Canada. This means that a layer of clean water permanently maintains the lesser quality water at the bottom of the water column. Water monitoring since the pit flooding shows that the chemocline has formed, and results demonstrate that water quality continues to improve. The water at the surface, one-sixth and one-third depths met Saskatchewan's Surface Water Quality Objectives for all constituents with the exception of uranium. The uranium concentration meets the decommissioning surface water quality objectives throughout the water column.

Tailings management area cover performance

AREVA installed a cover over the TMA to eliminate direct surface exposure and minimize water percolation through the tailings to reduce the drainage migration of contaminants. The cover was vegetated with local species. Additional work was required over the years to improve drainage as water was found to be pooling in some areas. The seeded area is now on a natural revegetation trajectory. The uncertainties have now been addressed and AREVA routinely updates the groundwater flow and contaminants transport models using the infiltration data collected.

Island Lake fen's long-term ability to sequester contaminants

Island Lake is the primary water body that received effluent during the operation of the STS facility. The fen acts as a natural filter before drainage reaches Island Creek. As such, it accumulated a substantial contaminant load during the operating period. In 2003, CNSC staff raised concerns regarding the rate of release of these constituents of potential concern. Field investigations show that the Island Lake fen has limited, and continues to limit, the transport of constituents of potential concern. Moreover, different sections of the fen capture different constituents. It was identified that uranium and molybdenum form very strong associations with organic matter. CNSC staff verified and confirmed that geochemical and contaminant transport modelling support the conclusions of the field investigation.

Baseline wildlife and aquatic investigation survey

AREVA performed wildlife and aquatic baseline surveys to assess the success of reclamation activities and measure the recovery of the Island Lake system. Although CNSC staff observed some minor changes in the aquatic population since the end of decommissioning, they concluded that the environment and human health are not endangered by the current contaminant releases from the former Cluff Lake operation. CNSC staff will continue to survey the evolution of wildlife and aquatic population and monitor how the populations are adjusting to the decommissioning work.

Other follow-up program studies

Other studies were performed under the follow-up program to confirm or refine the transport or risk assessment modelling. These included:

- Source Term Verification Model Validation – Additional monitoring was incorporated to verify the source terms in the Claude mining area. The subsequent model update incorporated several improvements that enabled the model to more accurately reproduce observed groundwater flow conditions with low calibration error.
- Claude Pit Pore Water Quality – Additional information was gathered to better characterize the Claude pit pore water quality. The refined source term was used to update the groundwater modelling and ecological risk assessment.
- Tailings Pore Water Source Term – Refined source terms for the TMA were used to address uncertainties and update the transport model.
- Groundwater Flow System Monitoring – The updated groundwater model has improved upon the model developed for the comprehensive study for decommissioning. It addresses previous uncertainties and may be reliably used as a predictive tool for evaluating long-term contaminant transport.
- Toxicity Testing for Uranium – Due to the continued uncertainty associated with the potential influence of water hardness as a modifying factor for uranium toxicity, the uranium water quality guideline of 15 µg/L was used as a conservative screening tool in the updated environmental risk assessment.
- Selenium and Fish Reproduction – Overall, the results suggested that concentrations of selenium in fish tissue are beginning to recover from past operational treated effluent release, and indicated that fish reproduction should not be impaired.
- Risk to Wildlife Resulting from Chronic Exposure to Uranium and Molybdenum in the Island Lake Drainage – Site-specific data for constituents of potential concern in sediment, benthic invertebrates, fish and terrestrial and aquatic vegetation in Island Lake and nearby reference and exposure lakes were used to develop a quantitative decommissioning terrestrial wildlife baseline. This information was then used to update the environmental risk assessment provided in the Environmental Performance Technical Information Document.
- Tailings Vault Temporary Storage Area – Soil and vegetation monitoring as well as gamma radiation surveys were conducted. Results confirmed that the area poses no risk and clean-up objectives have been met.
- Groundwater Near Landfill Areas – Monitoring confirms that no seepage is coming from these sites with the potential to affect groundwater quality or water quality in downstream surface water receptors. The areas are performing as expected.
- Borrow Pit Northeast of Former DJN Waste Rock Pile – Geotechnical inspections completed after the backfilling found the site to be in good condition. Vegetation growth has been substantial in the area. No water accumulates at the surface making the area safe for wildlife.

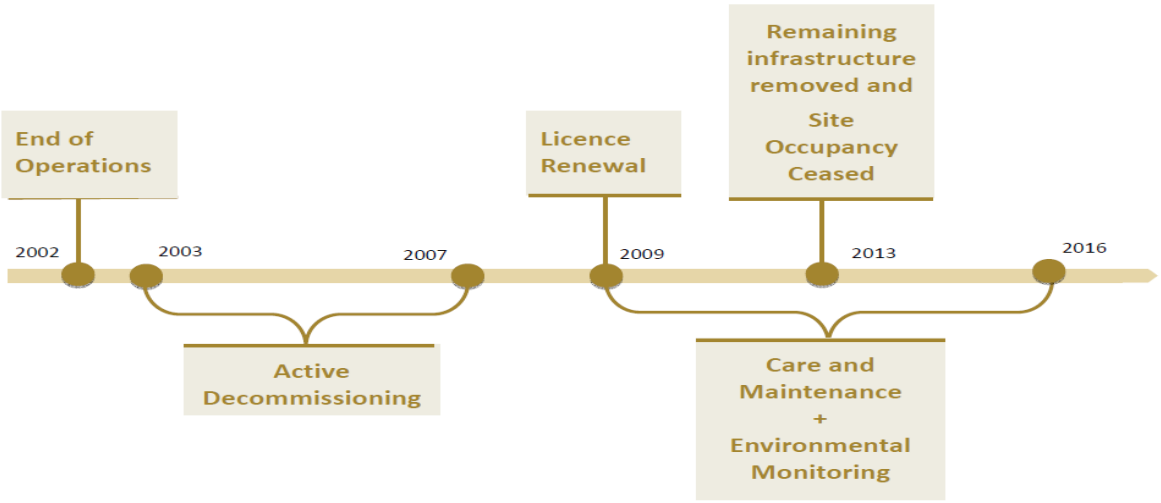
CNSC staff reviewed the results of the studies listed above and have no concerns.

CNSC staff concluded that the current environmental performance of the former Cluff Lake operation is within predictions made in the Cluff Lake Decommissioning Project Comprehensive Study Report. They concluded that the environment and the human health are not exposed to unreasonable risks from the former Cluff Lake operation.

Detailed activities, 2009 to 2015

The information provided below further describes detailed activities as part of the care and maintenance and environmental monitoring timeframe. Figure J.1 provides a timeline of activities during the decommissioning process.

Figure J.1: Cluff Lake – timeline of decommissioning process



2009

Between June and September 2009, AREVA applied 39 tonnes of fertilizer to the TMA and Claude waste rock pile areas. Revegetation activities in 2009 included grass fertilization, hydroseeding and tree planting. Some isolated patches were hydroseeded throughout the TMA.

From June 24 to June 28, AREVA planted trees in eight areas of the mine site (mainly secondary roads).

AREVA performed repair of erosion gullies and cover maintenance on the TMA. Clean till was hauled and placed throughout the TMA and the main dam abutment. The areas were hydroseeded following repairs to promote faster grass development.

2010

Following recommendation by consultants, AREVA stopped fertilizing the TMA and Claude waste rock pile to allow the grass cover to develop a natural succession cycle.

The 2010 maintenance activities consisted of:

- removing two south diversion ditch channel crossings
- covering areas surrounding the newly drilled wells through the TMA
- regrading low areas along the TMA road
- repairing the erosion of the Claude waste rock pile access road

Revegetation activities for 2010 consisted of hydroseeding:

- the slopes created by the removal of the two channel crossings
- any patches of poor growth around the TMA
- the Claude waste rock pile access road

An August 2010 inspection by CNSC staff confirmed that there was a decrease in vegetation cover and an increase in litter (e.g., dry and dead vegetation).

2011

AREVA surveyed the seeded and planted areas of the Cluff Lake project in early September 2011. In general, the forb cover on the seeded areas of the Claude waste rock pile and tailings management area remained low. From 2009 to 2011, litter cover (e.g., dry and dead vegetation) had increased and graminoid cover decreased in both areas. The decrease in graminoid cover was anticipated with the termination of fertilization.

The survey of trees and shrubs in planted areas revealed a substantial increase in the number of saplings as a result of natural establishment.

2012

AREVA pumped water from the north diversion ditch to the culvert near the cobble dam and filled some low-lying areas on TMA surface with clean till. Approximately 200 m^3 of till was placed on two areas of the TMA where pooling water was observed. Due to time, personnel and equipment limitations, further covering was postponed to 2013.

2013

In 2013, the remaining infrastructure at the Cluff Lake project was decommissioned. AREVA discontinued a full-time presence at the project site and transitioned to campaign monitoring. The first campaign took place in December 2013.

AREVA completed comprehensive gamma radiation clearance surveys in each infrastructure dismantled. The infrastructures passed radiological clearance criteria, demonstrating that the residual radiological risk is minimal. CNSC staff reviewed and approved the results of the gamma surveys.

TMA activities

Activities at the TMA primarily included earthwork to improve drainage in the area and lower the water table elevation. They also included:

- filling in several low areas near the divider dyke with glacial till
- adding fill to a ponded area upstream of the former fresh water diversion dam
- closing the swamp ditch
- regrading a short section of the north diversion ditch
- removing culverts from the north and south diversion ditches

Secondary treatment system activities

The STS plant had not been used for several years. It was demolished in 2013, and the following activities took place:

- demolition of the STS plant
- demolition of a small storage shack near the STS plant
- covering debris placed in the former B1 pond
- decommissioning of the A1 and A2 ponds

Prior to decommissioning the STS, AREVA removed the remaining reagents and disposed of them offsite. The plant and small storage shed were demolished and the concrete floor slab was perforated with a hydraulic hammer. Demolition debris was placed in the former B1 pond. A minimum of 1 metre thick glacial till cover was placed over the former B1 pond and the concrete foundations of the STS plant. The area was then revegetated using a seed mix previously used in TMA reclamation activities. The B2 pond does not contain a liner and was retained for a time for contingency water storage.

For decommissioning of the A1 and A2 ponds, the pond liner material was cut from the slopes and folded onto the pond floor. The folded liner and pond floor were then perforated using an excavator. A minimum 1 metre thick glacial till cover was placed over the A1/A2 ponds and graded to provide positive drainage. Riprap was installed at the runoff discharge point and the area was revegetated using a seed mix previously used in TMA reclamation activities.

Warehouse demolition

Warehouse demolition included:

- demolishing the cold storage and warehouse buildings
- breaking and covering the concrete floors
- demolishing the existing gasoline and diesel tanks

Demolition occurred in August 2013. Upon completion, the concrete floor slabs were perforated using a hydraulic hammer and a glacial till cover was placed on the slabs.

The warehouse area fuel tanks included two diesel tanks and one gasoline tank, each with a volume of 20,000 US gallons. Residual fuel was removed from the tanks and each tank was ventilated prior to demolition. The tanks were pulled over using an excavator and skidded to the landfill using a loader. At the landfill, an excavator was used to flatten the tanks prior to disposal. Following removal of the tanks, approximately 0.5 metres of subgrade beneath the tanks was removed and disposed of in the hydrocarbon land farm. Confirmation testing of subgrade materials was completed by AREVA.

Tower demolition

The communication tower near the former mill site, the airport beacon tower near Cluff Lake project center and the former communication tower near the South Gate were demolished and disposed of in the landfill. Prior to demolition, the surrounding buildings were removed and the electrical isolation of each structure was confirmed. A safety line was attached to each structure to control the direction of fall. Clean-up and minor regrading took place at each location after demolition.

Claude pit area

Three horizontal finger drains were installed across the ring-dyke road west of Claude pit in August. The purpose of the drains is to breech the barrier to groundwater movement created by the ring-dyke, thereby reducing the groundwater elevation in the area and the possibility of groundwater surfacing during periods of high precipitation.

Each trench was approximately 20 metres long, 3.5 metres wide and 2 metres deep. The drains extend approximately 3 to 4 metres into Claude Lake. Each trench was filled with gravel with a particle size below 50 millimetres. Following backfill, the lake bed organic materials were replaced above the gravel within Claude Lake, and the glacial till materials from the roadway were replaced above the gravel crossing the road.

A small steel building located adjacent to the Claude waste rock pile was also demolished and disposed of in the landfill.

Culvert removal

AREVA completed the removal of site culverts from the following locations as per the culvert removal design:

- Boulder Creek (downstream)
- Earl Creek (airport, batch plant, and main road)
- Peter River (main road)
- Claude Creek
- Lost Knife Creek

Removal of site culverts included excavation, culvert removal, stream bed and stream bank reconstruction, and the installation of sedimentation controls. Throughout these activities, AREVA personnel monitored upstream and downstream turbidity. To facilitate future access, channel side slopes were flattened at the Earl Creek airport and batch plant locations, Claude Creek and Lost Knife Creek.

Culverts at Beaver Creek, Boulder Creek upstream, Germaine Camp and Cluff Creek were left in place to facilitate year-round access to the site.

Camp demolition

Camp demolition involved the removal of the remaining residence buildings:

- the kitchen
- the recreation hall
- the potable water and sewage treatment plants
- the office trailers
- the ancillary structures such as generator and storage buildings

AREVA removed salvageable material from the buildings and isolated the electrical, pneumatic, mechanical and fuel sources. The buildings were demolished using an excavator and debris was hauled to the domestic landfill. Minor regrading of the former building areas was completed after demolition.

Landfill expansion

In order to accommodate the disposal of clean demolition materials, a domestic landfill expansion was required. All clean material from decommissioning was placed in this landfill. In May, the CNSC accepted AREVA's proposal to place radiologically contaminated material in the former B1 pond. Materials placed in the B1 pond included heavy equipment, vehicles and other miscellaneous equipment. These materials were historical mining and milling items that were not inherently radioactive, but which did not pass criteria for unrestricted future use. Materials resulting from the demolition of the STS building were also included in this disposal plan. Upon completion of disposal, the B1 area was covered with clean fill.

Campaign monitoring

Permanent site presence at the Cluff Lake project was discontinued in September 2013, and environmental monitoring has been transitioned to quarterly campaigns.

The first round of campaign monitoring took place from December 2 to 8, 2013, and was completed by Canada North Environmental Services under the supervision of AREVA.

2014

Environmental monitoring was successfully transitioned to quarterly campaigns. The first full year of campaign monitoring occurred in 2014.

Environmental monitoring campaigns of the Cluff Lake site occurred in March, June, September and December. Additional field work completed at the site in 2014 by AREVA included a cover monitoring inspection, a geotechnical inspection and aerial photos. Campaign monitoring work was completed without injury or environmental incident.

Post-decommissioning environmental performance objectives developed for the Cluff Lake project were achieved. Surface water quality objectives were met in water bodies downstream of areas impacted by mining activities, radiological exposures were low, and landforms were stable.

Monitoring for the Cluff Lake Project Follow-up Program Report and the Environmental Performance report also occurred in 2014 with additional sampling campaigns during March, August, September and December.

2015

In 2015, site environmental monitoring campaigns occurred in March, June, September and December. Surface water quality objectives were being met in water bodies downstream of areas impacted by mining activities, radiological exposures were low, and landforms were stable.

CNSC staff inspected the site annually since 2009 and were satisfied with AREVA's responses to the recommendations that resulted from those inspections. More adjustment of the cover may be required as the TMA settles.

In 2015 AREVA submitted four documents for the CNSC's consideration:

- Environmental Performance Technical Information Document Volume I, which consolidated environmental performance monitoring for the site from all environmental components
- Environmental Performance Technical Information Document Volume II, which updated the human health and environmental risk assessment based on the current understanding of environmental performance
- Hydrogeology and Groundwater Modelling Technical Information Document, which updated the groundwater models for both the mining area and the tailings management area.
- Follow-up Program Report, which closed the program resulting from the decommissioning environmental assessment to address uncertainties in the assessment and verify that mitigative measures are effective and adequate.

CNSC staff participated in AREVA's community engagement tour in northern Saskatchewan which presented the findings of environmental performance assessments and predictions to local stakeholders.

APPENDIX K: LINKS TO WEBSITES

AREVA Resources Canada Inc.

AREVA Resources Canada Inc. – McClean Lake operation

Cameco Corporation

Cameco Corporation – Cigar Lake operation

Cameco Corporation – McArthur River/Key Lake operations

Cameco Corporation – Rabbit Lake operation

Denison Environmental Services

Eastern Athabasca Regional Monitoring Program

Indigenous and Northern Affairs Canada

Ontario Ministry of Environment and Climate Change – Deloro

Saskatchewan Research Council – Gunnar Uranium Mine and Mill Site

APPENDIX L: ACRONYMS AND ABBREVIATIONS

AGTMF	above-ground tailings management facility
ALARA	as low as reasonably achievable
CCME	Canadian Council of Ministers of the Environment
CDWQG	Canadian Drinking Water Quality Guideline
CFM	cubic feet per minute
CMD	Commission member document
CNSC	Canadian Nuclear Safety Commission
COPC	constituents of potential concern
EARMP	Eastern Athabasca Regional Monitoring Program
ECOP	environmental code of practice
ERA	environmental risk assessment
FTE	full-time equivalent
HVAS	high-volume air sampler
IAEA	International Atomic Energy Agency
IC	institutional control
ICRP	International Commission on Radiological Protection
IEMP	Independent Environmental Monitoring Program
INAC	Indigenous and Northern Affairs Canada
LCH	licence conditions handbook
LLRD	long-lived radioactive dust
LTI	lost-time injury
MMER	*Metal Mining Effluent Regulations*
MNDM	Ministry of Northern Development and Mines
MOECC	Ministry of Environment and Climate Change
NEW	nuclear energy worker
NSCA	*Nuclear Safety and Control Act*
ODWQS	Ontario Drinking Water Quality Standards
OMOE	Ontario Ministry of Environment
OSLD	optically stimulated luminescence dosimeters
PAD	personal alpha dosimeters
PDP	Preliminary Decommissioning Plan

PPE	personal protective equipment
RLITMF	Rabbit Lake in-pit tailings management facility
RP	radiation protection
SABRE	Surface Access Borehole Resource Extraction
SCA	safety and control area
SOE	status of the environment
SRC	Saskatchewan Research Council
SSWQO	Saskatchewan Surface Water Quality Objectives
TLD	thermos luminescent dosimeters
TMA	tailings management area
TMF	tailings management facility
TSP	total suspended particulate
TSS	total suspended solids
WFOL	waste facility operating licence