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Annual Program Report

Rapport annuel sur les programmes

**Regulatory Oversight
Report for Uranium
Mines and Mills in
Canada: 2021**

**Rapport de surveillance
réglementaire des mines
et usines de
concentration d'uranium
au Canada : 2021**

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CNSC Staff

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Summary

This Commission member document (CMD) is on the *Regulatory Oversight Report for Uranium Mines and Mills in Canada, 2021*.

This CMD addresses the Commission's action outlined in the record of decision for CNSC staff to continue working with the licensees to increase transparency and make relevant information (except for proprietary information) on the preliminary decommission plan available to the public.

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

Résumé

Le présent document à l'intention des commissaires (CMD) porte sur le *Rapport de surveillance réglementaire des mines et usines de concentration d'uranium et des sites historiques et déclassés au Canada : 2021*.

Le présent CMD concerne les mesures prises par la Commission qui figurent dans le compte rendu des décisions et qui prévoient que le personnel de la CCSN poursuivra son travail auprès des titulaires de permis afin d'accroître la transparence et de mettre à la disposition du public les renseignements pertinents issus des plans préliminaires de déclassement, à l'exception de l'information de nature exclusive.

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

Signed/signé le

08 September 2022



Kavita Murthy

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PLAIN LANGUAGE SUMMARY

The *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2021* provides information about the Canadian Nuclear Safety Commission's (CNSC) work to verify the safety and protection of people and the environment around all operating uranium mines and mills in Canada. All these mines and mills are located in northern Saskatchewan and continued to operate safely in 2021. Monitoring continues to show that the country foods and water surrounding the mines and mills remain safe to eat and drink. There were no releases that could have harmed human health or the environment.

This report provides information on the 5 uranium mines and mills in Saskatchewan for the 2021 reporting period, namely:

- Cigar Lake – uranium mine (operating)
- McArthur River – uranium mine (in care and maintenance)
- Rabbit Lake – uranium mine and mill (in care and maintenance)
- Key Lake – uranium mill (in care and maintenance)
- McClean Lake – uranium mine and mill (operating)

When a site is in a state of care and maintenance, a mine and/or mill is not mining, milling or processing uranium ore, and is not producing uranium concentrate (yellowcake). These facilities still have sufficient staff onsite to complete ongoing maintenance, to maintain and operate water treatment systems, and to conduct environmental monitoring programs for the protection of workers, the public and the environment.

Each year, CNSC inspectors conduct inspections at uranium mines and mills. The number of inspections and the focus of the inspections depend on the performance and operating status of the mine or mill.

The CNSC uses a risk-informed approach when planning inspections and, since March 2020, has adapted its inspections within the COVID-19 pandemic conditions. In March 2020, all CNSC staff were directed to work from home due to measures taken against the COVID-19 pandemic. For this reason, most inspections of uranium mines and mills were conducted remotely. CNSC inspectors used a combination of video conferencing, email and document/photograph review to conduct these remote inspections. Onsite inspections were conducted only when there was a clear need and they could be done safely. This practice continued in 2021.

In 2021, CNSC staff performed a total of 18 inspections across the 5 operating mines and mills. As a result of the inspections, CNSC staff found 19 non-compliances. The operators have addressed all the concerns raised during the inspections.

Although the CNSC evaluates operating nuclear facilities across 14 safety and control areas, this report focuses on the following 3 areas:

- **Radiation protection:** In 2021, the maximum individual radiation dose to a worker at any of the 5 uranium mine and mill facilities was 12.1% of the annual regulatory limit. No workers exceeded their regulatory dose limit.
- **Environmental protection:** Each mine and mill facility uses water as part of the mining and milling process. All water used in the operation must be treated before being discharged back into the environment. In 2021, all discharged water met the federal or provincial discharge requirements, ensuring that people and the environment near the facilities are safe. Licensees also conduct air sampling and vegetation sampling around their sites. All results of the sampling in 2021 were well below the limits set by the environmental quality guidelines. In addition, CNSC licensees are required to report to the CNSC, and other relevant regulatory authorities, any unauthorized release of hazardous substances or nuclear substances to the environment. In 2021, 15 unauthorized releases were reported. These amounts were within the normal range of releases for uranium mines and mills. All releases were corrected by the mine or mill operators and no lasting impacts to the environment resulted from these releases.
- **Conventional health and safety:** Licensees of all mining and milling operations must report any lost-time, workplace-related injuries to the CNSC and provincial agencies. In 2021, 5 injuries required reporting. This is consistent with previous years and injury data from other mining sectors.

As an agent of the Government of Canada, the CNSC recognizes and understands the importance of building relationships with Indigenous peoples in Canada. In 2021, CNSC staff efforts continued to support their ongoing commitment to meeting consultation and engagement obligations and continuing to build relationships with Indigenous peoples with interests in Canada's uranium mines and mills. As a result of recommendations from the Commission, CNSC staff continued to meet with Indigenous Nations and communities before the public consultation period to provide information and seek opportunities for improvement on the regulatory oversight report.

In summary, CNSC staff confirm that:

- workers at each facility were safe and properly protected
- there were no releases that could harm the environment or the health and safety of people
- all water released from the facilities was safe
- airborne radiation was not increased as a result of these facilities' activities
- fish and plants were safe to eat
- COVID-19 did not affect the CNSC's ability to verify the safety of uranium mines and mills

1 INTRODUCTION

1.1 Background

The Canadian Nuclear Safety Commission (CNSC) regulates Canada's 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. This mandate is derived from the [Nuclear Safety and Control Act](#) (NSCA) [1]. Licensees must comply with the NSCA, the regulations made under it, and licence conditions imposed by the Commission which includes specific licence conditions as well as their licensing basis.

CNSC staff would like to acknowledge that the uranium mine and mill facilities within this report are located on Treaty 10 territory, the Homeland of the Métis, and is within the traditional territories of the Dene, Cree, and the Métis peoples.

Each year the CNSC produces a regulatory oversight report on the operating performance of Canada's uranium mine and mill licensees and licensed facilities. This report includes data for the 2021 calendar year for uranium mine and mill sites. Data for historic and decommissioned sites was last presented in the Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2020 [CMD 21-M34](#) [2] and is presented every 3 years.

This report:

- describes the CNSC's regulatory efforts, public information, Indigenous and community engagement activities, and the Independent Environmental Monitoring Program (IEMP)
- includes information on licensee operation, licence changes, major developments at licensed facilities, as well as any significant events
- presents the performance rating for each safety and control area (SCA) for uranium mine and mill facilities regulated by the CNSC
- presents performance data on the radiation protection, environmental protection and conventional health and safety SCAs for each licensed facility

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

- [Cigar Lake Operation](#)
- [McArthur River Operation](#)
- [Rabbit Lake Operation](#)
- [Key Lake Operation](#)
- [McClellan Lake Operation](#)

Throughout the review period, CNSC staff continued to conduct compliance verification activities, including inspections, technical assessments, reviews of reports submitted by licensees, event and incident reviews, and ongoing exchanges of information with the licensees of all uranium mine and mill facilities.

1.2 CNSC Regulatory Efforts

1.2.1 Licensing

The CNSC regulates each uranium mine and mill under a separate licence. A licence granted by the Commission defines licence terms, licensed activities and licence conditions. Tables summarizing the uranium mine and mill licences can be found in appendix A. Each uranium mine and/or mill licence issued by the Commission is accompanied by a licence conditions handbook (LCH) which contains compliance verification criteria used by CNSC staff to determine compliance with the conditions set out in the licence. All changes made to date during the licence term are also provided in appendix A.

1.2.2 Regulatory developments

CNSC staff continue to modernize the regulatory framework with the CNSC's series of regulatory documents. CNSC staff have an effective process in place to implement new regulatory documents once they are approved by the Commission. Licensees continue to be in compliance with the regulatory documents or applicable standards identified in their LCHs during the transition process. The licensees are on track for meeting all established deadlines. CNSC staff continue to monitor progress through regular licensing meetings.

Table 1.1 lists updates made to the CNSC regulatory documents since 2019 including the implementation status, that apply to the uranium mine and mill licensees.

Table 1.1: Regulatory documents applicable to uranium mine and mill facilities

Regulatory document	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
REGDOC-2.2.2, <i>Personnel Training</i> , Version 2 December 2016	Implemented as part of 2021 licence renewal	Implementation to be completed October 2022	Implementation to be completed October 2022	Implementation to be completed October 2022	Implemented
REGDOC-2.10.1, <i>Nuclear Emergency Preparedness and Response</i> , Version 2 February 2017	Implemented as part of 2021 licence renewal	To be implemented as part of next LCH update	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-2.9.1, <i>Environmental Protection: Environmental Principles, Assessments and Protection Measures</i> , Version 1.1, April 2017	Implemented as part of 2021 licence renewal	To be implemented as part of next LCH update	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-1.6.1, <i>Licence Application Guide: Nuclear Substances and Radiation Devices</i> , Version 2, May 2017	Implemented as part of 2021 licence renewal	Implemented	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-3.1.2, <i>Reporting Requirements, Volume I: Non-Power Reactor Class I Nuclear Facilities and Uranium Mines and Mills</i> , January 2018	Implemented as part of 2021 licence renewal	Implemented	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-2.13.1, <i>Safeguards and Nuclear Material Accountancy</i> February 2018	Implemented as part of 2021 licence renewal	To be implemented as part of next LCH update	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-2.5.4, <i>Design of Uranium Mines and Mills: Ventilation Systems</i> March 2018	Implemented as part of 2021 licence renewal	Implemented	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-2.1.2, <i>Safety Culture</i> April 2018	Implementation completed June 2022	Implementation completed June 2022	Implementation completed June 2022	Implementation completed June 2022	Implemented
REGDOC-3.2.1, <i>Public Information and Disclosures</i> May 2018	Implemented as part of 2021 licence renewal	To be implemented as part of next LCH update	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented

Regulatory document	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
REGDOC-2.11.1, <i>Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management</i> May 2018	Not applicable	Not applicable	Not applicable	Not applicable	Implemented
REGDOC-2.11.1, <i>Waste Management, Volume II: Management of Uranium Mine Waste Rock and Mill Tailings</i> November 2018	Implemented as part of 2021 licence renewal	To be implemented as part of next LCH update	To be implemented as part of next LCH update	Implemented as part of 2021 LCH update	Implemented
REGDOC-2.11.1, <i>Waste Management, Volume I: Management of Radioactive Waste</i> January 2021	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022
REGDOC-2.11.2, <i>Decommissioning</i> January 2021	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022
REGDOC-3.3.1, <i>Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities</i> January 2021	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022
CSA N292.0:19, <i>General principles for the management of radioactive waste and irradiated fuel</i> 2019	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implemented
CSA N294:19, <i>Decommissioning of facilities containing nuclear substances</i> 2019	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implementation plan to be submitted September 2022	Implemented
CSA 393, <i>Fire protection for facilities that process, handle or store nuclear substances</i>	Implementation by December 31, 2023	Implementation by December 31, 2023	Implementation by December 31, 2023	Implementation by December 31, 2023	Implemented

1.2.3 Compliance

The CNSC determines licensee compliance through verification, enforcement and reporting activities. CNSC staff develop compliance plans for each facility commensurate with their associated risk and implement these plans by conducting regulatory activities which include onsite and remote inspections, technical assessments of licensee programs, processes and reports. Changes to compliance plans are made on an ongoing basis in response to events, facility modifications and changes in licensee performance.

On March 15, 2020, the CNSC activated the Business Continuity Plan in response to the COVID-19 pandemic. Effective March 16, 2020, all CNSC staff were directed to work from home. CNSC staff continued to conduct oversight activities during the ongoing COVID-19 pandemic to assess the protection of the environment, and the health and safety of workers and the public. Wherever possible, in 2021, inspections of uranium mines and mills were conducted remotely. 95% of inspections were conducted remotely, and 1 inspection was deferred until the onsite inspection would occur safely. Compliance activities of uranium mine and mill facilities continue remotely, and onsite verification activities have resumed on a risk informed basis in observance of relevant COVID-19 health protocols

Table 1.2 presents data on CNSC staff inspections conducted at uranium mines and mills since the calendar year 2017. Instances of non-compliance noted during these inspections were provided to the licensees in detailed inspection reports and recorded in the CNSC Regulatory Information Bank in order to ensure that corrective actions were tracked to completion. Examples of non-compliances include: failure to wear radiation monitoring equipment Canada, non-compliance with the [National Fire Code of 2015](#) [3], failure to follow procedures, additional personnel training needs identified, and incorrect or incomplete labelling or signage.

Table 1.2: Inspections at uranium mines and mills

	2017	2018	2019	2020	2021
Number of inspections	30	26	20	17	18
Instances of non-compliance	23	31	23	11	19

All instances of non-compliance identified were of low safety significance. Safety significance is determined based on comparison to criteria developed and used in the CNSC Regulatory Information Bank. Examples of the criteria are included in the appendices to this report in tables H-2, I-2, J-2 and K-2. Additional details on the inspections covered in this reporting period can be found in appendix B. CNSC staff assessed the licensees' corrective actions taken in response to the identified instances of non-compliance and verified that these actions were appropriate and acceptable. All instances of non-compliance were addressed appropriately by the licensees to meet all regulatory requirements and have been closed by CNSC staff.

Other regulatory bodies that conduct inspections at the facilities include the Saskatchewan Ministry of Environment, the Saskatchewan Ministry of Labour Relations and Workplace Safety, and Environment and Climate Change Canada (ECCC).

These regulatory bodies focus primarily on the areas of conventional health and safety and environmental protection. CNSC staff take into account the findings from these regulatory bodies when assessing licensees' performance. When logistically reasonable, joint inspections are conducted with other federal or provincial regulatory agencies. No joint inspections occurred in 2021.

1.2.4 Safety and control area framework

SCAs are the technical topics that CNSC staff use across all regulated facilities and activities to assess, evaluate, review, verify and report on regulatory requirements and performance. The CNSC's SCA framework, which staff use to evaluate licensee safety performance, includes 14 SCAs. Each SCA is subdivided into specific areas (SpAs) that define its key components. Appendix C provides definitions of these SCAs and their SpAs.

CNSC staff use the following 3 ratings, defined in appendix D, to grade licensee performance in each applicable SCA:

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

This report contains CNSC staff's performance ratings for all applicable SCAs, with a focus on 3 SCAs that cover many of the key performance indicators for mining and milling operations: radiation protection, environmental protection, and conventional health and safety.

For 2021, all SCA performance ratings for uranium mines and mills were rated satisfactory.

CNSC staff concluded, based on the results of regulatory oversight activities, that uranium mine and mill facilities met the following requirements:

- as low as reasonably achievable (ALARA) principle, which considers social and economic factors, as a result:
 - no worker doses exceeded regulatory effective dose limits
 - where action level exceedances occurred, they were reported and investigated to determine the causes, and corrective actions were identified by the licensee and verified by CNSC staff
- environmental protection programs were effective, and as a result, emissions and effluents remained well below regulatory limits:
 - where action level exceedances occurred, they were reported and investigated, and corrective measures were implemented by the licensee and verified by CNSC staff

- conventional health and safety programs continued to protect workers:
 - where a lost-time injury (LTI) was reported, corrective measures were implemented by the licensee and verified by CNSC staff

Appendix E provides the uranium mines and mills SCA performance ratings for the previous 5 years, from 2017 to 2021.

1.2.5 Independent Environmental Monitoring Program (IEMP)

The CNSC requires that each nuclear facility licensee develops, implements and maintains an environmental monitoring program to demonstrate that the public and the environment are protected from any releases to the environment related to the facility's nuclear activities. CNSC staff evaluate and assess the results of these monitoring programs to determine compliance with the applicable requirements and limits, as set out in the regulations that govern Canada's nuclear industry.

The CNSC implements an IEMP to build Indigenous and public trust in the CNSC's regulation of the nuclear industry, via an independent, technical environmental sampling program in publicly accessible areas around nuclear facilities, while using CNSC resources effectively and efficiently. The IEMP is a regulatory tool that complements and informs the CNSC's ongoing compliance verification program. The IEMP does not rely on licensees to provide samples. CNSC staff or independent contractors obtain samples from publicly accessible areas around nuclear facilities, then measure and report the amounts of radiological and hazardous substances present in these samples to the Commission, Indigenous Nations and communities, and the public.

In 2021, CNSC staff conducted independent environmental monitoring at Key Lake and McArthur River. The 2021 IEMP results, which are posted on the [CNSC's IEMP web page](#), demonstrate that persons and the environment around these facilities are protected, and that no adverse environmental or health effects are expected as a result of these facility operations. In addition, these results are consistent with the results submitted by the licensees. The IEMP results add to the body of evidence and supports CNSC staff's assessment that the public and the environment in the vicinity of the uranium mines and mills are protected and that the licensees' environmental protection programs are effective.

1.3 Public Information and Indigenous Engagement

CNSC's REGDOC-3.2.1, [Public Information and Disclosure](#) [4] sets out the requirements for public information and disclosure. The primary goal of the program is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities is shared with the public in a format relevant to the audience. The program includes a commitment and protocol for ongoing, timely dissemination of information related to the licensed facility. As the operating mine and mill sites are located in northern Saskatchewan, an area with a predominantly Indigenous population, this dissemination of information frequently includes and is accompanied by Indigenous engagement activities.

As an agent of the Government of Canada, the CNSC recognizes and understands the importance of consulting and building relationships with Indigenous peoples in Canada. CNSC staff are committed to building long-term relationships with Indigenous Nations who express an interest in CNSC-regulated facilities within their traditional and/or treaty territories. By pursuing informative and collaborative ongoing interactions, the CNSC's goal is to build partnerships and trust.

The CNSC's Indigenous engagement practices are consistent with the principles of upholding the honour of the Crown and reconciliation. These practices include information sharing and funding support (through the [CNSC's Participant Funding Program](#) [PFP]) to assist Indigenous peoples to meaningfully participate in Commission proceedings and ongoing regulatory activities.

A list of Indigenous Nations and communities whose traditional and/or treaty territories are in proximity to operating uranium mine and mill sites are available in appendix N.

1.3.1 Public information and disclosure programs

In 2021, licensees faced many continuing challenges due to the COVID-19 pandemic and had to adapt their public information programs accordingly. This included moving away from traditional in-person meetings, tours and events, and offering webinars and increased digital communications whenever possible. While many of the uranium mines and mills were in care and maintenance during 2021, licensees were still required to maintain their public information and disclosure program and disclose important information to the public.

Upon review, CNSC staff determined that the public information and disclosure programs implemented by Cameco Corporation (Cameco) and Orano Canada Inc. (Orano) complied with REGDOC-3.2.1 [4], and that they provided regular information and engagement opportunities on the status of their facilities to key audiences, by adapting to a virtual environment. This included:

- holding and attending virtual meetings to discuss the effect of COVID-19 on operations, licence renewals and preliminary decommissioning plans
- providing website updates on the pandemic and other items of interest
- increasing their social media presence

Licensees continue to implement their respective public information and disclosure programs to ensure their audiences are receiving the appropriate information at the right time in a way that is meaningful to the community. In 2021, both licensees provided pertinent information related to health, safety and environment through methods adapted to the pandemic reality.

1.3.2 Indigenous consultation and engagement

CNSC staff worked with Indigenous groups and organizations in northern Saskatchewan to identify opportunities for formalized and regular engagement throughout the lifecycle of these sites, including meetings and facilitated workshops. There were no [Northern Saskatchewan Environmental Quality Committee](#) meetings conducted in 2021 because of the ongoing COVID-19 pandemic. The majority of engagement and consultation with Indigenous groups in northern Saskatchewan in 2021 occurred via remote means due to public health recommendations related to COVID-19.

As a result of recommendations from the Commission, CNSC staff continue to hold an annual meeting with Indigenous groups and communities in northern Saskatchewan before the public consultation period to provide updated information on, and seek opportunities for improvement of, the regulatory oversight report such as the plain language summary that is now included. Indigenous groups with an interest in Canada's uranium mines and mills are also provided a copy of the regulatory oversight report for review each year.

In October of 2021, CNSC staff hosted a virtual meeting with Indigenous Nations and communities with interests in the uranium mine and mill sites in northern Saskatchewan to discuss areas, sites and projects including: Beaverlodge Project (Cameco), McArthur River Operation (Cameco), Cigar Lake Operation (Cameco), Rabbit Lake Operation (Cameco), Key Lake Operation (Cameco), Cluff Lake Project (Orano), McClean Lake Operation (Orano) as well as the Gunnar legacy uranium mine (SRC) and the former Lorado mill site (SRC).

In addition, CNSC staff also carried out a number of engagement activities with Indigenous groups in northern Saskatchewan/Alberta. The majority of these activities were conducted virtually.

- Provided updates of and held meetings directly with a number of Indigenous Nations and communities on Cameco's Cigar Lake Operation licence renewal.
- Provided updates and held meetings directly with a number of Indigenous Nations and communities on Orano's McClean Lake Operation licence amendment.
- Provided notice of the [PFP opportunities for the annual uranium mines and mills](#) regulatory oversight report, Cameco's Cigar Lake Operation licence renewal, Orano's McClean Lake Operation application for a licence amendment, and Cameco's Beaverlodge licence amendment to all potentially interested Indigenous Nations and communities.
- Provided notice of the PFP opportunity to interested Indigenous Nations and communities to provide comment and review of Denison's Wheeler River Project Draft Environmental Assessment.
- Provided general updates on the IEMP to verify that the public, Indigenous Nations and communities, and the environment around nuclear facilities are safe.

- Engaged with the English River First Nation and with the Métis Nation-Saskatchewan regarding the 2021 IEMP at Key Lake and McArthur River operations.
- Provided updates to Indigenous Nations and communities on the Canadian Uranium Workers Study and informed communities of how they may become involved in the study, if interested.
- Continued engagement and consultation activities with several Indigenous Nations and communities on the ongoing environmental assessments at NexGen Energy Ltd.'s Rook I Project and Denison Mines Wheeler River Project; both are located in northern Saskatchewan.
- Conducted regular meetings with the Ya'thi Néné Lands and Resources Office, Clearwater River Dene Nation, the Métis Nation-Saskatchewan and English River First Nation.
- Provided updates and held meetings directly with Indigenous Nations and communities on Cameco's request to amend its waste facility operating licence for the Beaverlodge properties.
- Provided updates and held a meeting with Clearwater River Dene Nation on Orano's request to amend its waste facility operating licence for Cluff Lake.

2 OVERVIEW

This report focuses on the regulatory performance of the 5 operating uranium mines and mills in Canada in 2021. During this time frame, 3 of 5 of these facilities were in a state of care and maintenance. The facilities listed are located within the Athabasca Basin of northern Saskatchewan and are shown in figure 2.1. Active sites are shown in red, and facilities which were in a state of care and maintenance in 2021 are shown in black.

- [Cigar Lake Operation](#) (mine)
- [McArthur River Operation](#) (mine – care and maintenance in 2021)
- [Rabbit Lake Operation](#) (mine and mill – care and maintenance in 2021)
- [Key Lake Operation](#) (mill – care and maintenance in 2021)
- [McClellan Lake Operation](#) (mine and mill)

Figure 2.1: Location of uranium mines and mills in Saskatchewan



The Cigar Lake, McArthur River, Key Lake and Rabbit Lake facilities are operated by Cameco, while the McClellan Lake facility is operated by Orano.

In 2016, Cameco entered the Rabbit Lake mine and mill into a state of care and maintenance and has remained in said state since that time. In 2018, Cameco entered Key Lake and McArthur River operations into a state of care and maintenance, and both have remained in that state to the end of 2021. CNSC inspectors have confirmed that staffing levels remained appropriate at all 3 of these facilities, and that workers have the capability and the time needed to perform all expected functions while the facilities are in care and maintenance.

Where the licensee reduces a service, such as ventilation volumes, CNSC staff evaluate how the reduction will impact workers in the area. CNSC staff also verify that sufficient protective measures, such as alarming detectors, are in place to warn of potentially unsafe situations. Licensees continue to train workers to understand both the safety implications of the monitors and the actions they need to take if any condition triggers an alarm. CNSC staff review changes which may impact licensed activities to determine that the licensee maintains an equivalent level of safety.

In 2021, CNSC staff continued routine compliance verification inspections at all facilities to determine whether the licensee continued to meet regulatory expectations. The 2021 uranium production data for uranium mine and mill facilities are shown in table 2.1. CNSC staff concluded that all facilities operated within their authorized annual production limits in 2021.

Table 2.1: Uranium mines and mills, mining and milling production data, 2021

Production data	Cigar Lake	McArthur River¹	Rabbit Lake¹	Key Lake¹	McClellan Lake²
Mining – ore tonnage (Mkg/year)	34.3	0	0	N/A	2.5
Mining – average ore grade mined (%U)	16.6	N/A	N/A	N/A	6.8
Mining – U mined (Mkg U/year)	4.83	N/A	N/A	N/A	0.017
Milling – mill ore feed (Mkg/year)	N/A	N/A	0	0	35.2
Milling – average mill feed grade (%U)	N/A	N/A	N/A	N/A	13.82
Milling – mill recovery (%U)	N/A	N/A	N/A	N/A	98.7
Milling – U concentrate produced (Mkg U/year)	N/A	N/A	0	0	4.75
Authorized annual production (Mkg U/year)	9.25	9.6	4.25	9.60	9.23

¹ McArthur River, Rabbit Lake and Key Lake were in a state of care and maintenance throughout 2021.

² McClellan Lake mill processing ore from Cigar Lake.

N/A = Not applicable.

Mkg = 1,000,000 kg

Licensees are required to develop and update preliminary decommissioning plans throughout the entire lifecycle of the facility and provide associated [financial guarantees](#). Financial guarantees ensure that sufficient financial resources are available to fund all approved decommissioning and waste management activities should the licensee not be able to fulfill its obligation. Financial guarantee values for the mine and mill facilities range from approximately C\$42 million at the McArthur River Operation to C\$223 million at the Key Lake Operation. The values of the financial guarantees for each uranium mine and mill are listed in appendix F. Financial guarantees cover all costs necessary to fully decommission and remediate a uranium mine and/or mill to ensure the protection of people and the environment.

2.1 Performance

CNSC staff use expert professional judgement to rate SCA performance at uranium mine and mill facilities. Ratings are based on the review of key performance indicators (e.g., accident/event occurrences, responses to accidents/events, desktop review of reports, dose information, environmental [radiological and non-radiological] results) and the results of compliance activities, such as inspections and technical assessments.

The performance ratings are compared across the 5 operating uranium mines and mills and to the rating definitions in appendix D to ensure that consistent ratings are assigned. The SCA performance ratings for the mine and mill facilities are presented in table 2.2; the SCA ratings for each facility from 2017 to 2021 are in appendix E.

Table 2.2: Uranium mines and mills, SCA performance ratings, 2021

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

SA = satisfactory

This report provides detailed information about 3 SCAs that cover many of the key performance indicators for these facilities. These SCAs are radiation protection, environmental protection, and conventional health and safety. Additional SCAs are covered in each operating site's respective section of this report.

Licensees are required to develop and maintain management systems that include integrated links to all 14 SCAs. Management systems are the framework that establish the processes and programs required to determine that an organization achieves its safety objectives, continuously monitors performance, identifies inadequacies, fosters a healthy safety culture and continually improves that culture. Throughout 2021, CNSC staff reviewed and assessed program performance and key performance indicators through regular compliance verification activities.

For 2021, CNSC staff concluded that the overall performance of the operating uranium mines and mills was satisfactory.

2.2 Radiation Protection

Uranium mine and mill licensees in Canada are required to implement and maintain radiation protection programs. Each program must ensure that contamination levels and radiation dose received by individuals are monitored, controlled, maintained below regulatory limits and are kept consistent with the as low as reasonably achievable (ALARA) principle, considering economic and social factors.

For 2021, CNSC staff rated the radiation protection SCA at all 5 operating facilities as satisfactory based on regulatory oversight activities.

Radiation protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

Sources of radiation exposure at uranium mines and mills include:

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

CNSC staff's compliance activities confirmed these hazards were controlled by the licensees' radiation protection programs, including practices relating to the effective use of time, distance and shielding, source control, ventilation, contamination control, and personal protective equipment.

Radiation protection program performance

During 2021, CNSC staff conducted regulatory oversight activities for the radiation protection SCA for all 5 facilities. These activities were carried out to verify that licensees were complying with regulatory requirements for the implementation of radiation protection programs.

Radiation protection programs include codes of practice that outline licensee administrative levels and action levels for exposures and dose of radiation. Action levels and administrative levels are identified for all radiological hazard types, applied to normal operating conditions and are followed to ensure optimal conditions for workers. Licensees are responsible for identifying the parameters for their programs that represent timely indicators of potential losses of control. For this reason, action and administrative levels are licensee-specific and may change over time, depending on operational and radiological conditions. If an action level is reached, it may indicate the loss of control of part of a licensee's radiation protection program. The licensee is then required to establish the cause, notify the CNSC and if applicable, restore the effectiveness of the radiation protection program.

Administrative levels include a list of specific actions to be taken by the licensee based on radiological monitoring in the workplace. Exceedances of these levels are not reportable to the CNSC. The radiation protection programs include actions to be taken under specific conditions, for example:

- continue to work while monitoring or investigating a parameter
- leave the area and initiate an investigation

As radiation levels or worker exposure levels increase, the required protective actions become more stringent, which is consistent with a risk-informed approach.

The 5 operating uranium mines and mills have the same individual nuclear energy worker (NEW) radiation dose action level of 1 millisievert (mSv) per week and 5 mSv per quarter of a given year.

CNSC staff confirmed that during the reporting period, the radiation protection programs and practices at uranium mines and mills remained effective at controlling radiological exposure to workers.

Application of ALARA

The radiation protection programs implemented by uranium mine and mill licensees include responsibilities and processes for ensuring that exposures to workers are consistent with the ALARA principle.

Through compliance verification activities and desktop reviews, CNSC staff verified that key elements of these ALARA programs (e.g., management control over work practices, personnel qualification and training, control of occupational and public exposure to radiation planning for unusual situations) were effectively implemented by uranium mine and mill facilities in 2021.

This report includes the reporting of annual collective dose values for NEWs for each mine and mill (see sections 3.2, 4.2, 5.2, 6.2 and 7.2). The collective dose value is the sum of the effective doses received by all NEWs at a given site over a calendar year. Collective dose is a radiation protection performance indicator that provides the total exposures associated with each operation. It supplements other performance statistics, like average dose, which have been affected by factors including changes in the number of workers or workers who receive radiation exposures over very short periods of time. Collective dose shows the effect of increased or reduced facility activities, for example, due to care and maintenance status or as a response to the COVID-19 pandemic.

Worker dose control

In accordance with the [Radiation Protection Regulations](#) [5], uranium mine and mill licensees' radiation protection programs include processes and criteria to provide assurance that all individuals identified as NEWs under section 2 of the [Nuclear Safety and Control Act](#) [1] are appropriately designated and trained. This includes licensees' employees and contractors. Radiation exposures are ascertained through approved dosimetry methods and workers are notified of the results.

Figure 2.2 shows a continuous air monitor, an alphaNUCLEAR PRISM, used in mine and mill operations to measure radon gas and radon progeny.

Figure 2.2: AlphaNUCLEAR PRISM at an underground mine

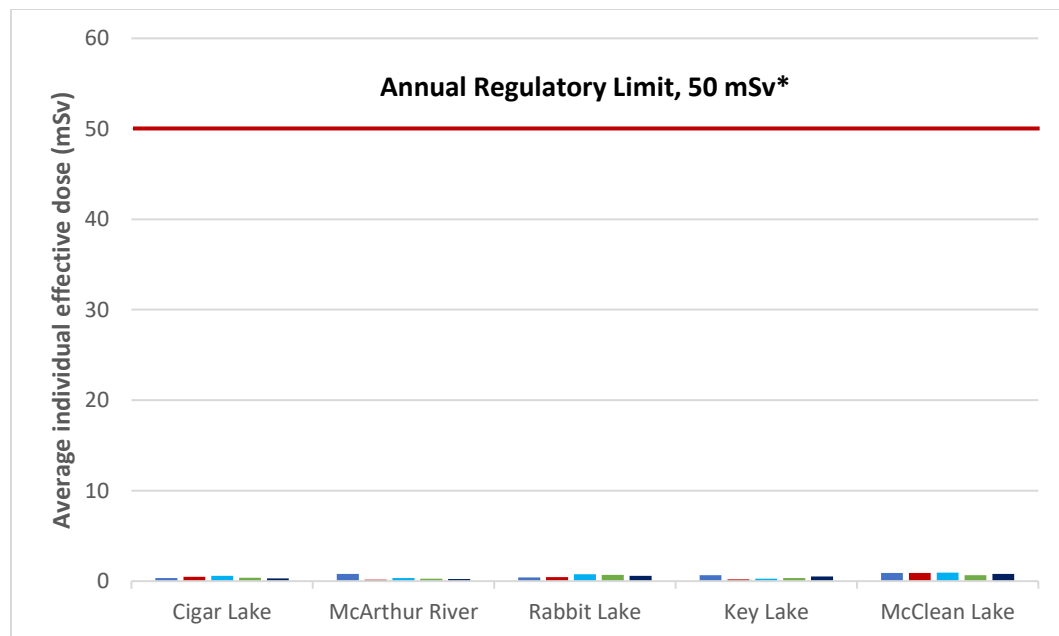


Source: CNSC

At all operating uranium mines and mills, NEWs are issued optically stimulated luminescence dosimeters that measure external gamma radiation exposure. Where required, workers also wear personal alpha dosimeters (PADs) to measure internal alpha radiation exposure from radon progeny and long-lived radioactive dust (LLRD). Optically stimulated luminescence dosimeters and PAD readings are measured by CNSC-licensed dosimetry service providers. Where direct monitoring through dosimeters is not warranted or practical, dose estimation methods authorized under the *Radiation Protection Regulations* [5] (such as area/group monitoring and time cards) are used in keeping with CNSC regulatory guidance. CNSC staff confirmed that all licensees for the facilities discussed in this section of the report met the regulatory requirements for the use of licensed dosimetry during the reporting period.

Figures 2.3 and 2.4 show the average individual effective dose and maximum individual effective dose during the 5-year period from 2017 to 2021 for the 5 facilities. In 2021, no worker at any facility exceeded the regulatory individual effective dose limit of 50 mSv in 1 year and 100 mSv in a 5-year dosimetry period.

Figure 2.3: Uranium mines and mills, average individual effective dose to nuclear energy workers, 2017–21

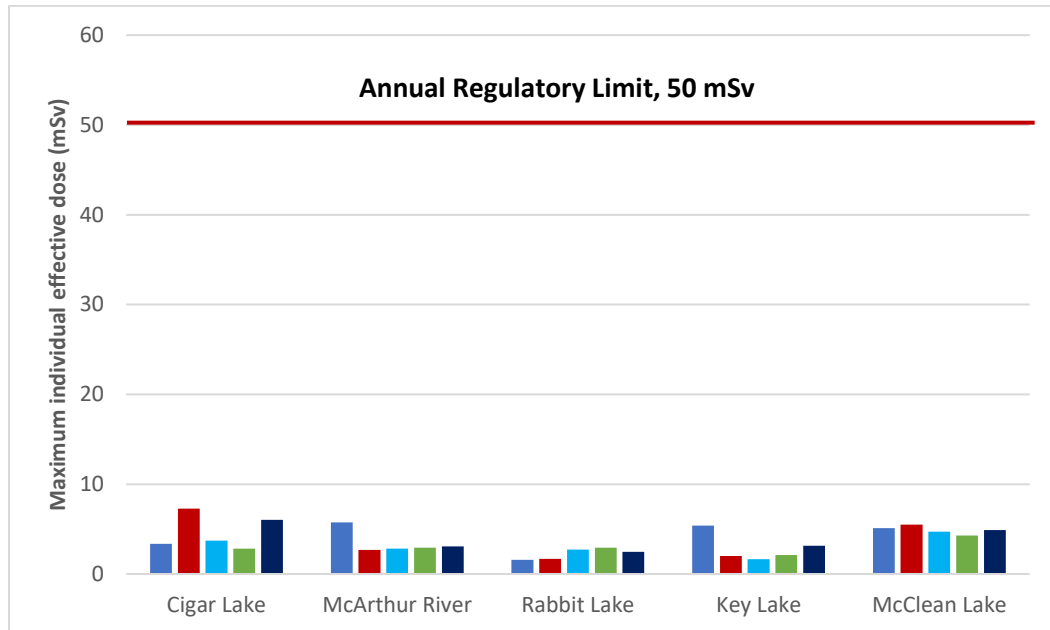


	Cigar Lake (mSv)	McArthur River (mSv)	Rabbit Lake (mSv)	Key Lake (mSv)	McClean Lake (mSv)
2017	0.34	0.79	0.4	0.66	0.91
2018	0.47	0.15	0.46	0.19	0.9
2019	0.57	0.33	0.75	0.27	0.93
2020	0.38	0.27	0.7	0.35	0.67
2021	0.32	0.25	0.57	0.52	0.79

*No regulatory limits exist for average dose to NEWs, annual dose limit used for reference

Increases and decreases over time in the effective dose to NEWs are explained in the facility-specific sections of this report, in the subsection on worker dose control.

Figure 2.4: Uranium mines and mills, maximum individual effective dose to nuclear energy workers, 2017–21



	Cigar Lake (mSv)	McArthur River (mSv)	Rabbit Lake (mSv)	Key Lake (mSv)	McClean Lake (mSv)
2017	3.36	5.73	1.56	5.39	5.12
2018	7.28	2.67	1.7	2.02	5.5
2019	3.7	2.82	2.73	1.64	4.7
2020	2.82	2.94	2.93	2.11	4.28
2021	6.03	3.06	2.47	3.13	4.89

The highest maximum individual effective dose to a worker at a uranium mine or mill in 2021 occurred at the Cigar Lake Operation. The worker at Cigar Lake was assigned a dose of 6.03 mSv, this value is 12.1 % of the annual dose limit of 50 mSv. This dose is linked to an action level exceedance described in section 3.2.

Appendix G displays the number of NEWs with the corresponding average individual effective dose and maximum individual effective dose for each facility from 2017 to 2021.

2.3 Environmental Protection

Uranium mine and mill licensees in Canada are required to implement and maintain environmental protection programs, which include a set of action levels. Each program must ensure 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.

Based on regulatory oversight activities, CNSC staff rated the 2021 performance of all 5 operating uranium mine and mill facilities for the environmental protection SCA as satisfactory. CNSC staff concluded the licensees' environmental protection programs were effectively implemented and are sufficiently effective.

Environmental protection ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
SA	SA	SA	SA	SA

SA = satisfactory

2.3.1 Environmental management system

The CNSC requires licensees to develop and maintain environmental management systems that provide a framework for integrated activities related to environmental protection at their operation. Environmental management systems are described in approved environmental management programs and include activities such as establishing annual environmental objectives, goals and targets. The licensees conduct internal audits of their programs as identified in their CNSC-approved management system program. CNSC staff confirmed the licensees' objectives, goals and targets through regular compliance verification activities. Facility-specific details are provided in sections 3.3, 4.3, 5.3, 6.3 and 7.3 of this report.

2.3.2 Effluent and emissions control

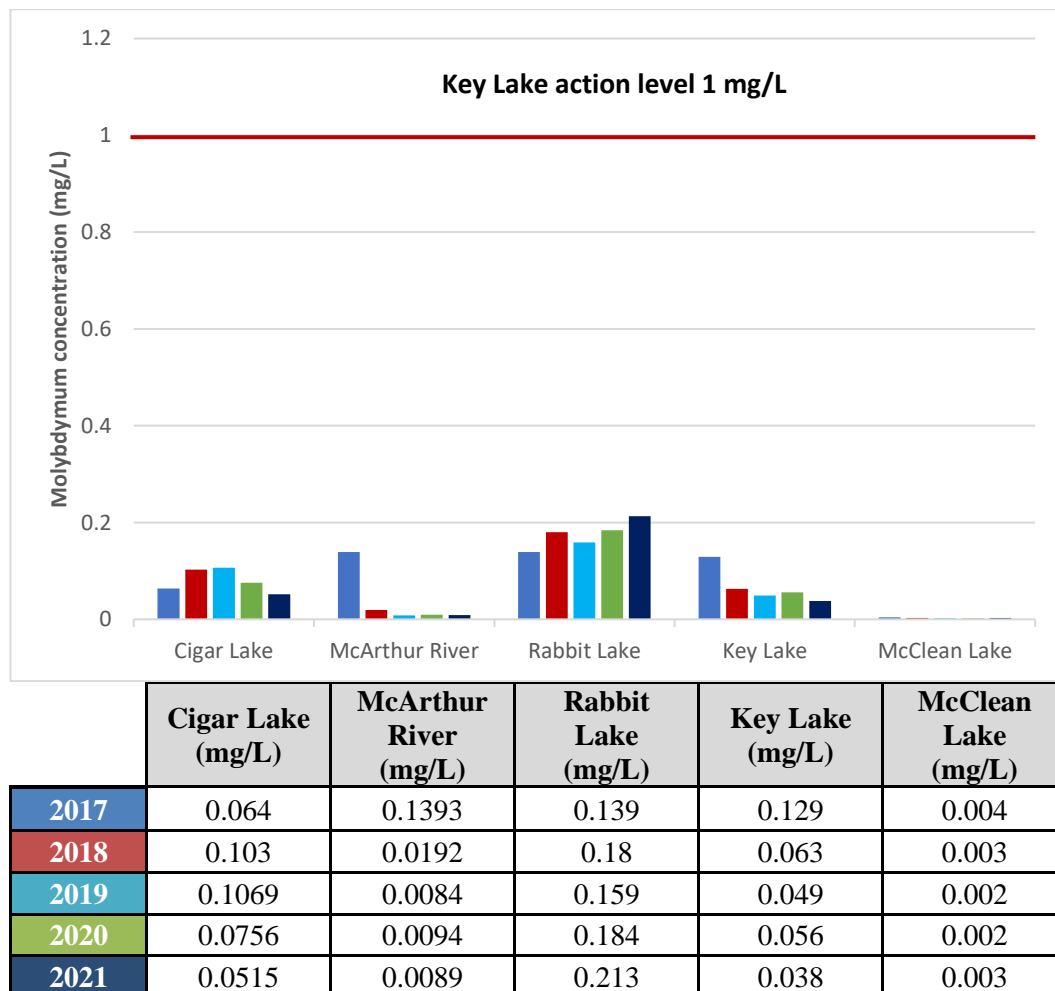
Effluent and emissions control programs are associated with an environmental code of practice that sets out administrative levels and action levels for select constituents of potential concern (COPC) with the potential for adverse environmental effects. An administrative level represents the upper range of design specifications for a specific parameter. Reaching an administrative level 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; it triggers notification to the CNSC, an immediate investigation, subsequent corrective actions and preventive measures 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 facility design envelope. Facility action levels are determined using actual operating data and following the methodology described in CSA Group standard N288.8-17 *Establishing and Implementing Action Levels for Releases to the Environment from Nuclear Facilities* [6].

Treated effluent released to the environment

Environmental risk assessments (ERAs) identified releases of molybdenum, selenium and uranium with the potential for adverse environmental effects at uranium mines and mills. As a result, improved engineering controls and treatment technologies to reduce effluent releases of these contaminants were implemented where required. In 2021, the treatment technologies implemented continued to keep these contaminant concentrations stable, and below regulatory limits. Figures 2.5 to 2.7 show the 2021 average annual effluent concentrations for molybdenum, selenium and uranium at the 5 mine and mill facilities.

In the absence of federal or provincial effluent discharge limits for molybdenum, the CNSC required licensees to develop facility-specific effluent controls within the codes of practice of their environmental protection programs. The 2017 to 2021 average concentrations of molybdenum in effluent for the 5 facilities were below the most stringent action level used across the 5 operating facilities, that is, 1.0 mg/L used at Key Lake and McArthur River. This level is shown in figure 2.5 for reference only.

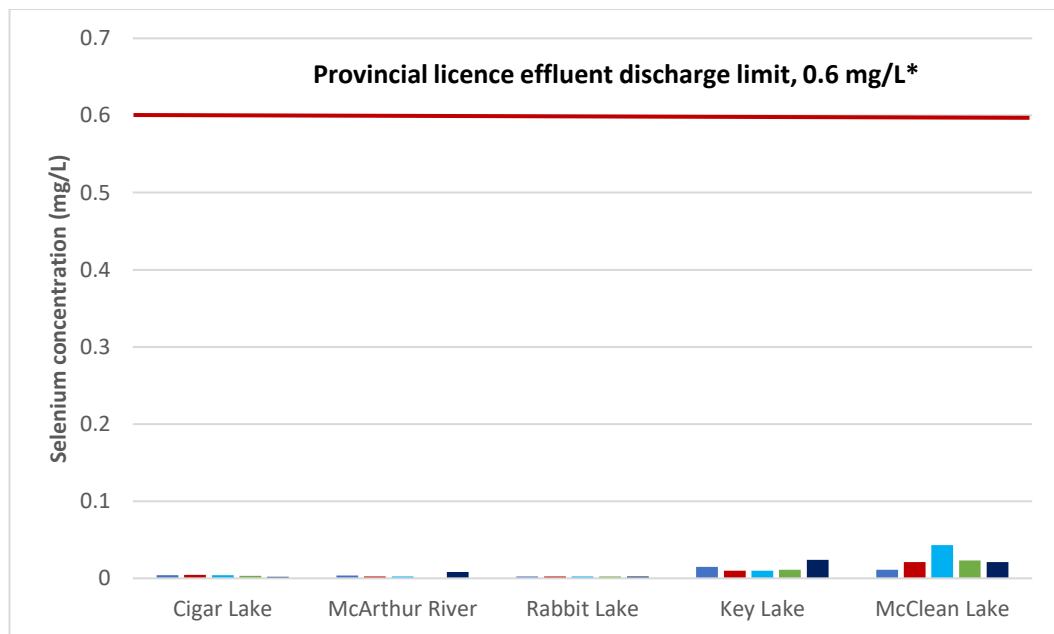
Figure 2.5: Annual average concentration of molybdenum in effluent released to the environment, 2017–21



Figures 2.6 and 2.7 show that concentrations of selenium and uranium in treated effluent released to the environment by mine and mill facilities from 2017 to 2021 remained below the licensed maximum monthly mean effluent discharge limits of 0.6 mg/L and 2.5 mg/L respectively. As indicated in figure 2.7, the CNSC identified an interim objective for uranium of 0.1 mg/L. This was derived from the treatment technologies in place at the uranium mines and mills and based on what would be achievable by the uranium metal mining sector. The interim objective was applied to all uranium mine and mill facilities since it was the most stringent and has been consistently met since 2016.

The interim objective for uranium in effluent is in place until CNSC's REGDOC-2.9.2, *Controlling Releases to the Environment*, is approved by the Commission and implemented by licensees. Draft REGDOC-2.9.2, which was made available for public consultation from May 2021 to July 2021, contains proposed requirements and guidance for establishing and implementing licensed release limits. CNSC staff presented this REGDOC to the Commission in September 2022, and should it be approved, CNSC staff will implement it via the established process.

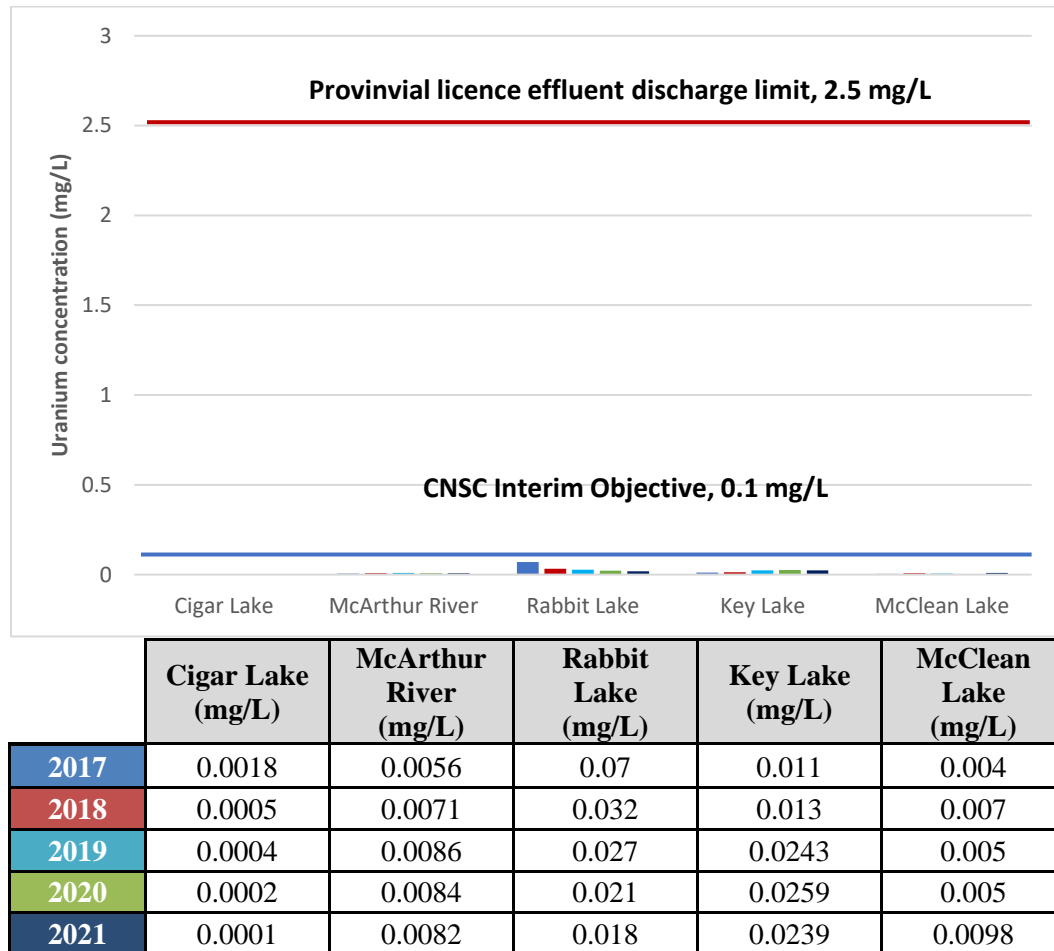
Figure 2.6: Annual average concentration of selenium in effluent released to the environment, 2017–21



	Cigar Lake (mg/L)	McArthur River (mg/L)	Rabbit Lake (mg/L)	Key Lake (mg/L)	McClean Lake (mg/L)
2017	0.0042	0.0036	0.0024	0.015	0.011
2018	0.0044	0.0023	0.0026	0.01	0.021
2019	0.0041	0.0024	0.0023	0.01	0.037
2020	0.0034	0.0003	0.0026	0.011	0.042
2021	0.002	0.0003	0.0025	0.010	0.0211

* Provincial effluent limit: 0.6 mg/L.

Figure 2.7: Annual average concentration of uranium in effluent released to the environment, 2017–21



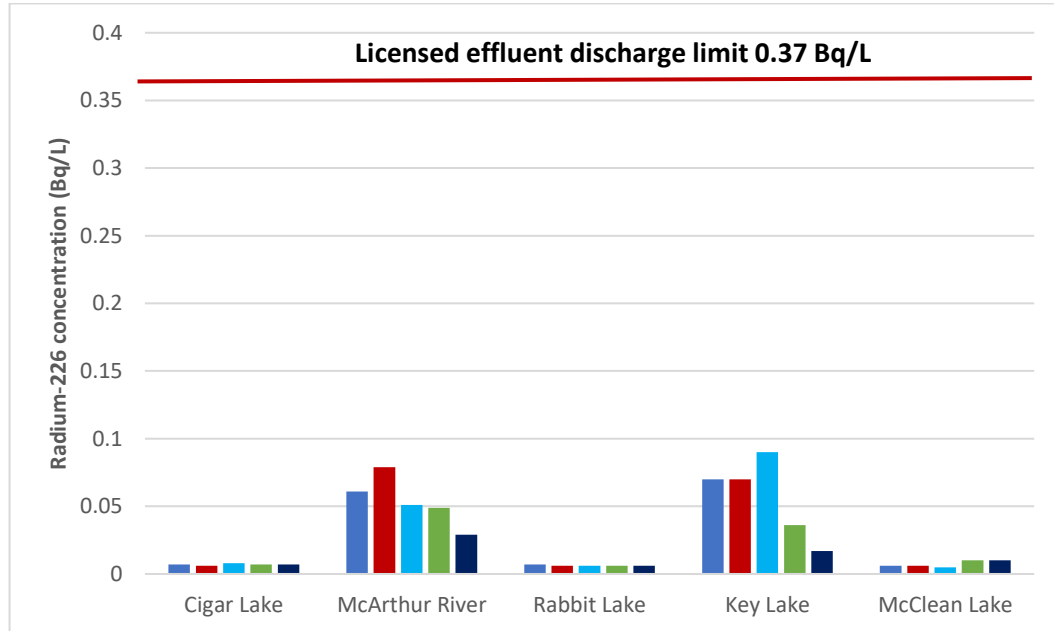
Appendix L includes information on the total annual release of relevant radionuclides to the environment from these facilities from 2017 to 2021.

Uranium mines and mills, like other industrial activities in Canada, must respect the reporting requirements of the [National Pollutant Release Inventory](#) (NPRI) [7]. There was a 2016 request from non-government organizations to include radionuclides as reportable substances under the NPRI. Environment and Climate Change Canada (ECCC) reviewed this request and determined that radionuclides were not reportable substances under the NPRI as releases were monitored and reported by another government agency, the CNSC [4]. This is the last year this information will be presented in the regulatory oversight report.

To increase public access to data on releases of radionuclides to the environment from nuclear facilities, the CNSC provides this information in the appendices of this regulatory oversight report along with maintaining and annually updating downloadable databases on the CNSC Open Government Portal.

In addition to the above COPCs with the potential for adverse environmental effects, a graph showing concentrations of radium is provided in figure 2.8. From 2017 to 2021, the annual average effluent concentrations of radium-226 for the 5 facilities were well below the CNSC's licence-authorized monthly mean effluent discharge limit of 0.37 Bq/L.

Figure 2.8: Annual average concentration of radium-226 in effluent released to the environment, 2017–21



	Cigar Lake (Bq/L)	McArthur River (Bq/L)	Rabbit Lake (Bq/L)	Key Lake (Bq/L)	McClean Lake (Bq/L)
2017	0.007	0.061	0.007	0.07	0.006
2018	0.006	0.079	0.006	0.07	0.006
2019	0.008	0.051	0.006	0.09	0.006
2020	0.007	0.049	0.006	0.036	0.010
2021	0.007	0.029	0.006	0.017	0.010

Uranium mine and mill facilities also analyze treated effluent for concentrations of other regulated contaminants and COPCs such as arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. Table 2.3 shows the annual average parameter concentration values in effluent for these substances released in 2021, as well as the discharge limits described in the [Metal and Diamond Mining Effluent Regulations](#) (MDMER) [8] made under the [Fisheries Act](#) [9]. All metal mines and mills in Canada are subject to the MDMER. The CNSC incorporates the effluent limit requirements of the MDMER in uranium mine and mill licences. In 2021, all treated effluent released to the environment from licensed mining and milling activities for the above substances met the effluent discharge limits.

Table 2.3: Annual average parameter concentration values in effluent released to the environment, 2021

Parameters	MDMER discharge limits	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
Arsenic (mg/L)	0.3*	0.0649	0.0001	0.0012	0.0109	0.044
Copper (mg/L)	0.3	0.0004	0.0005	0.0002	0.002	0.002
Lead (mg/L)	0.2	0.0001	0.0001	0.0001	0.0004	0.0005
Nickel (mg/L)	0.5	0.0007	0.0022	0.0014	0.094	0.016
Zinc (mg/L)	0.5	0.0293	0.0024	0.0009	0.005	0.002
Molybdenum (mg/L)	1**	0.0515	0.0089	0.213	0.038	0.004
Selenium (mg/L)	0.6***	0.0020	0.0003	0.0025	0.010	0.020
TSS (mg/L)	15	1	1	1	1.7	2.2
Un-ionized ammonium (mg/L)	0.5	0.01	<0.01	0.01	0.02	0.02
pH annual mean value	6.0–9.5	7.18	7.39	7.18	7.0	7.10

*MDMER discharge limit changed in 2021 from 0.5 mg/L to 0.3 mg/L

**Key Lake action level

***Saskatchewan provincial limit

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

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 MDMER [8] made under the federal *Fisheries Act* [9]. Compliance with MDMER limits provides a good comparison of the effluent treatment in the uranium mining sector to other metal mining sectors across Canada. The quality of the effluent treatment at the uranium mine and mill facilities compares favorably to that in other mining sectors of base metal, precious metal and iron mines.

The data used for this comparison are acquired from ECCC. Figure 2.9 and tables 2.4 and 2.5 provide the sector-specific MDMER [8] information available for 2018 for effluent constituents of molybdenum, selenium and uranium. ECCC effluent quality data for 2017 and 2018 for arsenic, copper, nickel, lead, zinc, pH, TSS and acute lethality testing was not available at the time of writing this report.

A comparison of these parameters for the most recent available MDMER data (2016) is presented in the *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017* [10]. This 2017 regulatory oversight report concluded that the uranium sector was similar or better than the other 3 metal mining sectors with regard to the following performance indicators: effluent concentrations, compliance with regulatory limits and toxicity test results.

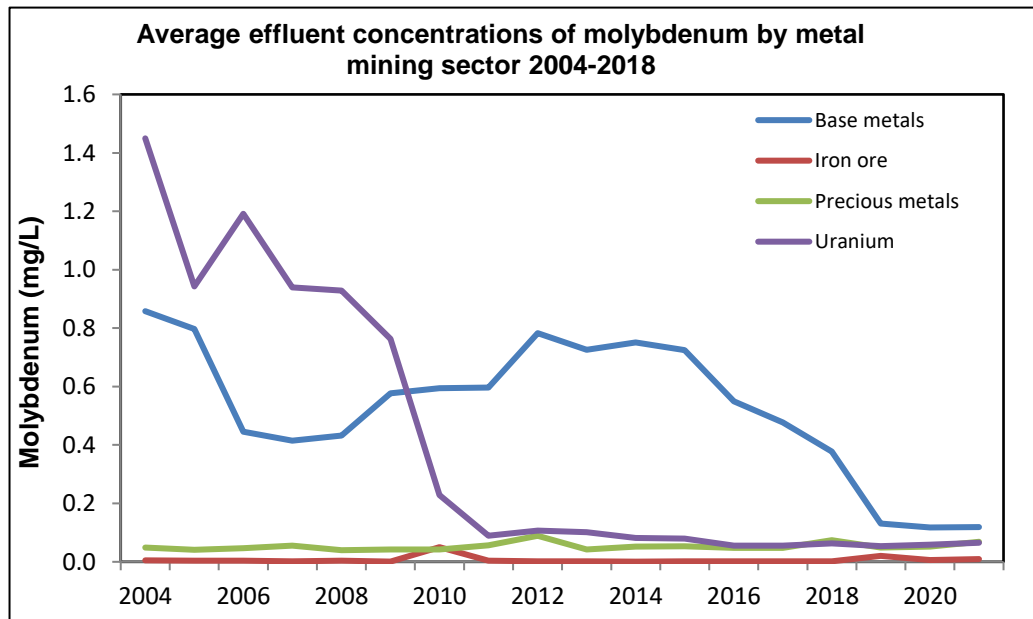
The mines that published treated effluent reporting under MDMER [8] are grouped into 4 metal mining sectors based on the primary metal produced. The metal mining sectors are:

- uranium – 5 facilities
- base metals (such as copper, nickel, molybdenum or zinc) – 47 facilities
- precious metals (such as gold or silver) – 56 facilities
- iron – 8 facilities

The MDMER [8] requires routine monitoring of molybdenum concentrations in treated effluent. Ecological risk assessments completed in the mid-2000s indicated that releases of molybdenum posed a risk to biota that warranted adaptive management. Following a request from the Commission, licensees added administrative controls and treatment technology upgrades to their effluent management systems. The success of these actions is evident in figure 2.9, which shows that molybdenum releases in the uranium mining sector have decreased substantially.

In 2021, molybdenum concentrations in uranium mining effluent were similar to those measured in precious metal and iron mine effluent, and lower than those measured in base metal mine effluent.

Figure 2.9: Average treated effluent concentration of molybdenum by metal mining sector, 2004–18



In mid-2012, the requirement to monitor selenium was added to the *Metal Mines Effluent Regulations*. Table 2.4 summarizes the average selenium concentration in treated effluent from each mining sector using data collected since 2012. The selenium concentration in uranium sector effluent was similar to that of other metal mining sectors in Canada.

Table 2.4: Average selenium concentration in treated effluent by metal mining sector, last half of 2012 and all of 2013–18

Year	Metal mining sector			
	Uranium (mg/L)	Base metals (mg/L)	Precious metals (mg/L)	Iron (mg/L)
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
2016	0.008	0.006	0.003	0.003
2017	0.004	0.008	0.004	0.001
2018	0.006	0.006	0.004	0.003
2019	0.007	0.009	0.006	0.002
2020	0.007	0.033	0.003	0.001
2021	0.005	0.008	0.016	0.001

Uranium concentrations were added as a parameter to be monitored and reported under the MDMER [8] in 2018. Table 2.5 presents the average uranium concentrations in treated effluent by metal mining sector. As shown in table 2.5, the uranium sector had an average uranium concentration of 0.0119 mg/L in 2018. Uranium mines have elevated natural uranium concentrations compared to other conventional mining operations. For context, action levels in the environmental code of practice range from 0.08 mg/L to 0.35 mg/L, and the Saskatchewan regulatory limit for uranium is 2.5 mg/L. CNSC staff continue to verify that releases of uranium are controlled and reduced to the extent practicable by reviewing effluent quality data, scrutinizing proposed facility changes that could affect effluent quality and validating the effectiveness of the licensees' programs to minimize the release of contaminants.

Table 2.5: Average uranium concentration in treated effluent by metal mining sector, 2017–18

Year	Metal mining sector			
	Uranium (mg/L)	Base metals (mg/L)	Precious metals (mg/L)	Iron (mg/L)
2017	0.0185*	0.0062	0.0027	0.0002
2018	0.0119*	0.0027	0.0010	0.0036
2019	0.0108	0.0026	0.0033	0.0019
2020	0.0092	0.0015	0.0027	0.0019
2021	0.0083	0.0029	0.0074	0.0017

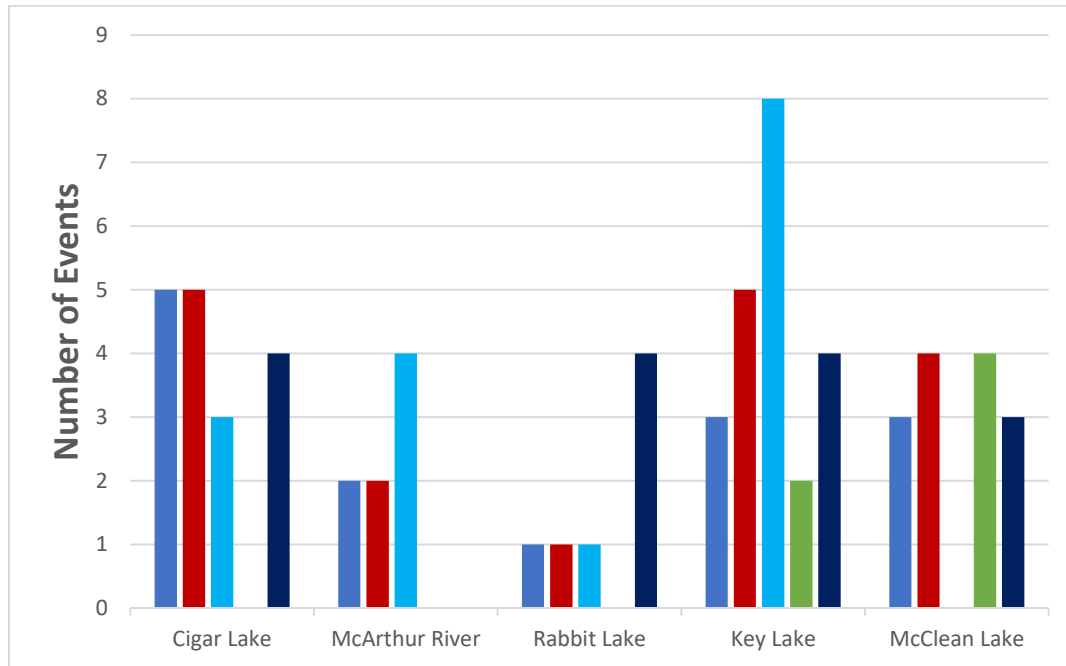
* Data not available from Environment and Climate Change Canada; value calculated from licensee annual reports.

Uncontrolled releases

Licensees are required to report to the regulatory authorities, including the CNSC, any unauthorized releases (spills) of hazardous or radioactive substances to the environment.

Figure 2.10 shows the number of environmental reportable spills for uranium mine and mill facilities during the 2017 to 2021 reporting period. In each case, CNSC staff reviewed and evaluated the licensee’s actions to verify effective remediation and prevention and were satisfied with actions taken by the licensee. CNSC staff rated all 2021 spills as “low significance” resulting in no residual impact on the environment.

The facility-specific sections and appendix I describe each reportable spill and the licensee’s corrective actions response. The CNSC’s spill rating definitions are also found in appendix I-2.

Figure 2.10: Uranium mines and mills reportable environmental spills, 2017–21

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
2017	5	2	1	3	3
2018	5	2	1	5	4
2019	3	4	1	8	0
2020	0	0	0	2	4
2021	4	0	4	4	3

Air emissions released to the environment

Uranium mines and mills environmental programs include monitoring the effects of operations on the surrounding air and soil. Licensees measure airborne particulate levels and concentrations of regulated contaminants and COPC, as well as the concentration of radon gas in ambient air. Soil and vegetation may be affected by atmospheric deposition of particulate containing adsorbed metals and radionuclides associated with onsite activities. Licensees monitor contaminant concentrations in soil and terrestrial vegetation to verify that operational impacts are below regulatory limits.

Facilities with milling operations 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 operation's performance against predictions made in ERAs.

CNSC staff verified that the mines and mills demonstrated satisfactory performance mitigating and monitoring the effects of their operations on the surrounding air and soil. Soil monitoring results around the facilities indicated that all measured parameters are within background levels. As would be expected, air monitoring for radon gas near tailings management facilities and waste rock piles shows results higher than the regional background level of 25 Bq/m³. However, the concentrations fall to background levels within a short distance – less than 2 km from the facility. The monitoring results indicate negligible impacts to the environment from atmospheric releases and confirm that all uranium mines and mills are in compliance with their environmental programs and provincial standards.

2.3.3 Assessment and monitoring

In accordance with the [Uranium Mines and Mills Regulations](#) [11], each uranium mine and mill licensee has an environmental monitoring program that monitors concentrations of nuclear and hazardous substances in the environment, and characterizes and monitors effects to the environment associated with the licensed facility. Nuclear and hazardous substances associated with monitoring programs are selected based on regulated COPCs identified through the licensee's ERA. COPCs identified through the ERA that have the potential for adverse environmental effects are managed through increased monitoring, inclusion in the environmental code of practice and further study or implementation of additional controls by licensees. CNSC staff review and evaluate environmental monitoring programs as criteria for assessing environmental performance.

The results of the licensee's environmental monitoring programs relative to the ERA predictions are provided in a licensee's environmental performance report (EPR) that is typically completed every 5 years and provides environmental data collected over the previous 5-year period. CNSC staff and the Saskatchewan Ministry of Environment staff review the EPRs once these reports are released.

2.3.4 Environmental risk assessment

The CNSC uses facility-specific ERAs developed by licensees as a regulatory tool throughout the lifecycle of uranium mine and mill facilities. Applicants use ERAs during initial environmental assessments for new facilities and for changes to existing facilities or activities at licensed operations where applicable. The ERA identifies the need for mitigation technologies or practices and predicts:

- physical disturbances
- releases to the atmosphere
- releases to surface water
- air quality
- soil and sediment quality
- surface water quality
- groundwater quality

- changes to the physical environment
- biological and human health effects

ERAs are reviewed at a minimum every 5 years, and if necessary, are updated. ERAs are updated based on changes to operational activities, revised predictions, environmental monitoring data collected over the previous 5 years and the latest science. Table 2.6 shows the year of the most recent ERA submitted for each uranium mine and mill and the year the next ERA updates will be submitted to the CNSC for review. CNSC staff regularly review ERAs to determine the potential risks to human health and the environment and to verify that mitigation measures are adequate.

Table 2.6: ERAs – current and upcoming submissions

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
Current ERA	2017	2020	2020	2020	2016
Upcoming ERA	2021	2025	2025	2025	2025*

* Deferred to align environmental monitoring and reporting frequencies, subject annual adequacy reviews, as approved by the CNSC on August 12, 2020.

2.3.5 Protection of people

Each licensee must demonstrate that persons are protected from exposures to radiological and hazardous substances released from an operation. Protection of people is assessed in the ERA, which contains a human health risk assessment (HHRA). The HHRA assesses hazardous and radiological releases from facilities, and it models the resultant concentrations of contaminants in air, water, soil and traditional foods (such as fish, waterfowl and moose). The concentrations of contaminants consumed by a typical local resident are assessed against human health benchmarks in the HHRA. For all facilities, the HHRAs confirm that the concentrations of contaminants for a typical local resident are well below concentrations that could cause health effects. Therefore, it has been determined that the health of persons in areas surrounding the facilities is protected.

Doses to persons are calculated based on an individual expected to have the highest possible exposure using conservative assumptions. Calculated dose values are determined for both camp workers (e.g., cook) and persons that are expected to be in close vicinity to the licensed site (such as trappers and local residents). To be conservative, the dose calculations assume that local Indigenous residents (including adult, child and toddler) obtain their dietary components throughout the year from the local area.

CNSC staff reviewed the HHRAs submitted by the uranium mines and mills and concluded that the estimated doses are a small fraction of the regulatory public dose limit of 1 mSv/year.

Eastern Athabasca Regional Monitoring Program

The [Eastern Athabasca Regional Monitoring Program \(EARMP\)](#) is a well-recognized environmental monitoring program designed to gather data on long-range environmental information and potential cumulative impacts downstream from uranium mining and milling operations. The program was initiated in 2011 with funding from the Saskatchewan government and the uranium mining industry (Cameco and Orano) as a sub-element of the Province of Saskatchewan's Boreal Watershed Initiative, which ended in 2017. The CNSC became a funding partner in 2017 to 2018 to support the publication of an EARMP final report (2011 to 2017) with a 5-year long-term funding agreement (2018–2019 to 2022–2023) signed in 2018 between the Saskatchewan Government, the CNSC and industry. The community program monitors the safety of traditionally harvested country foods by analyzing water, fish, berries and wild meat (e.g., grouse, rabbit, caribou and moose) from representative northern Saskatchewan communities. The program contractor is an Indigenous-owned business in northern Saskatchewan. Samples are collected from areas identified by community members, with members either assisting in sample collection or providing samples from their own harvesting activities.

Harvesting and consuming traditional country foods are an important part of the culture in northern Saskatchewan. The intent of 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 program has demonstrated that concentrations of COPC have been relatively consistent over time and are within the regional reference range indicating no evidence of long-range transport of contaminants associated with uranium mining.

Evaluation of country food data from previous years confirms 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 consuming country foods were similar to exposures of the general Canadian population. The EARMP has proven to be a productive means of involving the community in monitoring the health of their local environment and provides them with confidence in the safety of their traditional foods. The conclusion of the EARMP is that water and country foods are considered safe for consumption.

The annual reports and data are available at the [EARMP website](#). The CNSC continues to support the EARMP and CNSC staff are working to further collaborate on this valuable program.

Estimated dose to the public

Uranium mine and mill operations are located in remote areas, away from local populations. The [Radiation Protection Regulations](#) [5] set out a public radiation dose limit of 1 mSv per year above natural background radiation to ensure the protection of health and the public.

Radiological exposures measured at the boundaries of these remote licensed facilities are close to measured background radiation levels.

In 2021, CNSC staff were satisfied that uranium mine and mill licensees controlled radiation doses to persons, such that they are at levels well below the regulatory limits and are ALARA. This conclusion was based on the outcome of inspections, as well as reviews of licensees' radiation protection programs, radiological hazard control, worker dose control and application of the ALARA principle.

2.4 Conventional Health and Safety

Uranium mine and mill licensees in Canada are required to implement a conventional health and safety program. Each program must cover the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

For 2021, CNSC staff rated the conventional health and safety SCA at uranium mine and mill facilities as satisfactory, following acceptable performance in health and safety practices, awareness and performance.

Conventional health and safety ratings

Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
SA	SA	SA	SA	SA

SA = satisfactory

Practices

The CNSC requires licensees 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 in collaboration with the 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 and reviews of compliance reports and health and safety events.

CNSC staff confirmed that licensees at uranium mines and mills implemented effective conventional health and safety practices in their activities. In addition to CNSC staff's regulatory oversight, the Saskatchewan Government conducts regular inspections of occupational health and safety, mine safety and fire protection through an agreement with the Government of Canada.

Awareness

CNSC staff observed how the implementation of conventional health and safety programs continued to provide workers with education, training, tools and support (for example, see figure 2.11). Each facility licensee promotes the idea that safety is the responsibility of all individuals; this message is reinforced by the licensees' management, supervisors and workers. The licensees' management stress the importance of conventional health and safety through regular communication, management oversight and the continual improvement of safety systems. Through remote inspections, CNSC staff have identified a high level of communication and awareness in the area of conventional health and safety. CNSC staff concluded that in 2021, licensees of uranium mines and mills were committed to accident prevention and safety awareness, and focused on safety culture.

Figure 2.11: Warning signage in underground work area



Source: CNSC

Performance

Key performance measurement criteria for conventional health and safety are the number of lost-time injuries (LTIs) and the total recordable incident rate (TRIR) that occur at each facility. An LTI is a workplace injury that results in the worker being unable to return to work for a period of time. In reviewing each LTI, CNSC staff consider injury severity and frequency rates. The TRIR is the incident frequency rate, measuring the number of fatalities, LTIs and other injuries requiring medical treatment. Table 2.7 shows the number of LTIs at the uranium mines and mills, along with severity, frequency and TRIRs.

Table 2.7: Uranium mines and mills, lost-time injury statistics, 2021 (including contractors)

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClean Lake
Lost-time injuries¹	2	0	0	0	3
Severity rate²	6.31	0	0	0	49.8
Frequency rate³	0.37	0	0	0	0.9
Total Recordable Incident Rate⁴	2.97	0.70	1.04	1.33	5.6

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months] x 200,000.

Appendix K provides additional details on LTIs that occurred at the Cigar Lake Operation and the McClean Lake Operation in 2021 and the corrective actions taken. Information about these events can also be found in sections 3.4 and 7.4, respectively. CNSC staff and the Saskatchewan Ministry of Labour Relations and Workplace Safety monitor and review each reportable injury to verify the cause is identified and the corrective actions taken are satisfactory. When applicable, injury information is shared among the facilities for lessons learned to improve safety and prevent reoccurrences.

CNSC staff concluded through their compliance verification activities that the health and safety programs at all uranium mines and mills met regulatory requirements in 2021.

Lost-time injuries: Comparison of the uranium mining sector to other mining sectors in Saskatchewan

Table 2.8 displays the various safety statistics concerning mining sectors within Saskatchewan. Data for the uranium sector is presented both with and without contractor data, because while contractors are included in CNSC oversight as workers under the NSCA, contractor data is not available for the other sectors. The data indicates that the uranium mining and milling sector exhibits performance similar to other mining sectors for LTIs and frequency rate.

Table 2.8: Safety statistics for mining sectors in Saskatchewan, 2021

Mining sector	Number of LTIs¹	Accident frequency rate (200,000 person-hours)¹	Accident severity rate (200,000 person-hours)¹	Total Recordable Incident Rate (200,000 person-hours)³
Potash (underground)	4	0.1	6.8	1.3
Solution (potash)	3	0.4	5.8	0.77
Minerals (sodium sulphate, sodium chloride)	2	0.7	2.5	--
Hard rock (gold, diamond)	10	0.8	31.1	3.62
Coal (strip mining)	6	1.1	38.4	2.10
Uranium	2	0.08	8.5	1.74
Uranium (including contractors)²	2	0.06	14.0	2.74 ⁴

¹ Saskatchewan Ministry of Labour Relations and Workplace Safety.

² Statistics for all the other mining sectors do not include contractors.

³ Saskatchewan Mining Association, data provided voluntarily by member companies.

⁴ See tables 3.3, 4.3, 5.4, 6.3 and 7.3 for the data for each individual licensed uranium operation.

CNSC staff benchmarked the injury frequency rate at Saskatchewan uranium mines and mills with national and international mining statistics. The variation in definitions of a workplace injury is a limitation to consider when comparing safety-related statistics. However, where possible, efforts are made to compare and assess licensee performance against relevant national and international benchmarks. Table 2.9 shows various international benchmarks related to workplace incident frequency rates. The performance of the uranium mining and milling sector in Canada is similar.

Table 2.9: National and international benchmarking related to workplace safety

Publication/Standard	Lost Time Frequency rate	Total Recordable Incident Rate	Notes
Government of Western Australia Department of Mines, Industry Regulation and Safety¹	2.3, 3.1	N/A	Lost time frequency rate of 2.3 across all mining sectors, and 3.1 in non-metal mining environments; rates are per million hours worked for 2016/2017
International Council on Mining and Metals²	4.3	N/A	Average rate are per million hours worked for 2016 based on statistics from 27 of the largest international mining companies
2017 Workplace Fatality and Injury Rate Report – Canada³	1.9	N/A	Average rate across all Canadian provinces and territories per million hours worked
The National Institute for Occupational Safety and Health⁴ (US)	1.7	N/A	Average rate per 200,000 hours worked in 2015
International Council on Mining and Metals (ICMM)⁵	N/A	3.94	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2017
International Council on Mining and Metals (ICMM)⁵	N/A	4.26	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2016
International Council on Mining and Metals (ICMM)⁵	N/A	4.70	Total Recordable Injury Frequency Rate for ICMM Members. Rate per 200,000 hours worked in 2015

¹ Safety performance in the Western Australian mineral industry 2016-17, Government of Western Australia, Department of Mines, Industry Regulations and Safety, 2018.

² Benchmarking 2016 Safety Data: Progress of ICMM Members, International Council on Mining and Metals.

³ 2017 Workplace Fatality and Injury Rate, Tucker. S, University of Regina, 2017.

⁴ Number and rate of mining nonfatal lost-time injuries by year, 2006-15, The National Institute for Occupational Safety and Health.

⁵ Benchmarking 2017 safety data; progress of ICMM members, International Council on Mining and Metals.

N/A = not available.

3 CIGAR LAKE OPERATION

Cameco Corporation (Cameco) is the operator of the Cigar Lake Operation, which is located approximately 660 kilometers north of Saskatoon, Saskatchewan.

The Cigar Lake Operation consists of an underground uranium mine with surface facilities for loading ore slurry into trucks, waste management facilities, a water treatment plant, surface freeze plants, administration offices and warehouses. Figure 3.1 shows an aerial view of the Cigar Lake Operation.

In June 2021, following a public hearing held virtually, the Commission issued a 10-year licence to Cameco for the Cigar Lake Operation. Cameco's licence expires on June 30, 2031.

Figure 3.1: Cigar Lake Operation – aerial view looking north



Source: Shaw Global

Table 3.1 presents the mining production data from 2017 through 2021.

Table 3.1: Cigar Lake Operation - mining production data, 2017–21

Mining	2017	2018	2019	2020	2021
Ore tonnage (Mkg/year)	36.49	43.06	46.09	24.6	34.3
Average ore grade mined (%U)	18.85	16.1	17.9	17.3	16.6
Uranium mined (Mkg U/year)	6.88	6.94	6.98	3.61	4.83
Authorized annual production (Mkg U/year)*	9.25	9.25	9.25	9.25	9.25

*Mining up to 7.0 Mkg of uranium per year, with a production flexibility up to 9.25 Mkg of uranium.

In 2021, production mining at Cigar Lake started in April and continued through the year. Cigar Lake is authorized to mine up to 7.0 MKg U per year, with additional production flexibility to mine up to 9.25 MKg U per year. CNSC staff confirmed the Cigar Lake Operation production remained within the authorized CNSC licence limit for the 2021 calendar year and is carrying forward a cumulative production shortfall of 18.3 million kg of uranium since 2013. This shortfall can be recouped in future years by increasing production in accordance with the production flexibility limits in the Cigar Lake LCH.

3.1 Performance

For 2021, CNSC staff rated all 14 SCAs for the Cigar Lake Operation as “satisfactory”. The SCA ratings for the 5-year period from 2017 to 2021 are provided in appendix E.

In 2021, CNSC staff conducted 5 inspections that covered the following SCAs: operating performance, fitness for service, environmental protection, conventional health and safety, radiation protection, waste management, emergency management and fire protection, and packaging and transport.

There were 12 non-compliances identified through CNSC inspections at the Cigar Lake Operation for the 2021 calendar year. These non-compliances were of low risk and related to the management system; human performance management; operating performance; radiation protection, environmental protection; emergency management and fire protection SCAs. Each non-compliance may be related to more than one SCA. For all non-compliances in 2021, corrective actions were implemented by the licensee, then reviewed and accepted by CNSC staff. A complete list of these inspections, including the dates the reports were sent to licensees and SCAs assessed, can be found in appendix B.

3.2 Radiation Protection

For 2021, CNSC staff continued to rate the radiation protection SCA at Cigar Lake as “satisfactory” based on regulatory oversight activities.

Cigar Lake Operation - radiation protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The main source of radiological exposure at the Cigar Lake Operation is from mining high-grade uranium ore. The effective dose contributors to nuclear energy workers (NEWs) at Cigar Lake remained similar to previous years, with gamma radiation (46%), radon progeny (RnP, 34%) and long-lived radioactive dust (LLRD 20%), and less than 1% attributed to radon gas (RnG). Gamma radiation hazards are controlled through the effective use of time, distance and shielding. Exposures to radon progeny, LLRD, and radon gas are controlled through source control, ventilation, contamination control and personal protective equipment.

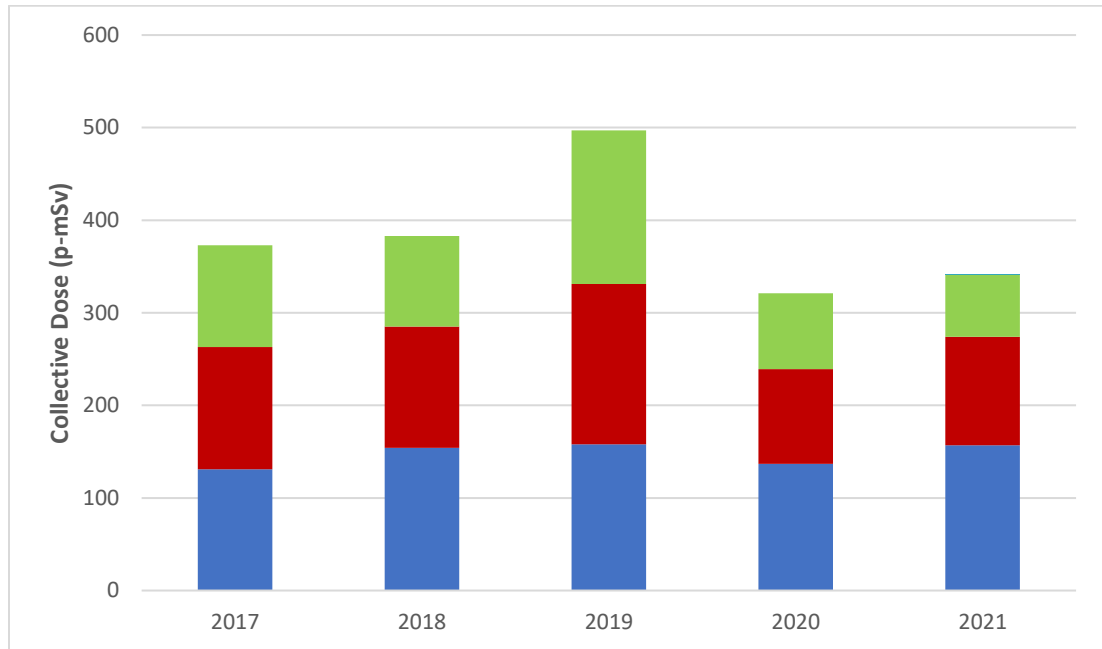
Radiation protection program performance

CNSC staff confirmed that the radiation protection program and practices at the Cigar Lake Operation remained effective in controlling radiological exposure to workers. In November 2021, Cameco reported that a worker had an elevated personal alpha dosimeter result for September. The event resulted in an employee exceeding the weekly action level. Cameco's response to the action level exceedance complied with subsection 6(2) of the [Radiation Protection Regulations](#) [5] and corrective actions were taken to verify ongoing effectiveness of the Radiation Protection Program. Further information on this reported event is included in appendix H.

Application of ALARA

In 2021, the collective radiation exposure to NEWs at the Cigar Lake Operation was 340.2 person-millisieverts (p-mSv). This value is similar to the 2020 value of 323.3 p-mSv.

Figure 3.2 illustrates the annual collective radiation exposures at the Cigar Lake Operation from 2017 to 2021.

Figure 3.2: Cigar Lake Operation – annual collective dose, 2017–21

	2017	2018	2019	2020	2021
Gamma (p-mSv)	131	154	158	137	157
RnP (p-mSv)	132	131	173	102	117
LLRD (p-mSv)	110	98	166	82	67
RnG (p-mSv)	0	0	0	0	0
Total*	376	387	498	323	340

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* The total collective dose may not match the individual components due to rounding errors.

In 2021, Cameco continued the practice of identifying workers with the top 25 highest effective doses from the previous year and then working with both the supervisors and workers to reduce their effective dose. Based on a pro-rated exposure value due to the partial year of production, 10 of the 25 workers were successful in reducing their total effective dose, while the remaining 15 were slightly above the prorated individual target. Challenges due to staffing as a result of COVID was considered a factor in reaching the planned ALARA targets.

Worker dose control

During 2021, the average individual effective dose to NEWs was 0.32 millisieverts (mSv), compared to the average effective dose of 0.38 mSv in 2020. The maximum individual dose increased from 2.82 mSv in 2020 to 6.03 mSv, which is related to the action level discussed below. The 5-year dosimetry period of 2021 to 2025 has just started. So far, the maximum dose is 6.03 mSv (~6% of the regulatory dose limit of 100 mSv).

As indicated in section 2 figures 2.3 and 2.4, no worker exceeded the regulatory individual effective dose limit of 50 mSv per 1-year dosimetry period. CNSC staff verified that Cigar Lake Operation provided assurance that radiological hazards are anticipated and verified through suitable radiological monitoring by Cameco.

In November 2021, Cameco reported that a worker had exceeded the weekly action level of 1 mSv (appendix H). Cameco identified 4 corrective actions as a result of this event. CNSC staff reviewed the corrective actions and are satisfied with the actions taken.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results for 2021, CNSC staff were satisfied that the Cigar Lake Operation continued to be effective at controlling radiation doses to workers.

3.3 Environmental Protection

For 2021, CNSC staff continued to rate the environmental protection SCA as "satisfactory". CNSC staff concluded that the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Cigar Lake Operation - environmental protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Cigar Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental management program at the Cigar Lake Operation, as identified in the CNSC-approved management system program. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities. CNSC staff confirmed that Cameco continued to conduct routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to assess continual improvement and to confirm that the controls put in place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

CNSC staff confirmed that constituent concentrations in treated effluent were low and remained below treated-effluent discharge limits at the Cigar Lake Operation. CNSC staff verified that treated effluent released to the environment was well below regulatory requirements. At the Cigar Lake Operation throughout 2021, concentrations for molybdenum, selenium and uranium (shown in figures 2.5 to 2.7) remained below their respective action levels and well below provincial licence effluent discharge limits.

The Cigar Lake Operation is required to monitor concentrations of other regulatory constituents and COPCs, such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH. CNSC staff reviewed the Cigar Lake Operation effluent treatment concentrations and confirmed that it continued to meet [MDMER](#) [8] discharge limits (shown in section 2.3). There were no exceedances of the action levels in the environmental code of practice.

In 2016, the Cigar Lake Operation Environmental Performance Report (EPR) identified an increasing arsenic trend in effluent. While below regulatory limits, arsenic concentrations in the treated effluent were above environmental assessment predictions and above concentrations previously measured in the effluent prior to achieving full ore production. In response, Cameco created a working group to identify the causes of the elevated concentration and develop mitigation strategies. Cameco continues to implement several mitigation techniques to reduce arsenic loadings to the environment, such as improving the recycling of process water captured onsite for use in underground processes. As a result, arsenic loadings and mean concentrations decreased. CNSC staff reviewed the 2016-2020 EPR and the 2021 annual compliance report and noted that arsenic loadings and concentrations increased during 2016-2019 before decreasing in 2020 and 2021. For example, the arsenic loadings and mean concentrations were 23.4 kg and 0.065 mg/L in 2021 and 22.2 kg and 0.063 mg/L in 2020 compared to 33.4 kg and 0.095 mg/L in 2019. CNSC staff are satisfied that Cameco is taking appropriate actions to lower arsenic concentrations in the effluent.

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

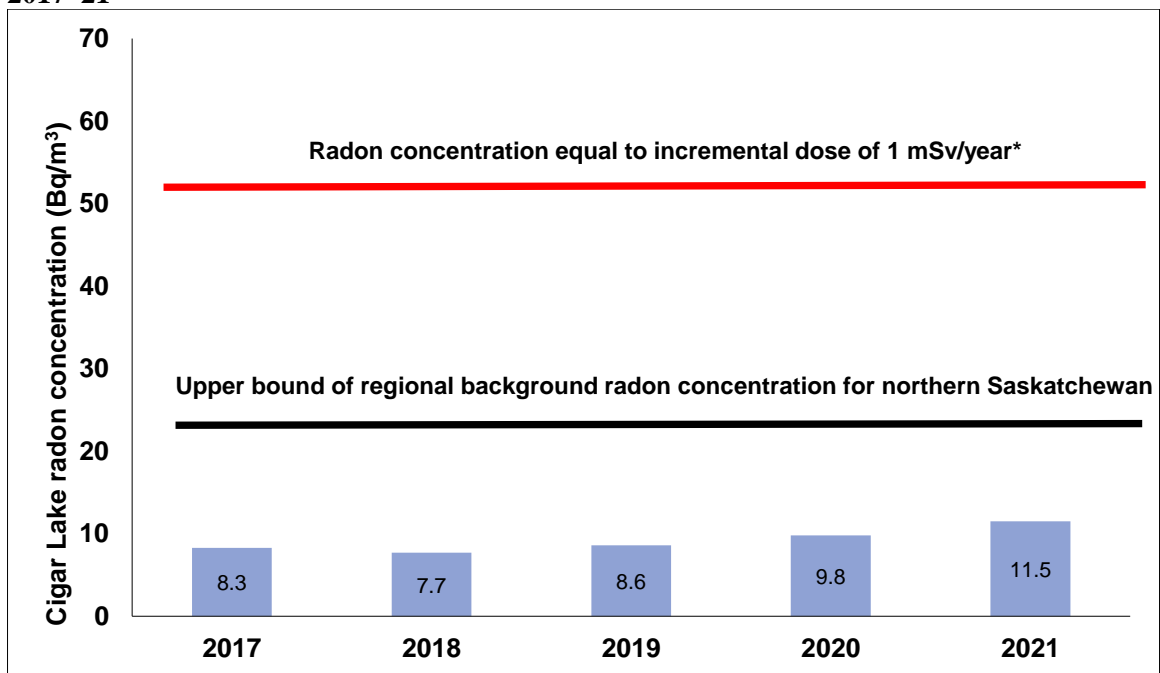
Air emissions released to the environment

As required by the CNSC, the Cigar Lake Operation maintains an air and terrestrial monitoring program. Air 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. Lichen samples are analyzed to determine the level of airborne particulate contaminants deposited on the surface of the lichen as a means of estimating the level of contamination, if any, entering lichen consumers, such as caribou.

Radon in ambient air is measured using passive track etch cups at 8 monitoring stations around the operation. The background concentration of radon in northern Saskatchewan ranges from less than 7.4 Bq/m³ to 25 Bq/m³.

Figure 3.3 illustrates the average concentrations of radon in the air at the Cigar Lake Operation from 2017 to 2021 and shows that measured values are similar to values measured as northern Saskatchewan regional background. The average radon concentrations are less than the reference level of 60 Bq/m³, which represents an incremental dose of 1 mSv per year over background. CNSC staff noted that concentrations remained well below the reference level. Note: 12 of the 15 sample points that were used for the 2021 average were below the detection limits.

Figure 3.3: Cigar Lake Operation - average concentrations of radon in ambient air, 2017–21



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m³ above natural background) based on ICRP 115. Values are calculated as geometric means.

A high-volume air sampler was used to collect and measure TSP in air. Results showed that the TSP levels were lower than provincial standards (see table 3.2). In addition, 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.

Table 3.2: Cigar Lake Operation - concentrations of metal and radionuclides in air, 2017–21*

Parameter	Reference annual air quality levels	2017	2018	2019	2020	2021
TSP ($\mu\text{g}/\text{m}^3$)	60 ⁽³⁾	30.3	18.9	19.9	8.9	23.5
As ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.00039	0.00023	0.00026	0.00019	0.00029
Mo ($\mu\text{g}/\text{m}^3$)	23 ⁽¹⁾	0.0002	0.0003	0.0002	0.0001	0.0003
Ni ($\mu\text{g}/\text{m}^3$)	0.04 ⁽¹⁾	0.00103	0.00083	0.00060	0.00030	0.00062
Pb ($\mu\text{g}/\text{m}^3$)	0.10 ⁽¹⁾	0.0008	0.0008	0.0007	0.0004	0.0005
Se ($\mu\text{g}/\text{m}^3$)	1.9 ⁽¹⁾	0.00004	0.00003	0.00003	0.00002	0.00003
Pb-210 (Bq/m^3)	0.021 ⁽²⁾	0.00036	0.00037	0.00025	0.00031	0.00029
Po-210 (Bq/m^3)	0.028 ⁽²⁾	0.00012	0.00013	0.000089	0.000095	0.000096
Ra-226 (Bq/m^3)	0.013 ⁽²⁾	0.000031	0.000026	0.000013	0.000015	0.000017
Th-230 (Bq/m^3)	0.0085 ⁽²⁾	0.000023	0.000018	0.000009	0.000012	0.000014
U ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.00151	0.00103	0.00096	0.00078	0.00082

¹ Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).

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

³ *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario Ambient Air Quality Criteria and are shown for reference only. No federal or Saskatchewan provincial limits were established at the time of this report.

Soil and terrestrial vegetation may be affected by the atmospheric deposition of particulate, adsorbed metals and radionuclides associated with onsite activities. Lichen and soil samples were collected in 2019 as required under the triennial sampling program. COPC concentrations measured in the soil samples collected from the study area were comparable to historical results. Concentrations of metals remained below existing [Canadian Environmental Quality Guidelines](#) [12] set by the Canadian Council of Ministers of the Environment, 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.

The lichen chemistry results from exposure stations in 2016 were similar to those of the reference stations and historic data. CNSC staff concluded that the level of airborne particulate contaminants was acceptable and did not pose a risk to lichen consumers.

Uncontrolled releases

In 2021, 4 events were reported where hazardous substances were released to the environment at the Cigar Lake Operation. None of these events resulted in residual impact to the environment. CNSC staff were satisfied with the licensee's reporting of releases and the corrective actions taken. CNSC staff rate spills in accordance with the definitions provided in appendix I, table I-2. Figure 2.10 in section 2 displays the number of environmental reportable spills at the Cigar Lake Operation from 2017 to 2021.

Appendix I contains a brief description of reported spills, the corrective actions taken by the licensee, CNSC staff's assessment of those actions and the significance ratings for 2021.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Cigar Lake Environmental Protection Program, successfully carried out the required environmental monitoring.

Through the compliance verification activities conducted and the review of annual reports and EPRs, CNSC staff concluded that the environmental monitoring conducted at the Cigar Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remained protected.

Environmental risk assessment

The CNSC uses environmental risk assessments (ERAs) to determine that people and the environment are protected. With the exception of arsenic, the Cigar Lake ERA 2017 submission indicated that contaminant levels in the receiving water and sediment were within the predictions made in the 2011 environmental assessment. Although arsenic levels in Seru Bay of Waterbury Lake were above ERA predictions, they remained below the [Saskatchewan Surface Water Quality Objectives](#) of 5 µg/L. Cameco implemented measures to address arsenic in the effluent as noted above, and CNSC staff verified that arsenic loading to the environment remains below 2017 levels.

The Cigar Lake EPR and updated ERA for the period from 2011 to 2015 were submitted to the CNSC in 2016 and to the Saskatchewan Ministry of the Environment in 2017. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, surface water, groundwater, sediment and aquatic health indicators and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the Cigar Lake Operation to protect the environment.

Protection of people

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and LCH. The review of Cigar Lake Operation's hazardous (non-radiological) discharges to the environment indicates that the public and the environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Cigar Lake Operation remained within those predicted in the 2017 ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices and monitoring results for 2021, CNSC staff concluded that the Cigar Lake Operation's environmental protection program continued to be effective at protecting the public and the environment.

3.4 Conventional Health and Safety

CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities conducted during 2021.

Cigar Lake Operation - conventional health and safety ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Practices

CNSC staff monitored the implementation of the Cigar Lake Operation’s safety and health management program to verify the protection of workers. The program includes planned internal inspections, a safety permit system, occupational health and safety committees, training and incident investigations. Cameco’s incident reporting system includes reporting, trending and investigation of near misses, which helps reduce future incidents that could cause injury.

Cigar Lake implemented a “Safety Through Empowering Employee Leadership Committee”. This safety steering committee is unique to the Cigar Lake Operation along with the “Good Catch” reporting environment where facility staff are recognized for distinguishing near misses related to safety. These were found to be safety culture strengths at the Cigar Lake Operation.

CNSC staff verified that the conventional health and safety work practices and conditions at the Cigar Lake Operation continued to be effective in 2021.

Performance

Table 3.3 summarizes LTIs at the Cigar Lake Operation from 2017 to 2021. There were 2 LTIs at the Cigar Lake Operation in 2021. Events that took place as a result of the licensed operation were reported as required under section 29(1)h of the *General Nuclear Safety and Control Regulations*. The licensee identified causes and took appropriate corrective actions.

The total recordable incident rate (TRIR) for Cigar Lake is included for the last 5 years. The TRIR is the incident frequency rate that measures the number of fatalities, LTIs and other injuries requiring medical treatment, per 200,000 person-hours worked.

Table 3.3: Cigar Lake Operation – lost-time injury statistics, 2017–21

	2017	2018	2019	2020	2021
Lost-time injuries¹	0	0	0	0	2
Severity rate²	8.72	0	0	0	6.31
Frequency rate³	0	0	0	0	0.37
Total recordable incident rate⁴	1.58	1.00	1.67	2.08	2.97

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(# of incidents in last 12 months) / # of hours worked in last 12 months)] x 200,000.

Awareness

CNSC staff verified, through remote compliance activities, that Cameco implemented effective controls to ensure that ongoing activities continued to be conducted safely as a result of any changes. CNSC staff confirmed that conventional health and safety events at the operation were investigated and that effective corrective actions were implemented. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. The facility's management stresses the importance of conventional health and safety through regular communication, management oversight and the continual improvement of safety systems.

CNSC staff compliance verification activities concluded that the Cigar Lake Operation's health and safety program met regulatory requirements in 2021.

3.5 Additional SCAs

In addition to the 3 primary SCAs of radiation protect, environmental protection, and conventional health and safety, CNSC staff have provided a brief discussion of the additional SCAs; these are presented in the following sections.

3.5.1 Management system

The licensee includes program documentation for the management system SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

Although there were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the management system SCA, there were 2 notices of non-compliance related to this SCA during general inspections. The management system SCA was also identified as an applicable SCA to the radiation protection action level exceedance reported in 2021. Appendix B contains information related to the inspection findings.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.2 Human performance management

The licensee includes program documentation for the human performance management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

In August 2021, an inspection focused on personnel training was conducted remotely to verify the implementation and effectiveness of Cameco's human performance management at the Cigar Lake Operation. The inspection report outlined some deficiencies that resulted in 5 non-compliances related to training documentation and implementation (e.g., positions requiring a Systematic Approach to Training were not defined, out of date training documentation, and incomplete training change management process). Cameco provided an action plan to address these non-compliances. CNSC staff reviewed and confirmed that Cameco's actions are satisfactory to address the non-compliances in a timely manner. The human performance management SCA was also identified as an applicable SCA to the radiation protection action level reported in 2021.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.3 Operating performance

The licensee includes program documentation for the operating performance SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the operating performance SCA. There were no notices of non-compliance related to the operating performance SCA and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.4 Safety analysis

The licensee includes program documentation for the safety analysis SCA as part of the overall management system documents and these are part of the licensing basis for this facility in the LCH.

There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the safety analysis SCA. There was 1 notice of non-compliance related to the safety analysis SCA during a general inspection and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.5 Physical design

The licensee includes program documentation for the physical performance SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the physical design SCA and no notices of non-compliance related to this SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.6 Fitness for service

The licensee includes program documentation for the fitness for service SCA as part of the overall management system documents and these are part of the licensing basis for this facility in the LCH.

There was 1 inspection in 2021 at the Cigar Lake Operation focused on evaluating the fitness for service SCA. One notice of non-compliance related to this SCA was issued. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.7 Emergency management and fire protection

The licensee includes program documentation for the emergency management and fire protection SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There was 1 inspection in 2021 at the Cigar Lake Operation focused on evaluating the emergency management and fire protection SCA. There was 1 notice of non-compliance issued related to the emergency management and fire protection SCA and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.8 Waste management

The licensee includes program documentation for the waste management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the waste management SCA. There were no notices of non-compliance related to the waste management SCA and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.9 Security

The licensee includes program documentation for the security SCA as part of the overall management system documents and these constitute part of the licensing basis for this facility in the LCH.

There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the security SCA. There were no notices of non-compliance related to the security SCA and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.10 Safeguards and non-proliferation

The licensee includes program documentation for the safeguards and non-proliferation SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH. There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the safeguards and non-proliferation SCA. There were no notices of non-compliance related to the safeguards and non-proliferation SCA and no event reports for which this SCA was the main contributory factor.

In addition to CNSC compliance activities with respect to the specific areas under the safeguards and non-proliferation SCA, the International Atomic Energy Agency (IAEA) conducts its own inspections with coordination and support through the CNSC regulatory framework. No IAEA inspections were conducted at the Cigar Lake Operation during 2021.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

3.5.11 Packaging and transport

The licensee includes program documentation for the packaging and transport SCA as part of the overall management system documents and these form part of the licensing basis for this facility in the LCH. There were no inspections in 2021 at the Cigar Lake Operation focused on evaluating the packaging and transport SCA. There were no notices of non-compliance related to this SCA and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4 MCARTHUR RIVER OPERATION

Cameco Corporation (Cameco) is the operator of the McArthur River mine which is located approximately 620 kilometers north of Saskatoon, Saskatchewan.

The McArthur River Operation consists of an underground uranium mine, primary ore processing, ore slurry loading, waste management facilities, a water treatment plant, effluent storage ponds, surface freeze plants, administration offices and warehouses (see figure 4.1).

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

Figure 4.1: McArthur River Operation – aerial view



Source: Cameco

In 2018, the McArthur River Operation halted active mining and the mining facility was placed in safe care and maintenance. In 2022, Cameco indicated their intent to begin the process of transitioning the McArthur River Operation from care and maintenance to production. This will be reflected in next year's regulatory oversight report. Mining production data from 2017 to 2021 for McArthur River Operation is provided in table 4.1.

Table 4.1: McArthur River Operation – mining production data, 2017–21

Mining	2017	2018	2019	2020	2021
Ore tonnage (Mkg/year)	91.44	2.79	0	0	0
Average ore grade mined (%U)	7.09	6.42	N/A	N/A	N/A
Uranium mined (Mkg U/year)	6.48	0.18	N/A	N/A	N/A
Authorized annual production (Mkg U/year)	9.6	9.6	9.6	9.6	9.6

N/A = not applicable.

4.1 Performance

The SCA ratings at McArthur River Operation for the 5-year period from 2017 to 2021 are shown in appendix E. For 2021, CNSC staff rated all SCAs as “satisfactory”.

In 2021, CNSC staff carried out 2 inspections which evaluated the following SCAs: environmental protection, conventional health and safety, radiation protection, human performance management, and emergency management and fire protection.

There was 1 instance of non-compliance identified during CNSC inspections at the McArthur River Operation in 2021. The non-compliance was of low risk and related to updating the work instruction on site evacuation within the emergency management SCA. The licensee implemented corrective actions which were reviewed and accepted by CNSC staff. A complete list of inspections can be found in appendix B.

4.2 Radiation Protection

For 2021, CNSC staff continued to rate the radiation protection SCA as “satisfactory”, based on regulatory oversight activities.

McArthur River Operation - radiation protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Cameco includes the program documentation for the radiation protection SCA as part of the overall management system documents and these form part of the licensing basis in the LCH.

There were no exceedances of the regulatory dose limit and no exceedances of the weekly and quarterly action levels. There were 2 inspections conducted at the McArthur River Operation that focused on evaluating compliance with the radiation protection SCA. There were no event reports for which this SCA was the contributory factor.

Radiological hazard control

In 2021, the radiation dose to NEWs at the McArthur River Operation was contributed by radon progeny (59%), gamma radiation (26%) and long-lived radioactive dust (LLRD) (15%). This distribution is similar to that in the previous year during which the mine was also in care and maintenance. Exposures to radon progeny, radon gas and LLRD are managed through source control, ventilation, contamination control and personal protective equipment. Gamma radiation hazards are controlled through practices that involve the effective use of time, distance and shielding.

Radiation protection program performance

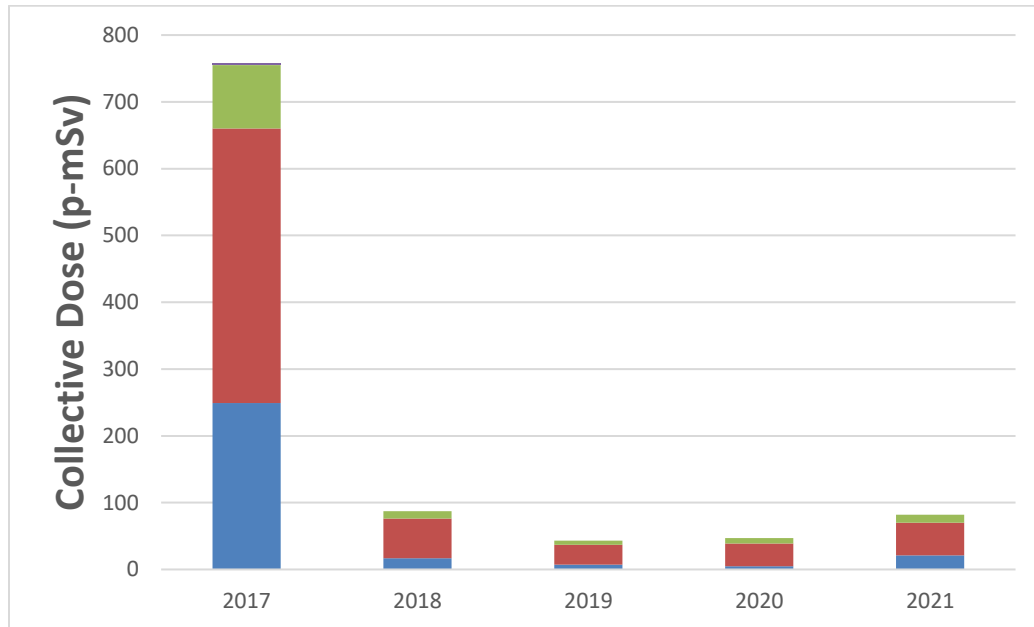
In 2021, CNSC staff were satisfied that the radiation protection program and practices at the McArthur River Operation remained effective at controlling radiological exposure to workers. The doses to workers remained below regulatory limits and ALARA. There were no exceedances of regulatory limits or action levels at the McArthur River Operation in 2021.

Application of ALARA

In 2021, the collective dose to NEWs at the McArthur River Operation was 83 p-mSv. The reduction in the collective dose reflects the state of care and maintenance of the facility over the last 3 years.

The ALARA focus at the McArthur River Operation was on radiation training during this period of reduced staff and care and maintenance activities.

Figure 4.2 displays the annual collective radiation exposures at the McArthur Operation from 2017-2021.

Figure 4.2: McArthur River Operation – annual collective dose, 2017–21

	2017	2018	2019	2020	2021
Gamma (p-mSv)	249	17	7	5	21
RnP (p-mSv)	411	59	30	34	49
LLRD (p-mSv)	95	11	6	8	12
RnG (p-mSv)	3	0	0	0	0
Total*	756	88	44	47	82

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* The total collective dose may not match the individual components due to rounding errors.

Worker dose control

The average individual effective dose to NEWs was 0.25 mSv. The maximum individual effective dose of 3.06 mSv was assigned to an underground support worker. The 2021 values are comparable with those from the previous year. All individual effective doses were well below the annual regulatory limit of 50 mSv, as indicated in section 2 figures 2.3 and 2.4. The 5-year dosimetry period of 2021 to 2025 has just started. So far, the maximum dose is 3.06 mSv (~3.1% of the 100 mSv dose limit).

Based on compliance verification activities, such as inspections, reviews of licensees' reports, work practices, monitoring results and individual effective dose results, CNSC staff were satisfied that the radiation dose to workers continued to be effectively controlled at the McArthur River Operation during 2021.

4.3 Environmental Protection

For 2021, CNSC staff continued to rate the environmental protection SCA as “satisfactory” based on regulatory oversight activities. CNSC staff verified that the environmental protection program was effectively implemented and met all regulatory requirements.

McArthur River Operation - environmental protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Cameco includes program documentation for the environmental protection SCA as part of the overall management system documents and these constitute part of the licensing basis in the LCH.

There was 1 inspection in 2021 at the McArthur River Operation focused on evaluating the environmental protection SCA. No issues were found during the inspection and there were no event reports for which this SCA was the main contributing factor.

Environmental management system

The environmental management system at the McArthur River Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental management program at the McArthur River Operation, as identified in their CNSC-approved management system program. CNSC staff reviewed and assessed the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco had continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to verify continual improvement and to confirm that the controls put in place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

CNSC staff verified that treated effluent released to the environment was below regulatory requirements and has remained stable or improved over the past 5-years. As discussed in section 2.3, constituents of potential concern (COPC) with potential to adversely affect the environment in treated effluent at multiple uranium mine and mill operations are molybdenum, selenium and uranium (figures 2.5, 2.6 and 2.7, respectively). Of the 3 COPCs, molybdenum posed an elevated risk at the McArthur River Operation. In response, Cameco implemented process changes prior to 2018 during active mining which reduced molybdenum concentrations in treated effluent. Since 2018, concentrations of molybdenum were further reduced by approximately 90% as a result of placing the facility into a state of care and maintenance.

Cameco analyzed treated effluent from the McArthur River Operation for other constituents such as radium-226, arsenic, copper, lead, nickel, zinc, total suspended solids (TSS) and pH, for which limits are defined in the McArthur River CNSC-issued licence and mirror those limits defined in the [MDMER](#) [8] (section 2.3). CNSC staff reviewed the effluent treatment concentrations and confirmed that the McArthur River Operation continued to meet the discharge limits.

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

Figure 4.3: McArthur River Operation – monitoring pond



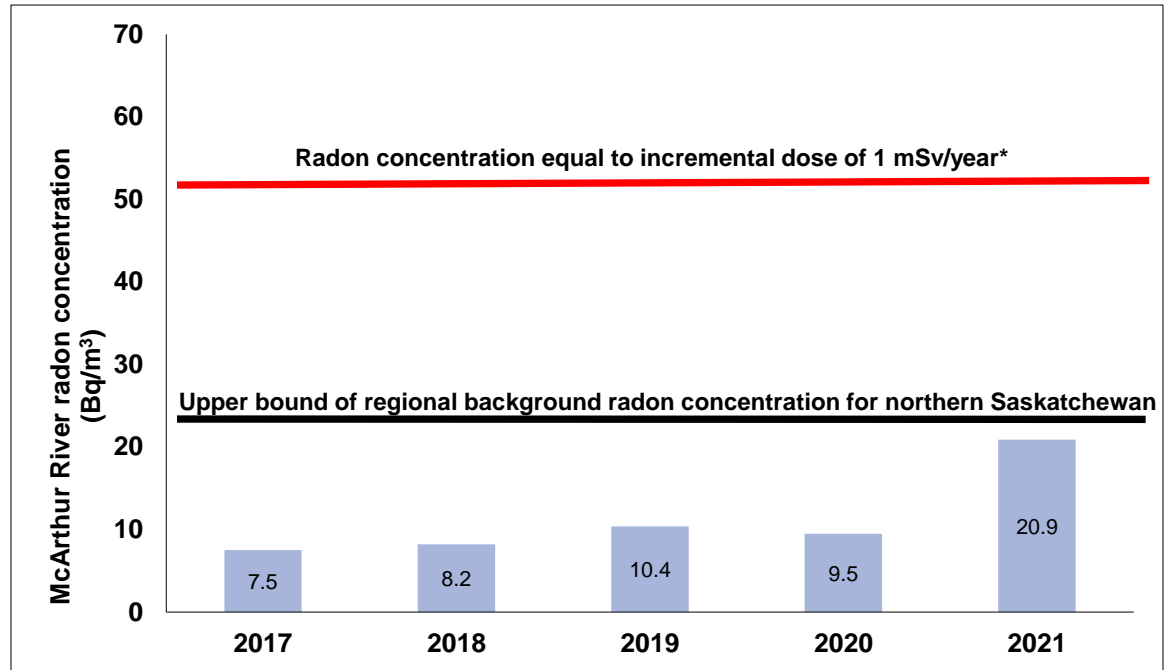
Source: Cameco

Air emissions released to the environment

The CNSC requires that Cameco maintain an air and terrestrial monitoring program at its McArthur River Operation. Air and terrestrial monitoring at the McArthur River facility includes ambient radon, total suspended particulate (TSP), soil sampling and lichen sampling to assess the impact of air emissions. An analysis of blueberry chemistry was also included to align with country food studies. Blueberry twigs are monitored to determine whether soil-borne contaminants (when present) are being absorbed through the roots into the growing plant parts. The monitoring of soil and blueberry stems/twigs was completed in the summer of 2018. The results are within the historical range for the stations sampled.

Radon in ambient air is monitored using passive track etch cups at 10 monitoring stations surrounding the operation. Figure 4.4 shows that the average concentrations of radon in ambient air from 2017 to 2021 were similar to past performance, with radon concentrations typical of the northern Saskatchewan regional background of less than 7.4 Bq/m³ to 25 Bq/m³. The average radon concentrations are less than the reference level of 60 Bq/m³, which represents an incremental dose of 1 mSv/year above background.

Figure 4.4: McArthur River Operation - concentrations of radon in ambient air, 2017–21



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m³ above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

** Part of change in value attributed to differing detection limit and laboratory performing analysis.

Two high-volume air samplers were used to collect and measure TSP in air. Taking the average of the 2 stations, the TSP levels were lower than provincial standards (see table 4.2). In addition, the mean concentrations of metal and radionuclides adsorbed to TSP were low and below the reference annual air quality levels identified in table 4.2.

Table 4.2: McArthur River Operation - concentrations of metal and radionuclides in air, 2017-21*

Parameter	Reference annual air quality levels	2017	2018	2019	2020	2021
TSP ($\mu\text{g}/\text{m}^3$)	60 ⁽³⁾	3.24	1.69	2.5	1.31	2.21
As ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.0001	0.00006	0.00004	0.00005	0.00005
Cu ($\mu\text{g}/\text{m}^3$)	9.6 ⁽¹⁾	0.0064	0.0072	0.0063	0.0042	0.007
Ni ($\mu\text{g}/\text{m}^3$)	0.04 ⁽¹⁾	0.0007	0.0006	0.00054	0.00049	0.00064
Pb ($\mu\text{g}/\text{m}^3$)	0.10 ⁽¹⁾	0.0006	0.0008	0.00063	0.00046	0.00419
Se ($\mu\text{g}/\text{m}^3$)	1.9 ⁽¹⁾	0.00004	0.00003	0.000025	0.0000025	0.00003
Zn ($\mu\text{g}/\text{m}^3$)	23 ⁽¹⁾	0.0084	0.0295	0.023	0.010	0.00608
Pb-210 (Bq/m^3)	0.021 ⁽²⁾	0.0004	0.0003	0.0003	0.0003	0.0003
Po-210 (Bq/m^3)	0.028 ⁽²⁾	0.0001	0.0001	0.0001	0.0001	0.00009
Ra-226 (Bq/m^3)	0.013 ⁽²⁾	0.00001	0.00001	0.000006	0.0000044	0.000004
Th-230 (Bq/m^3)	0.0085 ⁽²⁾	0.000007	0.00001	0.000008	0.000008	0.000008
U ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.0003	0.0001	0.0001	0.0001	0.000085

¹ Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).

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

³ *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Saskatchewan provincial limits were established at the time of this report.

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 triennial measurements of metals and radionuclides in soil and blueberry samples.

Soil, blueberry twig and lichen samples were last collected in 2021 as required by the triennial sampling program. The results indicated that the parameters measured were within historical ranges.

CNSC staff concluded that the level of airborne particulate contaminants produced by the McArthur River Operation is acceptable and does not pose a risk to the environment.

Uncontrolled releases

In 2021, no events reported to the CNSC were classified as a release (spill) of a hazardous substance to the environment. CNSC spill rating definitions can be found in appendix I, table I-2.

Figure 2.10 in section 2 shows the number of spills at the McArthur River Operation from 2017 to 2021.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the McArthur River environmental protection program, successfully carried out the required environmental monitoring.

Through the compliance verification activities conducted and the review of annual reports and environmental protection reports (EPRs), CNSC staff concluded that the environmental monitoring conducted at the McArthur River Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remains protected.

Environmental risk assessment

In 2020, the McArthur River EPR and updated Environmental Risk Assessment (ERA) for 2015 to 2019 were submitted to the CNSC and the Saskatchewan Ministry of Environment. CNSC staff have reviewed the environmental monitoring results for air, soil, vegetation, surface water, groundwater and sediment, as well as the health indicators for fish and their prey inhabiting sediment and confirmed the results to date were within those predicted in the ERA. After reviewing the EPR and ERA data that has been collected, CNSC staff concluded that adequate measures have been taken at the McArthur River Operation to protect the environment.

Protection of people

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and LCH. The review of McArthur River Operation's hazardous (non-radiological) discharges to the environment indicates that the public and the environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the McArthur River Operation remained within those predicted in the ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensees' reports, work practices and monitoring results for 2021, CNSC staff concluded that the McArthur River Operation's environmental protection program continued to be effective at protecting the public and the environment.

4.4 Conventional Health and Safety

CNSC staff rated the conventional health and safety SCA as “satisfactory” based on regulatory oversight activities conducted during 2021.

McArthur River Operation - conventional health and safety ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Cameco includes program documentation for the conventional health and safety SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were 2 inspections conducted at the McArthur River Operation that examined elements of the conventional health and safety SCA. As a result of these inspections, no non-compliances were identified. There were no event reports for which this SCA was the main contributory factor.

Practices

To promote continued effective safety performance, the McArthur River Operation has implemented a health and safety management program to identify and mitigate risks at the facility. The program includes a safety permit system, continued training, planned internal inspections, occupational health committees and incident investigations. The incident reporting system includes investigating and reporting on near misses and reduces chances of future incidents that could cause injury. CNSC staff verified that Cameco’s conventional health and safety work practices and conditions at the McArthur River Operation met regulatory requirements in 2021.

Performance

Table 4.3 summarizes LTIs at the McArthur River Operation from 2017 to 2021. There were no LTIs at the McArthur River Operation in 2021.

The TRIR for McArthur River is included for the last 5 years. The TRIR is the incident frequency rate that measures the number of fatalities, LTIs and other injuries requiring medical treatment, per 200,000 person-hours worked.

Table 4.3: McArthur River Operation – lost-time injury statistics, 2017–21

	2017	2018	2019	2020	2021
Lost-time injuries¹	1	0	0	0	0
Severity rate²	12.11	23.2*	0	0	0
Frequency rate³	0.15	0	0	0	0
Total recordable incident rate⁴	5.24	5.02	2.12	1.98	0.70

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(# of incidents in last 12 months) / # of hours worked in last 12 months)] x 200,000.

* Severity rating of 23.2 is related to time lost in 2018 due to injuries that occurred in 2016 and 2017.

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. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. The facility's management stresses the importance of conventional health and safety through regular communication, management oversight and the continual improvement of safety systems.

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

4.5 Additional SCAs

In this 2021 report, CNSC staff have provided a brief discussion of the additional SCAs; these are presented in the following sections.

4.5.1 Management system

Cameco maintains a quality management program which is part of the licensing basis for McArthur River Operation in the LCH.

There were no inspections at the McArthur River Operation focused on evaluating the management system SCA in 2021 and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.2 Human performance management

Cameco includes program documentation for the human performance management SCA as part of the overall management system documents; these form part of the licensing basis in the LCH.

There was 1 inspection at the McArthur River Operation focused on evaluating the human performance management SCA in 2021 and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.3 Operating performance

Cameco includes program documentation for the operating performance SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the McArthur River Operation focused on evaluating the operating performance SCA in 2021 and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.4 Safety analysis

Cameco includes program documentation for the safety analysis SCA as part of the overall management system documents; these constitute part of the licensing basis for McArthur River Operation in the LCH.

There were no inspections conducted in 2021 with a focus on evaluating the safety analysis SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.5 Physical design

Cameco includes program documentation for the physical design SCA as part of the overall management system documents; these form part of the licensing basis for McArthur River Operation in the LCH.

There was no inspection conducted in 2021 at the McArthur River Operation evaluating the physical design SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program with respect of this SCA remains satisfactory.

4.5.6 Fitness for service

Cameco includes program documentation for the fitness for service SCA as part of the overall management system documents; these constitute part of the licensing basis for the McArthur River Operation in the LCH.

There was no inspection conducted in 2021 at the McArthur River Operation that focused on evaluating the fitness for service SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.7 Emergency management and fire protection

Cameco includes program documentation for the emergency management and fire protection SCA as part of the overall management system documents; these form part of the licensing basis for McArthur River Operation in the LCH.

One inspection was conducted at the McArthur River Operation in 2021 evaluating the emergency management and fire protection SCA. There was 1 non-compliance found of low safety significance and CNSC determined the corrective action undertaken by the licensee sufficient. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.8 Waste management

Cameco includes program documentation for the waste management SCA as part of the overall management system documents; these form part of the licensing basis for McArthur River Operation in the LCH.

No inspections were conducted at the McArthur River Operation in 2021 that focused on evaluating the waste management SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

4.5.9 Security

Cameco includes program documentation for the security SCA as part of the overall management system documents; these constitute part of the licensing basis for McArthur River Operations in the LCH.

There were no inspections conducted at the McArthur River Operation that focused on evaluating the security SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program with respect of this SCA remains satisfactory.

4.5.10 Safeguards and non-proliferation

Cameco includes program documentation for the safeguards and non-proliferation SCA as part of the overall management system documents; these form part of the licensing basis for McArthur River Operation in the LCH. A CNSC inspection performed in 2021 verified McArthur River Operation's compliance regarding reporting requirements under the safeguard and non-proliferation SCA. There were no event reports for which this SCA was the main contributory factor.

In addition to CNSC compliance activities with respect to the specific areas under the safeguards and non-proliferation SCA, the International Atomic Energy Agency (IAEA) conducts independent inspections with coordination and support through the CNSC regulatory framework. No IAEA inspections were conducted at the McArthur River Operation during 2021.

CNSC staff concluded that the licensee's program in respect to this SCA remains satisfactory.

4.5.11 Packaging and transport

Cameco includes program documentation for the packaging and transport SCA as part of the overall management system documents; these form part of the licensing basis for McArthur River Operation in the LCH.

There were no inspections at the McArthur River Operation that focused on evaluating the packaging and transport SCA. There were no shipments of ore from McArthur River during 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5 RABBIT LAKE OPERATION

The Rabbit Lake Operation is located 750 kilometres north of Saskatoon, Saskatchewan. Owned and operated by Cameco Corporation (Cameco), the facility stretches across approximately 20 kilometres. It consists of an underground mine; 3 mined-out pits, of which 2 are reclaimed; an in-pit tailings management facility (TMF), a mill and supporting infrastructure. Figure 5.1 provides an aerial view of the mill area of the Rabbit Lake Operation.

In October 2013, following a public hearing in La Ronge, Saskatchewan, the Commission issued a 10-year licence to Cameco for the Rabbit Lake Operation. Cameco's licence expires on October 31, 2023. In March 2021, Cameco's licence was renewed to conform to the standardized CNSC licence format and conditions, and with a renewed financial guarantee.

Figure 5.1: Rabbit Lake Operation - aerial view of mill



Source: CNSC

Mining production data for the Rabbit Lake Operation are provided in table 5.1.

Table 5.1: Rabbit Lake Operation - mining production data, 2017–21

Mining	2017	2018	2019	2020	2021
Ore tonnage (Mkg/year)	0	0	0	0	0
Average ore grade mined (%U)	0	0	0	0	0
Uranium mined (Mkg U/year)	0	0	0	0	0

In 2016, Cameco halted mining and milling operations at the Rabbit Lake Operation and the facility was placed in a safe state of care and maintenance.

No uranium concentrate was produced nor was any ore production conducted at the Rabbit Lake Operation during the 2021 reporting period. Table 5.2 provides milling production data from 2017 to 2021.

Table 5.2: Rabbit Lake Operation - milling production data, 2017–21

Milling	2017	2018	2019	2020	2021
Mill ore feed (Mkg/year)	0	0	0	0	0
Average annual mill feed grade (%U)	0	0	0	0	0
Percent uranium recovery (%)	0	0	0	0	0
Uranium concentrate produced (Mkg U/year)	0	0	0	0	0
Authorized annual production (Mkg U/year)	4.25	4.25	4.25	4.25	4.25

5.1 Performance

For 2021, 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 5-year period from 2017 to 2021 are shown in appendix E.

In 2021, CNSC staff conducted 2 inspections which focused on the following SCAs: operating performance, emergency management and fire protection, fitness for service, conventional health and safety, radiation protection and human performance (training). There was 1 non-compliance identified as a result of the CNSC inspections of the Rabbit Lake Operation. One planned CNSC inspection at Rabbit Lake for 2021 was postponed until July 2022 in order to accommodate an onsite inspection. A list of inspections is provided in appendix B.

5.2 Radiation Protection

For 2021, CNSC staff continued to rate the radiation protection SCA at Rabbit Lake as “satisfactory” based on regulatory oversight activities.

Rabbit Lake Operation - radiation protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The sources of radiological exposure at the Rabbit Lake Operation during production were from mining at the Eagle Point underground mine and from milling uranium ore into yellowcake at the Rabbit Lake mill. The effective dose contributors to nuclear energy workers (NEWs) at Rabbit Lake were radon progeny (75%), gamma radiation (17%), long-lived radioactive dust (LLRD) (5%) and radon gas (3%). Effective doses to NEWs from exposures to radon progeny, radon gas and LLRD are controlled through the effective use of source control, ventilation, contamination control and personal protective equipment. Gamma radiation exposure is controlled through practices related to the effective use of time, distance and shielding.

Radiation protection program performance

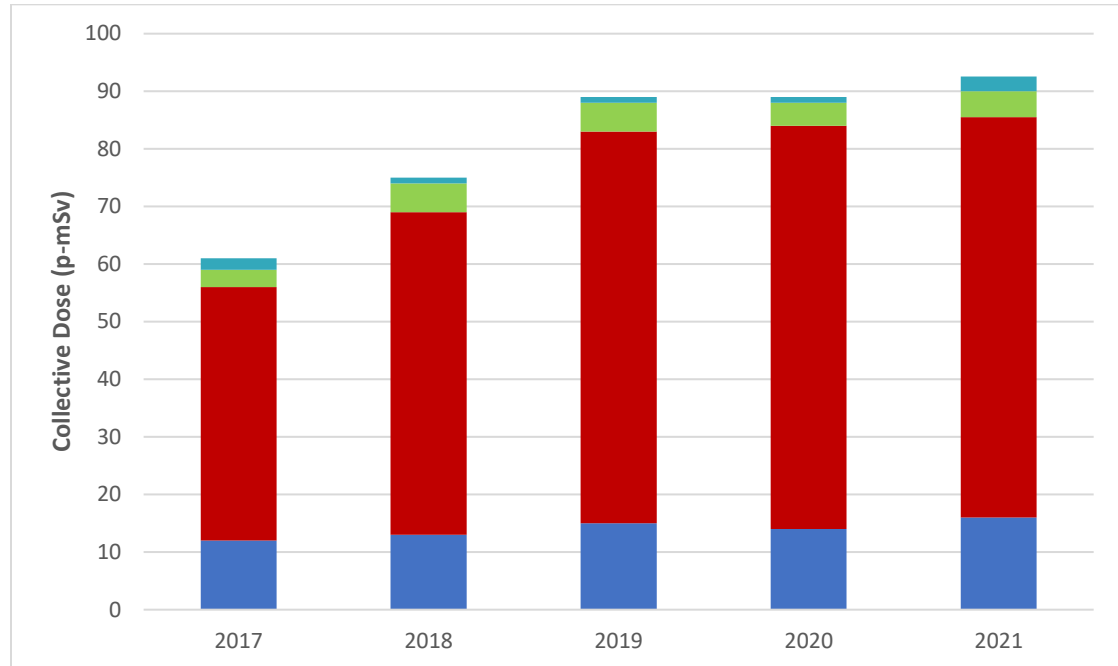
In 2021, CNSC staff were satisfied that the radiation protection program and practices at the Rabbit Lake Operation remained effective at controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). No exceedances of action levels were reported at the Rabbit Lake Operation in 2021.

Application of ALARA

In 2021, the collective dose to NEWs at the Rabbit Lake Operation was 93 person-millisieverts (p-mSv), a minor increase over the 2020 value of 89 p-mSv (see figure 5.2).

Figure 5.2 displays the annual collective radiation exposures at the Rabbit Lake Operation from 2017 to 2021.

Figure 5.2: Rabbit Lake Operation – annual collective dose, 2017–21



	2017	2018	2019	2020	2021
Gamma (p-mSv)	12	13	15	14	16
RnP (p-mSv)	44	56	68	70	70
LLRD (p-mSv)	3	5	5	4	5
RnG (p-mSv)	2	1	1	1	3
Total*	61	76	89	89	93

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* The total collective dose may not match the individual components due to rounding errors.

In 2021, the Rabbit Lake Operation identified 3 targets for the ALARA program. The first 2 are to investigate options to lower radon progeny levels in the mill shop and the mill warehouse. The third target is for follow-up sampling for all ventilation and heating optimization to ensure radon progeny levels are controlled.

CNSC staff have verified through regulatory oversight activities that Cameco continued to keep worker exposures ALARA.

Worker dose control

During 2021, the average individual effective dose for NEWs was 0.57 mSv and the maximum individual effective dose was 2.47 mSv. This is lower than the average effective dose of 0.70 mSv and the maximum individual dose of 2.93 mSv in 2020. As indicated in section 2 figures 2.3 and 2.4, all individual effective doses for NEWs were below the annual regulatory limit of 50 mSv. The 5-year dosimetry period of 2021 to 2025 has just started. So far, the maximum dose is 2.47 mSv (~ 2.5% of the 100 mSv dose limit).

Based on CNSC staff's compliance verification activities, such as inspections, reviews of licensees' reports and work practices, and monitoring of results and individual effective dose results for 2021, CNSC staff were satisfied that the Rabbit Lake Operation continued to be effective at controlling radiation doses to workers.

5.3 Environmental Protection

For 2021, CNSC staff continued to rate the environmental protection SCA at Rabbit Lake as "satisfactory" based on regulatory oversight activities. CNSC staff concluded that the licensee's environmental protection program was effectively implemented and met all regulatory requirements.

Rabbit Lake Operation - environmental protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Rabbit Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental protection program at the Rabbit Lake Operation as identified in its CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco continued to conduct routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to verify continual improvement and to confirm that the controls put in place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

For previously identified constituents of potential concern (COPC) with the potential to adversely affect the environment (i.e., uranium, molybdenum and selenium), the effluent treatment system at the Rabbit Lake Operation continued to meet performance expectations in terms of reducing the concentrations of these parameters (see figures 2.5 to 2.7 of section 2). At times in 2021, molybdenum concentrations were above the historical mean; however, the mean annual concentration (0.184 mg/L) remained relatively consistent with the 3-year historical mean (0.174 mg/l) and was stable most of the year. Molybdenum concentrations did not exceed action levels at any time in 2021.

As shown in section 2.3, CNSC staff verified that the Rabbit Lake Operation continued to meet the discharge limits set out in the [Metal and Diamond Mining Effluent Regulations](#) [8].

Cameco's environmental management system and effluent monitoring programs at the Rabbit Lake Operation met regulatory requirements, and all treated effluent discharged to the environment complied with licence requirements. In 2021, the concentrations of regulated parameters in treated effluent released to the environment were well below the regulatory limits and there were no exceedances of environmental action levels at the Rabbit Lake Operation. Figure 5.3 shows the B-Zone settling pond at the Rabbit Lake Operation. CNSC staff will continue to review effluent quality results to verify that effluent treatment performance remains effective.

Figure 5.3: Rabbit Lake Operation - B-Zone settling pond



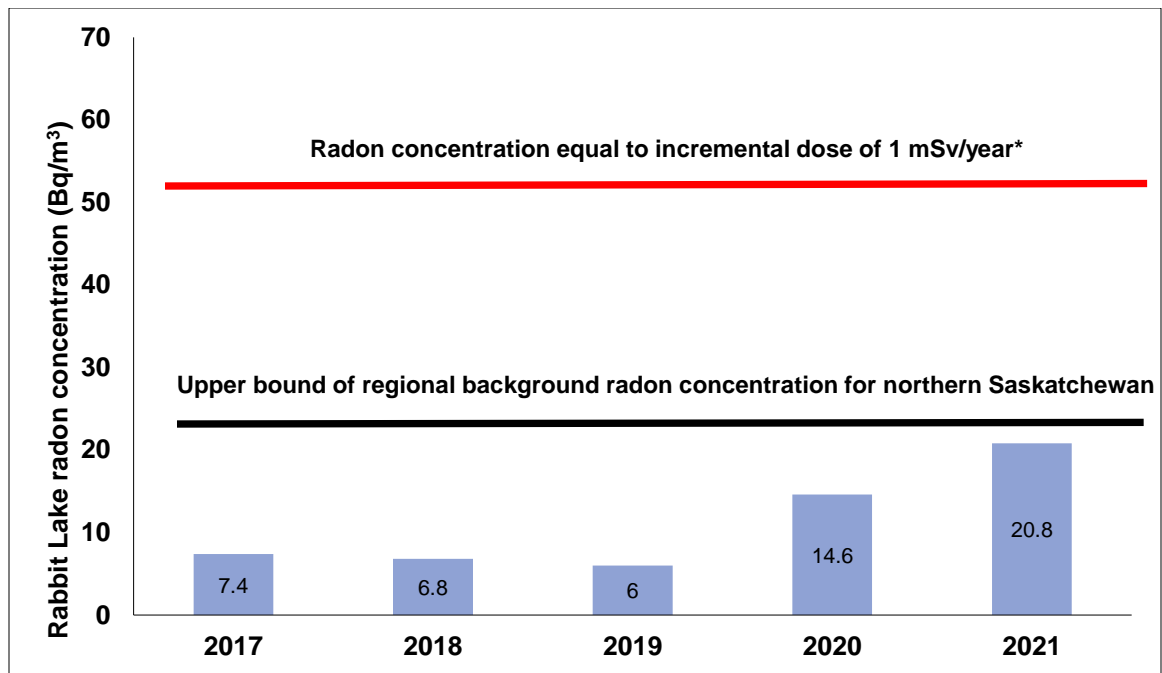
Source: Cameco

Air emissions released to the environment

Cameco also maintains an air and terrestrial monitoring program at the Rabbit Lake Operation. Air and terrestrial monitoring at the Rabbit Lake facility includes ambient radon, total suspended particulate (TSP), sulphur dioxide, soil sampling and lichen sampling to assess the impact of air emissions.

Radon in ambient air around the Rabbit Lake Operation is monitored at 19 stations using passive track etch cups. Figure 5.4 shows that the average concentrations of radon in ambient air from 2017 to 2021 is similar to background concentrations for northern Saskatchewan's regional baseline of less than 7.4 Bq/m³ to 25 Bq/m³. The average radon concentrations are less than the reference level of 60 Bq/m³, which represents an incremental dose of 1 mSv/year above background.

Figure 5.4: Rabbit Lake Operation - concentrations of radon in ambient air, 2017–21



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m³ above natural background) based on ICRP 115. Values are calculated as geometric means.

Three high-volume air samplers were used to collect and measure TSP in air. The TSP levels from the average of the 3 stations were lower than provincial standards (see table 5.3). 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.

Table 5.3: Rabbit Lake Operation – concentrations of metal and radionuclides in air, 2017–21

Parameter	Reference annual air quality levels*	2017	2018	2019	2020	2021
TSP ($\mu\text{g}/\text{m}^3$)	60 ⁽³⁾	4.79	3.91	4.31	3.00	3.67
As ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.000285	0.000365	0.000128	0.000247	0.000168
Ni ($\mu\text{g}/\text{m}^3$)	0.04 ⁽¹⁾	0.000404	0.000183	0.000140	0.000580	0.000157
Pb-210 (Bq/m^3)	0.021 ⁽²⁾	0.000013	0.000015	0.000006	0.000007	0.000010
Ra-226 (Bq/m^3)	0.013 ⁽²⁾	0.0000004	0.0000002	0.000000	0.0000002	0.000000
Th-230 (Bq/m^3)	0.0085 ⁽²⁾	0.0000004	0.0000003	0.0000000	0.0000000	0.000000
U ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.000190	0.000277	0.000117	0.00012	0.000148

¹ Reference annual air quality levels are derived from Ontario's 24-hour ambient air quality criteria (2012).

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

³ *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Saskatchewan provincial limits were established at the time of this report.

Daily in-stack monitoring of sulphur dioxide emissions from the mill acid plant was discontinued in 2017 for the duration of the care and maintenance period, as the acid plant and mill processing circuits have not operated in that time.

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 lichen.

Lichen sampling has been conducted for 3 decades at the Rabbit Lake Operation, most recently in 2019. 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.

Uncontrolled releases

In 2021, 4 events were reported where hazardous substances were released to the environment (spills) at the Rabbit Lake Operation. None of these events resulted in residual impact to the environment or human health. CNSC staff were satisfied with the licensee's reporting of releases and the corrective actions taken. CNSC staff rate spills in accordance with the definitions provided in appendix I, table I-2. Figure 2.10 in section 2 displays the number of environmental reportable spills at the Rabbit Lake Operation from 2017 to 2021.

Appendix I contains a brief description of reported spills, the corrective actions taken by the licensee, CNSC staff's assessment of those actions and the significance ratings for 2021.

Assessment and monitoring

CNSC staff confirmed that the licensee successfully carried out required environmental monitoring, in accordance with the Rabbit Lake environmental protection program.

Through the compliance activities conducted and the review of annual reports and EPRs, CNSC staff concluded that the environmental monitoring conducted at the Rabbit Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remains protected.

Environmental risk assessment

The Rabbit Lake Operation updated ERA for 2015 to 2019 was submitted to the CNSC and the Saskatchewan Ministry of Environment in December 2020. CNSC staff are currently finalizing their review of the environmental monitoring results for air, soil, vegetation, surface water, groundwater and sediment, as well as health indicators for fish and their prey inhabiting sediment, to confirm that the results were within those predicted in the ERA. The ERA review process is still ongoing at this time.

Protection of people

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the licence and the LCH. The review of Rabbit Lake Operation's hazardous (non-radiological) discharges to the environment indicates that the public and environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Rabbit Lake Operation remained within those predicted in the current 2015 ERA and that human health remained protected in 2021.

Based on compliance verification activities that included inspections, reviews of licensees' reports and work practices and monitoring results for 2021, CNSC staff concluded that the Rabbit Lake Operation's environmental protection program continued to be effective at protecting the public and the environment.

5.4 Conventional Health and Safety

For 2021, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory" based on regulatory oversight activities.

Rabbit Lake Operation - conventional health and safety ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Practices

Cameco's Rabbit Lake Operation has implemented a health and safety program to identify and mitigate risks. The program includes internal inspections, a safety permit system, occupational health committees, training and incident investigations. CNSC staff monitor this program through compliance activities to verify the protection of workers.

The incident reporting system at the Rabbit Lake Operation includes reporting on and investigating near misses with the aim of reducing future incidents that could cause injury. CNSC compliance verification activities confirmed that the Rabbit Lake Operation continued to focus on preventing accidents and injuries through the implementation of its health and safety management program.

Performance

No lost-time injuries were reported for the Rabbit Lake Operation in 2021. The LTI performance at the Rabbit Lake Operation from 2017 to 2021 is shown in table 5.4.

The TRIR at Rabbit Lake is included for the last 5 years. The TRIR is the incident frequency rate that measures the number of fatalities, LTIs and other injuries requiring medical treatment, per 200,000 person-hours worked.

Table 5.4: Rabbit Lake Operation – lost-time injury statistics, 2017–21

	2017	2018	2019	2020	2021
Lost-time injuries¹	0	0	1	0	0
Severity rate²	0	0	104.79	40.860	0
Frequency rate³	0	0	1.05	0	0
Total recordable incident rate⁴	1.03	5.03	2.10	1.13	1.04

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months] x 200,000.

Awareness

CNSC staff observed that Cameco’s conventional health and safety program at the Rabbit Lake Operation continued to provide education, training, tools and support to workers. Managers, supervisors and workers share and promote the idea that safety is the responsibility of all individuals. Facility management emphasizes the importance of conventional health and safety through regular communication, management oversight and the continual improvement of safety systems.

CNSC staff verified that the conventional health and safety program at the Rabbit Lake Operation remained effective at managing health and safety risks.

5.5 Additional SCAs

In this 2021 regulatory oversight report, CNSC staff have provided a brief discussion of the additional SCAs; these are presented in the following sections.

5.5.1 Management system

The licensee maintains a quality management program; this program forms part of the licensing basis for this facility in the LCH.

There were no inspections focused on evaluating the management system SCA at the Rabbit Lake Operation in 2021 and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee’s program in respect of this SCA remains satisfactory.

5.5.2 Human performance management

The licensee includes program documentation for the human performance management SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections focused on evaluating the human performance management SCA at the Rabbit Lake Operation in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.3 Operating performance

The licensee includes program documentation for the operating performance SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections focused on evaluating the operating performance SCA at the Rabbit Lake Operation in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.4 Safety analysis

The licensee includes program documentation for the safety analysis SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections conducted at the Rabbit Lake Operation focused on evaluating the safety analysis SCA in 2021 and no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.5 Physical design

The licensee includes program documentation for the physical design SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Rabbit Lake Operation focused on evaluating the physical design SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.6 Fitness for service

The licensee includes program documentation for the fitness for service SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the Rabbit Lake Operation that focused on evaluating the fitness for service SCA in 2021 and there were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.7 Emergency management and fire protection

The licensee includes program documentation for the emergency management and fire protection SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections conducted at the Rabbit Lake Operation focused on evaluating the emergency management and fire protection SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.8 Waste management

The licensee includes program documentation for the waste management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Rabbit Lake Operation focused on evaluating the waste management SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.9 Security

The licensee includes program documentation for the security SCA as part of the overall management system documents; these documents constitute part of the licensing basis for this facility in the LCH.

There were no inspections focused on evaluating the security SCA at the Rabbit Lake Operation in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.10 Safeguards and non-proliferation

The licensee includes program documentation for the safeguards and non-proliferation SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH. There were no inspections in 2021 at the Rabbit Lake Operation focused on evaluating the safeguards and non-proliferation SCA. There were no notices of non-compliance related to the safeguards and non-proliferation SCA and no event reports for which this SCA was the main contributing factor.

In addition to CNSC compliance activities with respect to the specific areas under the safeguards and non-proliferation SCA, the International Atomic Energy Agency (IAEA) conducts independent inspections with coordination and support through the CNSC regulatory framework. No IAEA inspections were conducted at the Rabbit Lake Operation during 2021.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

5.5.11 Packaging and transport

The licensee includes program documentation for the packaging and transport SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Rabbit Lake Operation focused on evaluating the packaging and transport SCA in 2021. There were no shipments of ore concentrate from Rabbit Lake during 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6 KEY LAKE OPERATION

Cameco Corporation (Cameco) is the owner and operator of the Key Lake Operation which is located approximately 570 kilometers north of Saskatoon. The operation began with 2 open-pit mines and a mill complex. The Gaertner open pit was mined from 1983 to 1987, followed by the Deilmann open pit until 1997. Uranium mining is no longer carried out at Key Lake. Figure 6.1 provides an aerial view of the Key Lake facility.

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

Figure 6.1: Key Lake Operation – aerial view



Source : Cameco

Milling of the stockpiled Deilmann ore continued until 1999. In 2000 the mill started processing ore from the McArthur River Operation. The Key Lake Operation continues today as a mill operation that is licensed to process McArthur River ore and residual special waste from previous mining at Key Lake.

After open pit mining in the eastern pit of the Deilmann ore body was completed in 1995, the pit was converted to the engineered Deilmann tailings management facility (TMF), while mining continued in other parts of the pit area (see figure 6.2). Mill tailings continue to be deposited in this facility today.

Figure 6.2: Key Lake Operation – Deilmann tailings management facility



Source: CNSC

In 2018, the Key Lake Operation halted milling activities and the mill facility was placed in safe care and maintenance. In 2022, Cameco indicated their intent to begin the process of transitioning the Key Lake Operation from care and maintenance to production. This will be reflected in next year's regulatory oversight report.

Milling data for the Key Lake Operation during the 5-year reporting period are presented in table 6.1. The Key Lake Operation operated in a state of care and maintenance for 2021.

Table 6.1: Key Lake Operation – milling production data, 2017-21

Milling	2017	2018	2019	2020	2021
Mill ore feed (Mkg/year)	143.26	0	0	0	0
Average annual mill feed grade (% U)	4.37	N/A	N/A	N/A	N/A
Percentage of uranium recovery (%)	99.05	N/A	N/A	N/A	N/A
Uranium concentrate produced (Mkg U/year)	6.20	0.06*	0.006**	0	0
Authorized annual production (Mkg U/year)	9.60	9.60	9.60	9.60	9.60

* Processing of remaining ore slurry from 2017.

**From calciner clean-out and disposal of laboratory samples.

6.1 Performance

The SCA ratings at the Key Lake Operation for the 5-year period from 2017 to 2021 are shown in appendix E. CNSC staff continued to rate all SCAs for 2021 as “satisfactory” based on regulatory oversight activities.

In 2021, CNSC staff carried out 3 inspections that covered multiple SCAs, as detailed in appendix B. No non-compliances were noted as a result of CNSC inspections at the Key Lake Operation for the 2021 calendar year. A list of inspections can be found in appendix B of this report.

This report covers all SCAs but focuses on the 3 SCAs that cover many of the key performance indicators for these mines and mills: radiation protection, environmental protection, and conventional health and safety.

6.2 Radiation Protection

Based on regulatory oversight activities during the reporting period, CNSC staff rated the radiation protection SCA at the Key Lake Operation as “satisfactory”.

Key Lake Operation - radiation protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

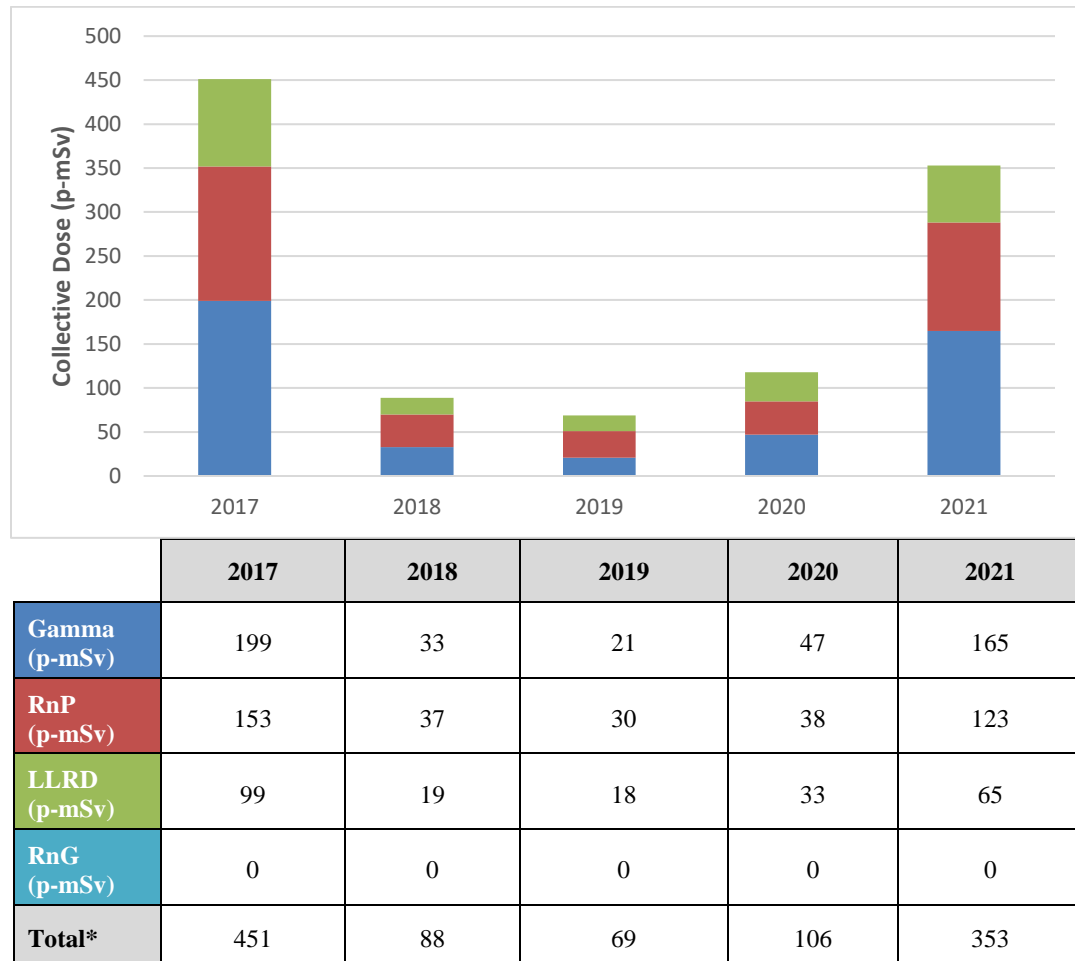
The effective dose contributors to nuclear energy workers (NEWs) at the Key Lake mill were gamma radiation (47%), radon progeny (35%) and long-lived radioactive dust (LLRD) (18%). Gamma radiation hazards are controlled through practices related to the effective use of time, distance and shielding. Radon progeny and LLRD are controlled through source control, ventilation contamination control and personal protective equipment.

Radiation protection program performance

In 2021, CNSC staff were satisfied that the radiation protection program and practices at the Key Lake Operation remained effective at controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). No exceedances of action levels were reported at the Key Lake Operation in 2021.

Application of ALARA

In 2021, the collective dose to NEWs at the Key Lake Operation was 353 person-millisieverts (p-mSv), a 233% increase from the 2020 value of 106 p-mSv (see figure 6.3). The collective dose in 2021 was elevated compared to 2020, however it remains well below the normal values during active processing of uranium ore.

Figure 6.3: Key Lake Operation - annual collective dose, 2017–21

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* The total collective dose may not match the individual components due to rounding errors.

Cameco continued to meet its objectives in 2021 for keeping doses consistent with the ALARA principle at the Key Lake Operation. To support this objective, the radiation area monitoring program was revised for the transition to care and maintenance.

Worker dose control

In 2021, the average individual effective dose to NEWs was 0.52 mSv, while the maximum individual effective dose received was 3.13 mSv. This compares to an average effective dose of 0.35 mSv and a maximum individual dose of 2.11 mSv in 2020. The effective doses received by workers from 2018 to 2021 are lower than historic values because the facility is in a state of care and maintenance.

The maximum individual effective dose at the Key Lake Operation was identified as a mill maintenance worker. The 5-year dosimetry period of 2021 to 2025 has just started. So far, the maximum dose is 3.13 mSv (~ 3.1% of the regulatory dose limit of 100 mSv dose limit). There were no administrative or action level exceedances in 2021.

Based on compliance verification activities, such as onsite inspections, reviews of licensee reports and work practices, monitoring of results and individual effective dose results, CNSC staff were satisfied that the Key Lake Operation continued to be effective at controlling radiation doses to workers in 2021.

6.3 Environmental Protection

For 2021, CNSC staff continued to rate the environmental protection SCA as “satisfactory” based on regulatory oversight activities. CNSC staff concluded that the licensees’ environmental protection program was effectively implemented and met all regulatory requirements.

Key Lake Operation - environmental protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the Key Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Cameco conducts internal audits of its environmental protection program at the Key Lake Operation, as identified in its CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Cameco had continued to conduct routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to verify continual improvement and to confirm that the controls put in place to protect the environment are effective.

Effluent and emissions control

Treated effluent released to the environment

At the Key Lake Operation, 2 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, then 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.

Monitoring confirmed that the effluent from dewatering wells is within design specifications and the predictions outlined in the ERA. Effluent from the reverse osmosis system was in compliance with regulatory limits and there were no environmental action level exceedances.

The treated effluent quality presented in table 6.2 refers only to the mill effluent as released to the David Creek system. CNSC staff verified that the concentration of all regulated contaminants in the treated mill effluent released in 2021 met regulatory limits. There were no exceedances of environmental action levels.

As discussed in section 2.3, constituents of potential concern (COPC) in treated effluent at uranium mine and mill operations with potential to adversely affect the environment are molybdenum, selenium and uranium (see figures 2.5 to 2.7). Of these, molybdenum and selenium concentrations were the primary concerns at the Key Lake Operation. The licensee previously completed process changes to reduce concentrations in treated effluent.

Reductions of molybdenum and selenium occurred from 2007 to 2009 when additional treatment components were installed and optimized. As indicated in section 2, figures 2.5 and 2.6 display stable or declining concentrations of molybdenum and selenium in treated effluent from 2017 to 2021, indicating these parameters are being effectively controlled. Cameco submitted a molybdenum and selenium follow-up program closure report in 2018. Based on the results of the follow-up program, Cameco proposed that current regulatory monitoring requirements were sufficient to monitor future changes in sediment and other environmental receptors and proposed that the formal follow-up program cease. CNSC staff confirmed in 2019 that the follow-up program could conclude, and, as a result, the monitoring requirements were added to the environmental monitoring program for the facility.

Section 2 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 analyzing treated effluent for uranium, molybdenum and selenium, Cameco analyzed treated effluent at Key Lake for concentrations of other COPCs, such as radium-226, arsenic, copper, lead, nickel, zinc and total suspended solids (TSS), as well as pH levels. As discussed in section 2.4, the Key Lake Operation continued to meet [MDMER](#) [8] discharge limits.

CNSC staff will continue to review effluent quality results to verify that the treatment of effluent remains effective.

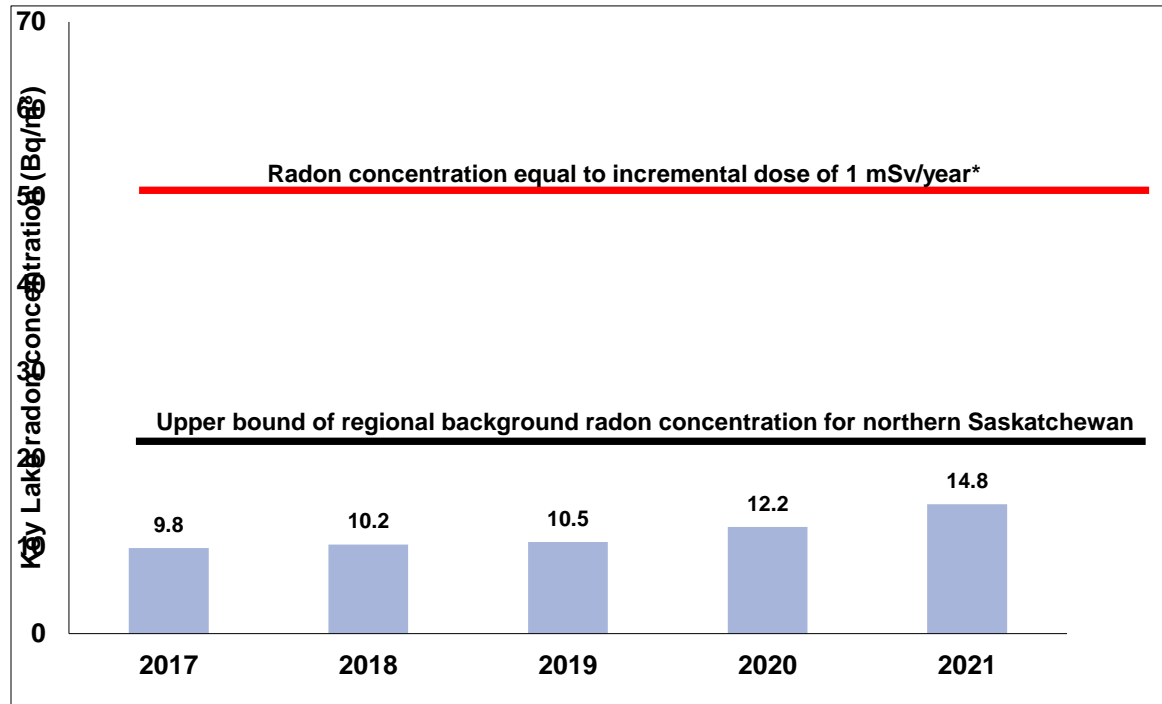
Air emissions released to the environment

The air and terrestrial monitoring program at the Key Lake Operation includes ambient monitoring for sulphur dioxide, radon and total suspended particulate (TSP), as well as soil and lichen sampling to assess air quality. Air emissions monitoring from the mill stacks is also included in the air-quality monitoring program.

The Key Lake calciner stack was not sampled in 2021 due to the facility not being in operation. Sulphur dioxide concentrations from the acid plant stack are monitored daily when in operation, however, the plant did not operate in 2021.

Radon in air around the Key Lake Operation is monitored at 5 stations using passive track etch cups. Figure 6.4 shows the average concentrations of radon in ambient air from 2017 to 2021. Ambient radon concentrations were typical of the northern Saskatchewan regional background of less than 7.4 Bq/m³ to 25 Bq/m³. The measured radon concentrations are also below a reference radon concentration of 60 Bq/m³, which is equal to an incremental dose of 1 mSv per year above background.

Figure 6.4: Key Lake Operation - concentrations of radon in ambient air, 2017–21



* Upper-bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m³ above natural background) based on ICRP 115. Values are calculated as geometric means.

Five high-volume air samplers were used to collect and measure TSP. 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. 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, as identified in table 6.2.

Table 6.2: Key Lake Operation - concentrations of metal and radionuclides in air, 2017–21

Parameter	Reference annual air quality levels*	2017	2018	2019	2020	2021
TSP ($\mu\text{g}/\text{m}^3$)	60 ⁽³⁾	11.90	8.80	6.91	6.04	7.00
As ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.0045	0.0021	0.0021	0.0008	0.0021
Ni ($\mu\text{g}/\text{m}^3$)	0.04 ⁽¹⁾	0.0029	0.0011	0.0017	0.0006	0.0015
Pb-210 (Bq/m^3)	0.021 ⁽²⁾	0.0004	0.0002	0.003	0.0002	0.0002
Ra-226 (Bq/m^3)	0.013 ⁽²⁾	0.0003	0.0001	0.0001	0.0001	0.0001
Th-230 (Bq/m^3)	0.0085 ⁽²⁾	0.0002	0.0001	0.0001	0.0001	0.0001
U ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.0085	0.0012	0.0008	0.0002	0.0056

¹ Reference annual air quality levels derived from Ontario's 24-hour ambient air quality criteria (2012).

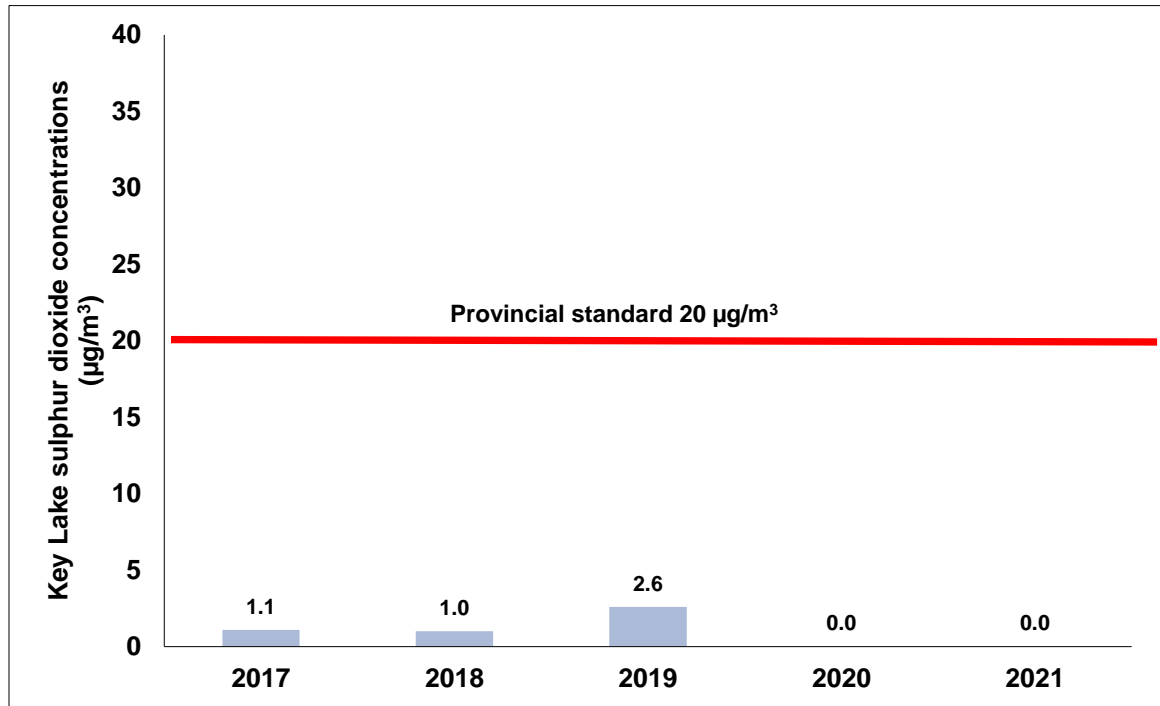
² Reference level from International Commission on Radiological Protection (ICRP) Publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.

³ *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Saskatchewan provincial limits were established at the time of this report.

A sulphur dioxide monitor is located approximately 300 metres downwind of the mill facility and is used to continuously measure the ambient sulphur dioxide associated with mill emissions. As the site has been in a state of care and maintenance, CNSC staff and the Saskatchewan Ministry of Environment granted approval to cease ambient sulphur dioxide monitoring. Monitoring will be required when the acid plant resumes operation.

Figure 6.5: Key Lake Operation - concentrations of ambient sulphur dioxide, 2017–21



* Monitoring temporarily suspended in 2020 due to shut down of acid plant during care and maintenance period.

In addition to ambient air monitoring for sulphur dioxide, sulphate levels have been monitored in 4 lakes to measure the effects of sulphur dioxide emissions from the operation. The results of the 2021 lake sampling program continued to show that sulphate concentrations remain relatively unchanged from historical concentrations. CNSC staff concluded that the operations at Key Lake and the 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 and soil samples were collected in 2021.

There were no significant differences in total lichen richness observed from 2011 to 2021. The similarity in results from the past decade indicate that species abundance has not been affected by the SO₂ emissions 4 km downwind of the Key Lake Operation. Overall epiphytic lichens were observed to be increasing in abundance and richness, a sign of a healthy epiphytic lichen community.

The 2021 lichen chemistry data indicate parameter concentrations tended to be higher at locations in closer proximity to the operation as compared to locations farther from site. Levels of arsenic, nickel, and uranium are generally declining with time and 2021 saw some of the lowest levels reported to date. Levels of radionuclides have been relatively low over time and again in 2021 some parameters were the lowest recorded to date. Results from the 2016 soil sampling program illustrate that parameter concentrations at all stations were comparable to, or lower than, historical results, with the exception of lead-210 and polonium-210 which increased in 2016 but returned to lower levels during the 2021 sampling period.

Uncontrolled releases

In 2021, there were 4 events reported to CNSC staff that were considered to be releases of hazardous substances to the environment:

- On February 12, 2021, approximately 3,000 litres of contaminated water was released to the ground from a valve shack adjacent to the Deilmann Tailings Management Facility. A split in a 3-inch pipe occurred as a result of the extreme cold temperatures. The contaminated water was largely recovered using a vacuum truck.
- On June 22, 2021, Cameco notified CNSC staff of the discovery of elevated concentrations of constituents of potential concern (COPCs), specifically ammonia and sulfate, in groundwater samples from monitoring well MT-19-01 and MT-19-12 in the 2020 and 2021 sampling program for these wells. These wells were installed as part of the site assessment for the 2018 reportable discharge from the molybdenum plant (refer to [CMD 19-M13](#) [13] and [CMD 19-M36](#) [14]). It was deemed likely that a release to the environment occurred prior to Key Lake going into a state of care and maintenance in 2018 and is not solely the result of previously reported historical discharges or discoveries at Key Lake. An update on the status of the 2018 discovery and 2021 discovery are included below.
- On September 13, 2021, an unknown quantity of propane was released from a leak on the propane line outside of the leaching building at the mill. A mill operator reported the smell of propane while conducting their inspection/rounds. The insulation cover on propane piping had deteriorated and corrosion occurred on a pipe which eventually led to the leak.
- On December 27, 2021, over 60 litres of propane was released from the propane storage area near the steam plant. A pressure gauge on the pipe near the propane pump broke resulting in the release. The powerhouse operator was alerted by an alarm and responded.

Appendix I provides a brief description of each release and the actions taken by the licensee. With the exception of the groundwater contamination discovery (see below), all corrective actions related to these spills have been completed and accepted by CNSC staff.

In 2018, Cameco required the completion of investigation and development of corrective action plans after the discovery of uranium contamination in groundwater under the mill terrace. A site assessment report was prepared and submitted to the CNSC in March 2020. The assessment confirmed that the uranium contamination is limited in geographic extent; there have been no impacts and no immediate risks to the surrounding environment. The assessment included source sampling, monitoring and borehole well installation, groundwater sampling, and hydraulic conductivity testing. The assessment was used to develop a corrective action plan which was submitted in September 2020. CNSC staff accepted that plan in June 2021, with the remediation involving the installation of recovery wells to pump out and treat the contaminated groundwater. As part of the corrective action plan, Cameco drilled ground water recovery wells and completed pump flow testing, as well as 2 rounds of water quality sampling in 2021. Cameco anticipates completing the installation and commissioning of the recovery wells in the fourth quarter of 2022. The environment remains protected while the remediation proceeds.

As part of the site assessment related to the 2018 uranium in groundwater event, Cameco installed and sampled several new wells. Water quality results from 2 of these newly installed wells showed elevated contaminant levels including ammonia and sulphate. These wells are also located on the mill terrace. This is not associated with the 2018 uranium in groundwater event but is thought to be from a separate discharge which occurred sometime before the facility went into care and maintenance. Cameco notified CNSC staff of these findings in June 2021 and continue to provide updates. Information provided to date from Cameco indicates that this new contamination is still limited to the mill terrace, and the environment remains protected. Cameco submitted another site assessment report in response to this discovery on May 17, 2022.

Figure 2.10 in section 2 displays the number of environmental reportable spills, as well as the number of releases of hazardous material to the environment from the licensed activities at the Key Lake Operation from 2017 to 2021.

Assessment and monitoring

CNSC staff confirmed that the licensee, in accordance with the Key Lake environmental protection program, successfully carried out the required environmental monitoring.

Through the compliance activities carried out and the review of annual reports and environmental protection reports (EPRs), CNSC staff concluded that the environmental monitoring conducted at the Key Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment remains protected.

Environmental risk assessment

The Key Lake Operation EPR and updated environmental risk assessment (ERA) for 2015 to 2019 were submitted to the CNSC and the Saskatchewan Ministry of Environment in December 2020. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, surface water, groundwater and sediment, as well as health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA.

After reviewing the EPR and ERA, CNSC staff concluded that adequate measures have been taken at the Key Lake Operation to protect human health and the environment.

Protection of people

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the Key Lake licence and licence conditions handbook (LCH). A review of the hazardous (non-radiological) discharges to the environment indicates that the public and the environment are protected. CNSC staff confirmed that environmental concentrations in the vicinity of the Key Lake Operation remained within those predicted in the 2013 ERA and that human health and the environment remained protected in 2021.

Based on compliance verification activities that included inspections, reviews of licensees' reports and work practices, and monitoring results for 2021, CNSC staff concluded that the Key Lake Operation's environmental protection program continued to be effective at protecting the public and the environment.

6.4 Conventional Health and Safety

For 2021, CNSC staff continued to rate the conventional health and safety SCA as "satisfactory", based on regulatory oversight activities.

Key Lake Operation - conventional health and safety ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Practices

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 before the incident record is closed. The Key Lake Operation continued its planned health and safety inspection program in 2021. Any items of concern found during these inspections are included in the licensee's incident reporting system.

Performance

Table 6.3 summarizes LTIs at the Key Lake Operation from 2017 to 2021. There were no LTIs at the Key Lake Operation between 2017 and 2021.

The TRIR for Key Lake is included for the last 5 years. The TRIR is the incident frequency rate that measures the number of fatalities, LTIs and other injuries requiring medical treatment.

Table 6.3: Key Lake Operation – lost-time injury statistics, 2017-21

	2017	2018	2019	2020	2021
Lost-time injuries¹	0	0	0	0	0
Severity rate²	0	0	0	0	0
Frequency rate³	0	0	0	0	0
Total recordable incident rate⁴	3.48	2.59	2.22	2.04	1.33

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(# of incidents in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

Awareness

CNSC staff evaluated Cameco's conventional health and safety program at Key Lake and determined that it continued to provide education, training, tools and support to workers. The idea that safety is the responsibility of all individuals is promoted by the licensee's managers, supervisors and workers. The licensee's management stresses the importance of conventional health and safety through regular communication, management oversight and continual improvement of safety systems.

CNSC staff's compliance verification activities concluded that Cameco's health and safety program at the Key Lake Operation met regulatory requirements in 2021.

6.5 Additional SCAs

In this 2021 regulatory oversight report, CNSC staff have provided a brief discussion of the additional SCAs; these are presented in the following sections.

6.5.1 Management system

The licensee maintains a quality management program and this program is part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation that focused on evaluating the management system SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.2 Human performance management

The licensee includes program documentation for the human performance management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the human performance SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.3 Operating performance

The licensee includes program documentation for the operating performance SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the operating performance SCA in 2021 and there were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.4 Safety analysis

The licensee includes program documentation for the safety analysis SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the safety analysis SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.5 Physical design

The licensee includes program documentation for the physical design SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the physical design SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.6 Fitness for service

The licensee includes program documentation for the fitness for service SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the fitness for service SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.7 Emergency management and fire protection

The licensee includes program documentation for the emergency management and fire protection SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the emergency management and fire protection SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.8 Waste management

The licensee includes program documentation for the waste management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the waste management SCA in 2021 and there were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.9 Security

The licensee includes program documentation for the security SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the security SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.10 Safeguards and non-proliferation

The licensee includes program documentation for the safeguards and non-proliferation SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH. There were no inspections in 2021 at the Key Lake Operation focused on evaluating the safeguards and non-proliferation SCA. There were no notices of non-compliance related to the safeguards and non-proliferation SCA and no event reports for which this SCA was the main contributing factor.

In addition to CNSC compliance activities with respect to the specific areas under the safeguards and non-proliferation SCA, the International Atomic Energy Agency (IAEA) conducts independent inspections with coordination and support through the CNSC regulatory framework. No IAEA inspections were conducted at the Key Lake Operation during 2021.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

6.5.11 Packaging and transport

The licensee includes program documentation for the packaging and transport SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the Key Lake Operation focused on evaluating the packaging and transport SCA in 2021. There were no shipments of ore concentrate from Key Lake during 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7 MCCLEAN LAKE OPERATION

Orano Canada Inc. (Orano) is the operator of the McClean Lake Operation. The McClean Lake Operation is a uranium mine and mill facility located approximately 750 kilometres north of Saskatoon in the Athabasca Basin of northern Saskatchewan. The McClean Lake Operation includes the John Everett Bates (JEB) milling area, Sue mining area, JEB tailings management facility (TMF) and the undeveloped McClean, Midwest and Caribou ore deposits. An aerial view of the facility is presented in figure 7.1.

Figure 7.1: McClean Lake Operation - aerial view



Source: Orano

CNSC staff confirmed that the McClean Lake Operation's production did not exceed the authorized annual production limit.

Though there were no conventional mining activities at the McClean Lake Operation in 2021, the Surface Access Borehole Resource Extraction (SABRE) program was successfully completed during a test mining session in 2021. Table 7.1 presents mining data for the McClean Lake Operation from SABRE for the 5-year reporting period.

Table 7.1: McClean Lake Operation - mining production data, 2017–21

Mining	2017	2018	2019	2020	2021
Ore tonnage (Mkg/year)	N/A	N/A	N/A	N/A	1.21
Average ore grade mined (%U)	N/A	N/A	N/A	N/A	5.66
Uranium mined (Mkg U/year)	N/A	N/A	N/A	N/A	0.058

The primary ore source for the McClean Lake mill was the ore slurry from the Cigar Lake Mine, while a separate smaller stream of McClean Lake Joint Venture ore through the SABRE program was co-milled in October and November. Table 7.2 presents milling production data for the McClean Lake Operation for the 5-year reporting period.

Table 7.2: McClean Lake Operation - milling production data, 2017–21

Milling	2017	2018	2019	2020	2021
Mill ore feed (Mkg/year)	36.35	42.9	46.2	26.3	35.2
Average annual mill feed grade (%U)	19.30	16.26	15.15	14.56	13.82
Percentage of uranium recovery (%)	99.03	98.94	98.91	98.81	98.7
Uranium concentrate produced (Mkg U)	6.93	6.94	6.94	3.88	4.75
Authorized annual production (Mkg U/year)	9.23	9.23	9.23	9.23	9.23

Licence Amendments

Following a public hearing held on June 7 and 8, 2017 in La Ronge, Saskatchewan, the current operating licence was renewed on July 1, 2017, and expires on June 30, 2027. The Commission amended the McClean Lake operating licence on July 1, 2018, to reflect the licensee's corporate name change from AREVA Resources Canada Inc. to Orano Canada Inc.

Orano has stated that milling of Cigar Lake ore produced more tailings per tonne of ore processed than initially expected. Current mining and milling plans indicate that the JEB TMF will reach its full storage capacity during the year of 2027. In order for Orano to secure future mining and milling plans, sufficient tailings capacity must be available to prevent production disruptions. Therefore, Orano submitted an application to amend the CNSC issued Uranium Mine Operating Licence UMOL-MINEMILL-McCLEAN.01/2027 for the expansion of the JEB TMF at the McClean Lake Operation [15]. This expansion would increase the JEB TMF embankment height to 468 meters above sea level (mASL) and the consolidated tailings to 462 mASL resulting in an increase of 10.5 meters in embankment height and the consolidated tailings by 14 metres in elevation. After a public hearing held on October 4, 2021, the Commission amended the CNSC licence for the McClean Lake Operation to allow JEB TMF expansion. The Commission also approved Orano’s revised financial guarantee of C\$102,098,000 for the McClean Lake Operation [16].

7.1 Performance

The SCA ratings at the McClean Lake Operation for the 5-year period from 2017 to 2021 are shown in appendix E. For 2021, CNSC staff rated all SCAs as “satisfactory” based on regulatory oversight activities.

In 2021, CNSC staff carried out 6 inspections that covered multiple SCAs, including 2 focused inspections (human performance, packaging and transport), and 1 reactive inspection (related to JEB TMF expansion) as detailed in appendix B.

For the 2021 calendar year, 5 instances of non-compliance were noted during CNSC inspections at the McClean Lake Operation. These instances of non-compliance were of low safety significance and related to the human performance and packaging and transport SCAs. The licensee has implemented corrective actions, which have been reviewed and accepted by CNSC staff. A list of inspections can be found in appendix B.

This report covers all SCAs but focuses on the 3 SCAs that cover many of the key performance indicators for these mines and mills: radiation protection, environmental protection, and conventional health and safety.

7.2 Radiation Protection

Based on regulatory oversight activities during the reporting period, CNSC staff rated the radiation protection SCA at McClean Lake as “satisfactory” as shown in the table below:

McClean Lake Operation - radiation protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Radiological hazard control

The source of radiological exposure at the McClean Lake Operation is the milling of high-grade uranium ore received from Cameco's Cigar Lake mine. The 3 primary dose contributors are gamma radiation (45%), RnP (33%) and LLRD (22%). Gamma radiation hazards are controlled through practices related to the effective use of time, distance and shielding. Effective doses to nuclear energy workers (NEWs) from exposures to RnP and LLRD are controlled through the effective use of source control, ventilation, contamination control and personal protective equipment.

Orano has incorporated specific radiation protection features into its design to process undiluted, high-grade uranium ore at McClean Lake. These design features were established to limit radiological hazards (for all types) to specific design hazard objectives. Orano continues to implement a comprehensive monitoring program for all hazards to confirm that the engineered control of hazards remains effective, verify that design hazard objectives continue to be met and identify opportunities for improvement at the McClean Lake Operation.

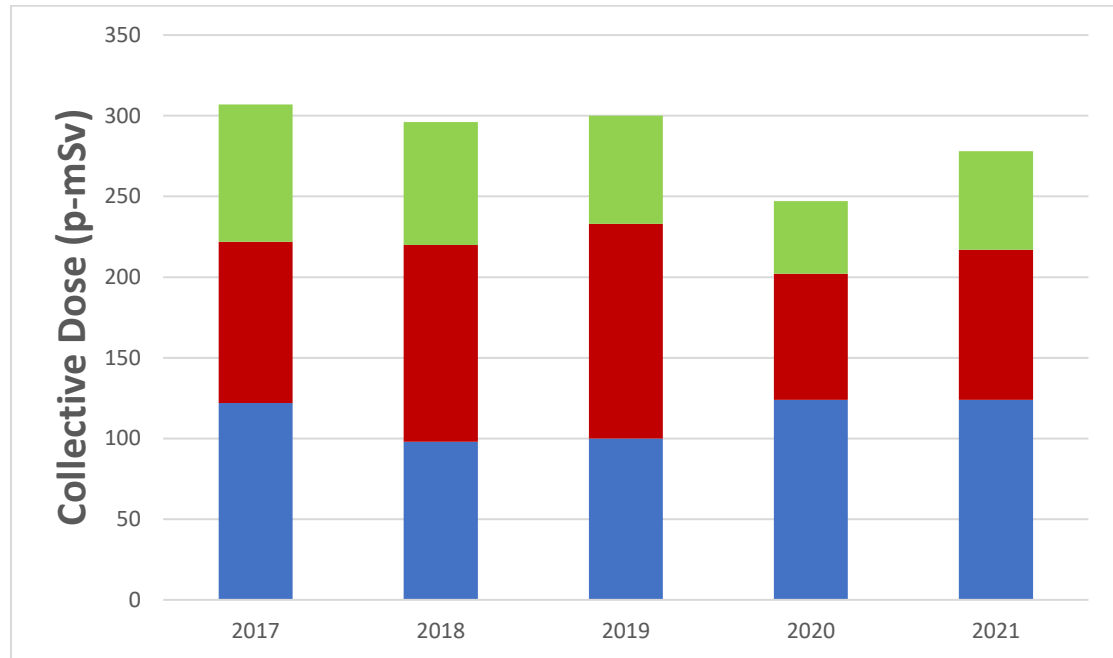
CNSC staff concluded that Orano continues to implement a comprehensive monitoring program and remains highly effective at controlling all radiological hazards at the McClean Lake Operation during 2021.

Radiation protection program performance

In 2021, CNSC staff were satisfied that the radiation protection program and practices at the McClean Lake Operation remained effective at controlling radiological exposure to workers. The doses to workers remained below regulatory limits and as low as reasonably achievable (ALARA). No exceedances of action levels were reported at the McClean Lake Operation in 2021.

Application of ALARA

In 2021, collective radiation exposure to NEWs at the McClean Lake Operation was 278 person-millisieverts (p-mSv), a 13% increase from the 2020 value of 246 p-mSv (figure 7.2). The year-over-year increase in collective dose is attributed to increased mill production days in 2021. Collective radiation exposure in 2021 remained lower than in 2017, 2018 and 2019.

Figure 7.2: McClean Lake Operation - annual collective dose, 2017–21

	2017	2018	2019	2020	2021
Gamma (p-mSv)	122	98	100	124	124
RnP (p-mSv)	100	122	133	78	93
LLRD (p-mSv)	85	76	67	45	61
RnG (p-mSv)	0	0	0	0	0
Total*	307	307	301	246	278

RnP = radon progeny; LLRD = long-lived radioactive dust; RnG = radon gas

* The total collective dose may not match the individual components due to rounding errors.

Through reviews of radiation monitoring, exposure reports and inspections, CNSC staff confirmed that the radiation protection program was highly effective and verified that worker exposures remained consistent with the ALARA principle in 2021.

Worker dose control

In 2021, the average individual effective dose to NEWs was 0.79 mSv, while the maximum individual effective dose received by a NEW was 4.89 mSv. These values compare to an average individual effective dose of 0.67 mSv and a maximum individual dose of 4.28 mSv in 2020. All individual effective doses received by NEWs were well below the CNSC’s regulatory dose limit of 50 mSv in a 1-year dosimetry period. The 5-year dosimetry period of 2021 to 2025 has just started. So far, the maximum dose is 4.89 mSv (~5% of the regulatory dose limit of 100 mSv).

Based on Orano’s compliance verification activities, such as inspections, reviews of licensee reports and work practices, and the monitoring of results and individual effective dose results in 2021, CNSC staff were satisfied that the McClean Lake Operation continued to be effective at controlling radiation doses to workers in 2021.

7.3 Environmental Protection

For 2021, CNSC staff continued to rate the environmental protection SCA as “satisfactory” based on regulatory oversight activities. CNSC staff concluded that the licensee’s environmental protection program was effectively implemented and met all regulatory requirements.

McClean Lake Operation - environmental protection ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Environmental management system

The environmental management system at the McClean Lake Operation includes activities such as establishing annual environmental objectives, goals and targets. Orano conducts internal audits of its environmental management program at the McClean Lake Operation, as identified in their CNSC-approved management system program. CNSC staff review and assess the objectives, goals and targets through regular compliance verification activities. CNSC staff noted that Orano continued with routine inspections, internal audits, environmental training and periodic reviews of environmental monitoring data. These activities were conducted to verify continual improvement and to confirm that the controls put into place to protect the environment are effective.

Effluent and emissions control

Effluent and emissions monitoring programs serve to demonstrate that the facility’s emissions, wastes, tailings and effluent discharges of nuclear and hazardous substances are properly controlled at the McClean Lake Operation.

Treated effluent released to the environment

At the McClean Lake Operation, 2 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.
- The Sue water treatment plant treats effluent which is pumped to control the water level from the mined-out open pits using a chemical precipitation and settling pond clarification process. This effluent is then released to the Sink/Vulture treated effluent management system.

The blended treated effluent is then released in a controlled manner.

The 2016 ERA identified future potential risks to aquatic organisms in McClean Lake east due to exposure to selenium from the milling of Cigar Lake ore. In the [*Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*](#) [10], CNSC staff reported on the selenium adaptive management plan developed and implemented by Orano. CNSC staff continue to review reported selenium concentrations in effluent through quarterly reports to verify that the receiving environment remains protected.

In April 2020, the CNSC requested that Orano propose a long-term solution for sustained reduction of selenium loading to the environment. In response, Orano submitted an update to the selenium adaptive management plan in September 2020, which provides an assessment of treatment technologies as well as the preferred option of the use of ferrous sulphate treatment technology. In October 2021, Orano submitted an implementation plan for the ferrous sulphate treatment at the JEB WTP for enhanced selenium removal, which will be operational in September 2022. CNSC staff will continue to monitor to ensure that the 12-month rolling average selenium loadings remain below the Environmentally Based Reference Level (EBRL) of 112 g/day. CNSC staff confirmed that selenium loadings in 2021 were below the EBRL.

Orano reported 1 action level exceedance of 25 mg/L for TSS, in excess of the MDMER discharge limit of 22.5 mg/L. All pond fill samples for the effluent associated with the discharge had TSS concentrations well below the administrative level of 4 mg/L. The probable cause for the apparent action level exceedance was sample contamination most likely due to iron-based scale from piping getting into the sampling line. The sampling station was cleaned and a standard for cleanliness and maintenance of the sampling port was implemented.

Orano analyzed treated effluent for concentrations of various substances such as radium-226, arsenic, copper, lead, nickel, zinc and TSS, and verified pH levels at McClean Lake. As discussed in section 2.3, the McClean Lake Operation continued to meet the discharge limits set out in the [MDMER](#) [8].

CNSC staff will continue to review results on the quality of effluent in order to verify that the treatment of effluent remains effective.

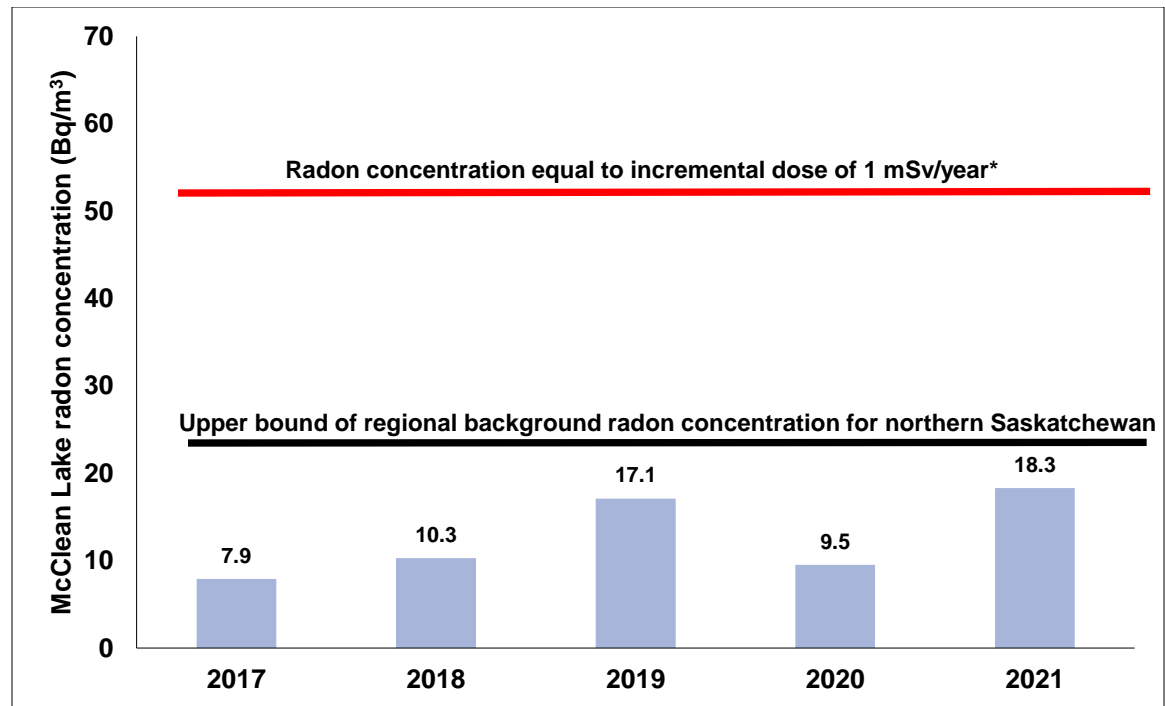
Air emissions released to the environment

Air quality at the McClean Lake Operation is monitored directly by measuring emissions from the mill and the ambient air quality near the operation, and indirectly by measuring metal accumulations in the terrestrial environment.

Air quality monitoring at the McClean Lake Operation includes ambient radon, total suspended particulate (TSP), sulphur dioxide and exhaust stack monitoring. Ambient sulphur dioxide and exhaust stack monitoring were commensurate with the mill commissioning activities and restarted in September 2014. Terrestrial monitoring components include soil and vegetation sampling.

Environmental monitoring for radon concentrations is conducted using the passive method of track etch cups. There are 23 monitoring stations in various locations around the site-lease boundary. Figure 7.3 shows the average concentrations of radon in ambient air from 2017 to 2021. Ambient radon concentrations were typical of the northern Saskatchewan regional background concentration of less than 7.4 Bq/m³ to 25 Bq/m³. The measured radon concentrations were also below the reference radon concentration of 60 Bq/m³, which is equal to an incremental dose of 1 mSv per year above background.

Figure 7.3: McClean Lake Operation - concentrations of radon in ambient air, 2017–21



* Upper bound of the incremental dose of 1 mSv per year above background (i.e., an incremental radon concentration of 30 Bq/m³ above natural background) based on ICRP Publication 115. Values are calculated as geometric means.

Five high-volume air samplers monitor TSP and are located at the McClean Lake Operation. As shown in table 7.2, TSP values remained low in 2021 and well below the provincial standard of 60 µg/m³.

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 the reference annual air quality levels identified in table 7.2.

Table 7.2: McClean Lake Operation - concentrations of metal and radionuclides in air, 2017–21

Parameter	Reference annual air quality levels*	2017	2018	2019	2020	2021
TSP ($\mu\text{g}/\text{m}^3$)	60 ⁽³⁾	4.96	8.00	5.00	3.24	10.26
As ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.000432	0.000354	0.000239	0.000122	0.000165
Cu ($\mu\text{g}/\text{m}^3$)	9.6 ⁽¹⁾	0.017159	0.018107	0.021454	0.0367798	0.040201
Mo ($\mu\text{g}/\text{m}^3$)	23 ⁽¹⁾	0.001028	0.001154	0.001005	0.00132060	0.000167
Ni ($\mu\text{g}/\text{m}^3$)	0.04 ⁽¹⁾	0.000321	0.000262	0.000144	0.0001016	0.000179
Pb ($\mu\text{g}/\text{m}^3$)	0.10 ⁽¹⁾	0.000406	0.000417	0.00025	0.0001648	0.000281
Zn ($\mu\text{g}/\text{m}^3$)	23 ⁽¹⁾	0.003165	0.004684	0.00839	0.0025862	0.0004419
Pb-210 (Bq/m ³)	0.021 ⁽²⁾	0.000309	0.000253	0.000261	0.0002894	0.000252
Po-210 (Bq/m ³)	0.028 ⁽²⁾	0.000100	0.000087	0.000083	0.000087	0.000192
Ra-226 (Bq/m ³)	0.013 ⁽²⁾	0.000014	0.000022	0.000022	0.000001	0.00006
Th-230 (Bq/m ³)	0.0085 ⁽²⁾	0.000006	0.000004	0.000005	0.0000052	0.000002
U ($\mu\text{g}/\text{m}^3$)	0.06 ⁽¹⁾	0.002029	0.001654	0.002497	0.000889	0.001173

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

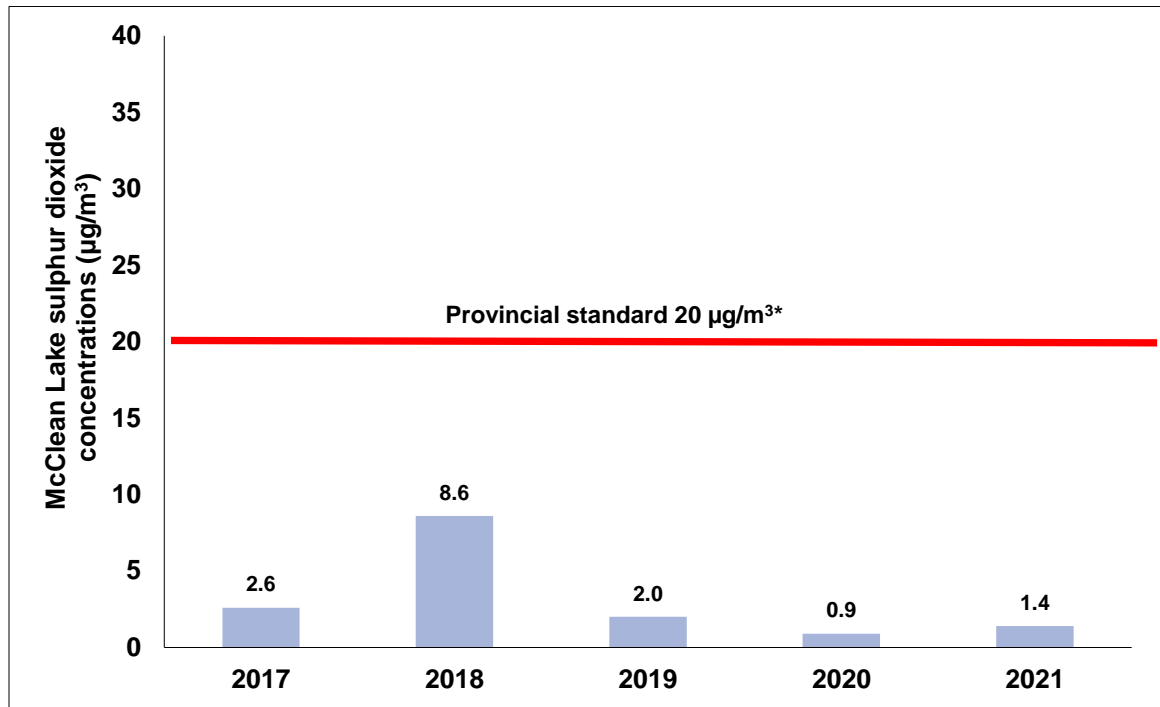
2 Reference level is derived from International Commission of Radiological Protection (ICRP) Publication 96, *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*.

3 *Saskatchewan Environmental Quality Guidelines*, Table 20: Saskatchewan Ambient Air Quality Standards. Values are calculated as geometric means.

* Reference levels based on Province of Ontario ambient air quality criteria and are shown for reference only. No federal or Saskatchewan provincial limits were established at the time of this report.

A sulphur dioxide monitor is used during operations to continuously measure ambient sulphur dioxide concentrations associated with mill emissions. The monitor is located approximately 200 metres in a predominantly downwind direction of the sulphuric acid plant stack. The measured sulphur dioxide monitoring data (see figure 7.4) showed no exceedances of the annual standard of $20 \mu\text{g}/\text{m}^3$ in 2021.

Figure 7.4: McClean Lake Operation - concentrations of ambient sulphur dioxide, 2017–21



*Province of Saskatchewan's ambient air quality standard is shown.

Orano's terrestrial monitoring program at McClean Lake determines whether any impact on the environment arises 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.

Soil monitoring results from soil samples collected in 2015 are presented in the 2016 Technical Information Document – Environmental Performance (TID-EP). The results show that the soil metal parameter concentrations were below the [Canadian Environmental Quality Guidelines](#) [12] set by the Canadian Council of Ministers of the Environment. Radionuclide concentrations in soils were 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 is acceptable and does not pose a risk to the environment.

Vegetation sampling was also presented in the 2016 TID-EP and shows that most parameters are within the range of concentrations previously measured in lichen, Labrador tea and blueberry twig samples. The concentrations of metals and radionuclides in lichen, Labrador tea and blueberry twigs were higher than background concentrations for some samples located in the immediate vicinity of mining and milling activities, although the concentrations decreased within a short distance. Overall, the results indicated that the McClean Lake Operation has had a localized effect on the vegetation in areas of activity.

These higher concentrations were below levels that are toxic to plants, and they decreased to within background concentrations at a short distance from the facility. Therefore, no changes are predicted to terrestrial habitat, both within and outside the facility boundary. The elevated concentrations of contaminants within the facility boundary were modelled in an ERA, and no adverse effects were predicted for terrestrial non-human biota.

In 2021, McClean Lake conducted its terrestrial and aquatic environmental monitoring program. This included sampling of sediment, benthic invertebrates, soil, lichen, vegetation and fish. The results will be included in the 2022 TID-EP.

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 browse (twigs and Labrador tea) and lichen consumers, such as caribou.

Uncontrolled releases

In 2021, 5 events reported to CNSC staff were identified as releases of hazardous substances to the environment:

- On January 29, 2021, approximately 1 m³ of T-Amine 950 reagent was released to the environment while moving a pallet.
- On June 9, 2021, approximately 150 m³ of partially treated Sue C pit water was released to the environment because of a hole in the pond liner.
- On October 9, 2021, based on the density, approximately 232 kg of tailings solids were released to the environment because the tailing's underflow pipeline failed at a valve.
- On November 23, 2021, approximately 10 m³ of reclaim water was released to the environment due to a failed pump rupture disc at the JEB TMF.
- On December 1, 2021, the Calciner scrubber was restarted after routine cleaning of the scrubber ducting. Material had loosened during the cleaning process and was discharged from the Calciner stack. Approximately 0.7 m³ of material discharged, which settled to the Mill Terrace in the immediate vicinity of the Calciner building.

All releases were of low safety significance and reporting met the requirements of [CNSC's REGDOC-3.2.1, *Public Information and Disclosure*](#) [4]. Appendix I describes the spills and corrective actions taken. As a result of the actions taken by Orano, no residual impacts to the environment and human health were caused by the releases. 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 2021 spills as being of low significance.

Section 2 figure 2.10 shows the number of reportable environmental spills that occurred at the McClean Lake Operation from 2017 to 2021.

Assessment and monitoring

CNSC staff confirmed that the licensee successfully carried out required environmental monitoring, in accordance with the McClean Lake environmental protection program.

Based on compliance activities and the review of annual reports and the environmental 2016 TID-EP, CNSC staff concluded that the environmental monitoring conducted at the McClean Lake Operation met regulatory requirements. Consequently, CNSC staff concluded that the environment and the public remain protected.

Environmental risk assessment

The McClean Lake Operation's TID-EP, submitted to the CNSC in 2016, contained environmental monitoring data from 2011 to 2015 as well as an updated ERA. CNSC staff reviewed the environmental monitoring results for air, soil, vegetation, surface water, groundwater and sediment, as well as the health indicators for fish and their prey inhabiting sediment and confirmed that the results were within those predicted in the ERA.

After reviewing the TID-EP and Orano's ongoing activities to ensure the protection of the environment, CNSC staff concluded that adequate measures have been taken at the McClean Lake Operation to protect the environment.

Protection of people

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

The CNSC receives reports of discharges to the environment through the reporting requirements outlined in the McClean Lake Operation CNSC-issued licence and LCH. The review of Orano's hazardous (non-radiological) discharges to the environment at the McClean Lake Operation in 2021 indicated that the public and environment were protected. CNSC staff confirmed the environmental concentrations in the vicinity of the McClean Lake Operation remained within those predicted in the 2016 ERA, and that human health remained protected.

Based on compliance verification activities that included inspections, reviews of licensee reports and work practices, and monitoring results for 2021, CNSC staff concluded that the McClean Lake Operation's environmental protection program continued to be effective at protecting the public and the environment.

7.4 Conventional Health and Safety

For 2021, CNSC staff continued to rate the conventional health and safety SCA as “satisfactory” based on regulatory oversight activities.

McClellan Lake Operation - conventional health and safety ratings

2017	2018	2019	2020	2021
SA	SA	SA	SA	SA

SA = satisfactory

Practices

As required under the [Nuclear Safety and Control Act](#) [1], Orano continued to take actions to improve performance and maintain health and safety programs at the McClellan Lake Operation to minimize occupational health and safety risks. CNSC staff confirmed that Orano had an effective occupational health and safety committee and that it was completing regular reviews of its safety program at the McClellan Lake facility.

Orano’s McClellan Lake Operation investigates safety concerns and incidents, including near-miss events. In 2021, several investigations were completed to determine the cause of incidents, near misses, injuries or property damage. Their incident investigation process employs a collaborative effort to identify a problem, analyze its causes and determine the best solutions. CNSC staff reviewed the investigation results and corrective actions and confirmed Orano’s commitment to accident prevention and safety awareness with a focus on safety culture.

Performance

Table 7.3 shows that from 2017 to 2021, Orano’s McClellan Lake Operation reported 9 LTIs. There were 3 LTIs reported in 2021. Details on the 2021 LTIs and corrective actions can be found in appendix K.

The TRIR for McClellan Lake is included for the last 5 years. The TRIR is the incident frequency rate that measures the number of fatalities, LTIs and other injuries requiring medical treatment.

Table 7.3: McClean Lake Operation - lost-time injury statistics, 2017–21

	2017	2018	2019	2020	2021
Lost-time injuries¹	0	1	3	2	3
Severity rate²	67.8	4.8	48	42.8	49.8
Frequency rate³	0.0	0.3	0.9	0.7	0.9
Total recordable incident rate⁴	1.4	0.75	3.15	2.7	5.6

¹ An injury that takes place at work and results in the worker being unable to return to work for a period of time.

² A measure of the total number of days lost to injury for every 200,000 person-hours worked at the facility. Accident severity rate = [(# of days lost in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

³ A measure of the number of LTIs for every 200,000 person-hours worked at the facility. Accident frequency rate = [(# of injuries in last 12 months) / (# of hours worked in last 12 months)] x 200,000.

⁴ A measure of the number of fatalities, lost-time injuries, and other injuries requiring medical treatment for every 200,000 person-hours worked at the facility. Recordable incident rate = [(#incidents in last 12 months) / # hours worked in last 12 months] x 200,000.

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

Awareness

CNSC staff observed that conventional health and safety programs provided education, training, tools, and support to verify worker protection at the McClean Lake Operation. An active onsite occupational health and safety committee completes regular reviews of the McClean Lake 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. CNSC staff's compliance verification activities concluded that the McClean Lake Operation's health and safety program met regulatory requirements in 2021.

7.5 Additional SCAs

In this 2021 regulatory oversight report, CNSC staff have provided a brief discussion of the additional SCAs; these are presented in the following sections.

7.5.1 Management system

The licensee maintains an Integrated Management System; this forms part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation that focused on evaluating the management system SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.2 Human performance management

The licensee includes program documentation for the human performance management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

In January 2021, a personnel training focused inspection was conducted remotely to verify the implementation and effectiveness of Orano's human performance management at the McClean Lake Operation. The inspection report outlined some deficiencies that resulted in 3 non-compliances related to training documentation and implementation (e.g., out of date training documentation, incomplete training change management process and inconsistent training program evaluations). Orano provided an action plan to address these non-compliances. CNSC staff reviewed and confirmed that Orano addressed the non-compliances in a timely and satisfactory manner and have taken appropriate corrective actions; therefore, all 3 non-compliances were closed.

There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.3 Operating performance

The licensee includes program documentation for the operating performance SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation with a focus on evaluating the operating performance SCA in 2021 and there were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.4 Safety analysis

The licensee includes program documentation for the safety analysis SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation focused on evaluating the safety analysis SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.5 Physical design

The licensee includes program documentation for the physical design SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There was 1 inspection at the McClean Lake Operation with a focus on evaluating the physical design SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.6 Fitness for service

The licensee includes program documentation for the fitness for service SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation focused on evaluating the fitness for service SCA. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.7 Emergency management and fire protection

The licensee includes program documentation for the emergency management and fire protection SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation focused on evaluating the emergency management and fire protection SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.8 Waste management

The licensee includes program documentation for the waste management SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation focused on evaluating the waste management SCA in 2021 and there were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.9 Security

The licensee includes program documentation for the security SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH.

There were no inspections at the McClean Lake Operation focused on evaluating the security SCA in 2021. There were no event reports for which this SCA was the main contributory factor.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.10 Safeguards and non-proliferation

The licensee includes program documentation for the safeguards and non-proliferation SCA as part of the overall management system documents; these constitute part of the licensing basis for this facility in the LCH. There were no inspections in 2021 at the McClean Lake Operation focused on evaluating the safeguards and non-proliferation SCA. There were no notices of non-compliance related to the safeguards and non-proliferation SCA and no event reports for which this SCA was the main contributing factor.

In addition to CNSC compliance activities with respect to the specific areas under the safeguards and non-proliferation SCA, the International Atomic Energy Agency (IAEA) conducts independent inspections with coordination and support through the CNSC regulatory framework. No IAEA inspections were conducted at the McClean Lake Operation during 2021.

CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

7.5.11 Packaging and transport

The licensee includes program documentation for the packaging and transport SCA as part of the overall management system documents; these form part of the licensing basis for this facility in the LCH.

In October 2021, a focused inspection was conducted remotely to verify the implementation and effectiveness of Orano's packaging and transport program at the McClean Lake Operation. The inspection report outlined some low-risk deficiencies that resulted in 2 non-compliances related to the packaging and transport documentation (i.e., TDG training certificate employee signature missing, information is to be presented in the prescribed order). Orano provided an action plan to address these non-compliances. CNSC staff reviewed and confirmed that Orano addressed the non-compliances and have taken appropriate corrective actions; therefore, both non-compliances were closed.

There were no event reports for which this SCA was the main contributory factor. CNSC staff concluded that the licensee's program in respect of this SCA remains satisfactory.

REFERENCES

1. [Nuclear Safety and Control Act](#), S.C. 1997, c. 9
2. [CMD 21-M34](#) Annual Program Report, *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2020*
3. [National Fire Code of Canada](#), S.C. 2015
4. CNSC REGDOC-3.2.1, [Public Information and Disclosure](#), Ottawa, Canada, May 2018
5. [Radiation Protection Regulations](#), SOR/2000-203
6. CSA Group, CSA N288.8-17, *Establishing and Implementing Action Levels to Control Releases to the Environment from Nuclear Facilities*, Toronto, Canada, 2017
7. Environment and Climate Change Canada, [National Pollutant Release Inventory](#)
8. [Metal and Diamond Mining Effluent Regulations](#), SOR/2002-222, 2018
9. [Fisheries Act](#), R.S.C, 1985
10. [CMD 18-M48](#), Annual Program Report, *Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada: 2017*
11. [Uranium Mines and Mills Regulations](#), SOR/2000-206
12. Canadian Council of Ministers of the Environment, [Canadian Environmental Quality Guidelines](#), 2014
13. [CMD 19-M13](#), Event Initial Report, *Uranium in groundwater monitoring well at Key Lake Operation*, 2018
14. [CMD 19-M36](#), Annual Program Report, *Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2018*
15. Correspondence from V. Laniece (Orano) to M. Leblanc (CNSC) McClean Lake Operation, Application to Amend Uranium Mine Operation Licence (UMOL-MINEMILL-McClean.01/2027) – JEB Tailings Management Facility Expansion (TMF) Project, June 16, 2020 (e-Doc 6319439)
16. CNSC Record of Decision, DEC 21-H6, In the Matter of Orano Canada Inc., Application to Amend Uranium Mine and Mill Licence for the Expansion of the JEB Tailings Management Facility, October 4, 2021 (e-Doc 6706444)

GLOSSARY

For definitions of terms used in this document, see [REGDOC-3.6, Glossary of CNSC Terminology](#), which includes terms and definitions used in the Nuclear Safety and Control Act and the Regulations made under it, and in CNSC regulatory documents and other publications. REGDOC-3.6 is provided for reference and information.

A. FACILITY LICENSING INFORMATION

The following tables present CNSC licensing information for the facilities discussed in this report.

A-1: Operating Uranium Mines and Mills – Licensing Information

Licensee/site/licence #	Licence effective	Last licence amendment	Licence expiration
Orano Canada Inc. McClellan Lake Operation Uranium Mine Licence UML-MINEMILL-McCLEAN.02/2027	July 1, 2017	January 13, 2022	June 30, 2027
Cameco Corporation Cigar Lake Operation Uranium Mine Licence UML-MINE-CIGAR.00/2031	July 1, 2021	June 28, 2022	June 30, 2031
Cameco Corporation Key Lake Operation Uranium Mill Licence UML-MILL-KEY.01/2023	November 1, 2013	July 29, 2020	October 31, 2023
Cameco Corporation Rabbit Lake Operation Uranium Mine and Mill Licence UML-MINEMILL-RABBIT.01/2023	November 1, 2013	March 9, 2021	October 31, 2023
Cameco Corporation McArthur River Operation Uranium Mine Licence UML-MINE-McARTHUR.01/2023	November 1, 2013	June 26, 2019	October 31, 2023

B. LIST OF INSPECTIONS

The following tables present CNSC's inspections by facility and safety control area (SCA) for the facilities discussed in this report.

Table B-1: Operating Uranium Mines and Mills - Inspections by facility and SCA

Facility	Method	Safety and control area	Notices of non-compliance	Inspection report issued
Cigar Lake Operation	Remote	Emergency Management and Fire Protection	None	March 26, 2021 (e-Doc 6478391)
	Remote	Operating Performance Fitness for Service Radiation Protection Conventional Health and Safety Environmental Protection Emergency Management and Fire Protection Waste Management Packaging and Transport Other Public Information and Disclosure	2	March 9, 2021 (e-Doc 6503579)
	Remote	Human Performance Management	5	August 24, 2021 (e-Doc 6607925)
	Remote	General Operating Performance Environmental Protection Radiation Protection Conventional Health & Safety Human Performance Emergency Management and Fire Protection Packaging & Transport	3	February 17, 2022 (e-Doc 6721071)
	Remote	Fitness for Service	2	November 25, 2021 (e-Doc 6666507)

Facility	Method	Safety and control area	Notices of non-compliance	Inspection report issued
McArthur River Operation	Remote	Radiation Protection Conventional Health & Safety Emergency Management & Fire Protection	1	November 1, 2021 (e-Doc 6652299)
	Remote	Environmental Protection Radiation Protection Conventional Health & Safety Human Performance Management	None	January 25, 2022 (e-Doc 6720770)
Rabbit Lake Operation	Remote	General	None	August 6, 2021 (e-Doc 6617132)
	Remote	General Management Systems Fitness for Service Radiation Protection Conventional Health & Safety	1	September 28, 2021 (e-Doc 6641862)
Key Lake Operation	Remote	General Management Systems Physical Design Human Performance Management Security	None	May 28, 2021 (e-Doc 6522138)
	Remote	Environmental Protection	None	September 21, 2021 (e-Doc 6628578)
	Remote	General	None	January 27, 2022 (e-Doc 671551)

Facility	Method	Safety and control area	Notices of non-compliance	Inspection report issued
McClean Lake Operation	Remote	Human Performance Management	3	February 26, 2021 (e-Doc 6479644)
	Remote	General Operating Performance Safety Analysis Physical Design Security	None	May 26, 2021 (e-Doc 6522136)
	Remote	General Management System Operating Performance Radiation Protection Emergency Management & Fire Protection	None	September 20, 2021 (e-Doc 6641862)
	Remote	General Management System Operating Performance Conventional Health & Safety Packaging & Transport	None	November 22, 2021 (e-Doc 6633595)
	Onsite	Safety Analysis Physical Design Waste Management	None	October 5, 2021 (e-Doc 6634881)
	Remote	Packaging and Transport	2	December 10, 2021 (e-Doc 6669308)

C. SAFETY AND CONTROL AREA DEFINITIONS

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 into 3 functional areas: management, facility and equipment, and core control processes.

Table C-1: Safety and Control Area Framework

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.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ Human performance program ▪ Personnel training ▪ Personnel certification ▪ Initial certification examinations and requalification tests ▪ Work organization and job design ▪ Fitness for duty
	Operating performance	Includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.	<ul style="list-style-type: none"> ▪ Conduct of licensed activity ▪ Procedures ▪ Reporting and trending ▪ Outage management performance ▪ Safe operating envelope ▪ Severe accident management and recovery ▪ Accident management and recovery

Safety and Control Area Framework			
Functional area	Safety and control area	Definition	Specific areas
Facility and equipment	Safety analysis	Covers maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventative measures and strategies in reducing the effects of such hazards.	<ul style="list-style-type: none"> ▪ Deterministic safety analysis ▪ Hazard analysis ▪ Probabilistic safety analysis ▪ Criticality safety ▪ Severe accident analysis ▪ Management of safety issues (including R&D programs)
	Physical design	Relates to activities that 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.	<ul style="list-style-type: none"> ▪ Design governance ▪ Site characterization ▪ Facility design ▪ Structure design ▪ System design ▪ Component design
	Fitness for service	Covers activities that impact the physical condition of structures, systems and components to ensure that they remain effective over time. This area includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.	<ul style="list-style-type: none"> ▪ Equipment fitness for service / equipment performance ▪ Maintenance ▪ Structural integrity ▪ Aging management ▪ Chemistry control ▪ Periodic inspection and testing
Core control processes	Radiation protection	Covers the implementation of a radiation protection program in accordance with the <i>Radiation Protection Regulations</i> . The program must ensure that contamination levels and radiation doses received by individuals are monitored, controlled and maintained ALARA.	<ul style="list-style-type: none"> ▪ Application of ALARA ▪ Worker dose control ▪ Radiation protection program performance ▪ Radiological hazard control ▪ Estimated dose to public

Safety and Control Area Framework			
Functional area	Safety and control area	Definition	Specific areas
	Conventional health and safety	The implementation of a program to manage workplace safety hazards and to protect workers.	<ul style="list-style-type: none"> ▪ 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.	<ul style="list-style-type: none"> ▪ Effluent and emissions control (releases) ▪ Environmental management system ▪ Assessment and monitoring ▪ Protection of people ▪ 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.	<ul style="list-style-type: none"> ▪ Conventional emergency preparedness and response ▪ Nuclear emergency preparedness and response ▪ Fire emergency preparedness and response
	Waste management	Covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This area also covers the planning for decommissioning.	<ul style="list-style-type: none"> ▪ Waste characterization ▪ Waste minimization ▪ Waste management practices ▪ Decommissioning plans
	Security	Covers the programs required to implement and support the security requirements stipulated in the regulations, the licence, orders, or expectations for the facility or activity.	<ul style="list-style-type: none"> ▪ Facilities and equipment ▪ Response arrangements ▪ Security practices ▪ Drills and exercises

Safety and Control Area Framework			
Functional area	Safety and control area	Definition	Specific areas
	Safeguards and non-proliferation	Covers the programs and activities required for the successful implementation of the obligations arising from the Canada/ International Atomic Energy Agency (IAEA) safeguards agreements, as well as all other measures arising from the <i>Treaty on the Non-Proliferation of Nuclear Weapons</i> .	<ul style="list-style-type: none"> ▪ Nuclear material accountancy and control ▪ Access and assistance to the IAEA ▪ Operational and design information ▪ Safeguards equipment, containment and surveillance ▪ Import and export
	Packaging and transport	Programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility.	<ul style="list-style-type: none"> ▪ Package design and maintenance ▪ Packaging and transport ▪ Registration for use
Other Matters of Regulatory Interest			
<ul style="list-style-type: none"> ▪ Environmental assessment ▪ CNSC consultation – Indigenous ▪ CNSC consultation – other ▪ Cost recovery ▪ Financial guarantees ▪ Improvement plans and significant future activities ▪ Licensee public information program ▪ Nuclear liability insurance 			

D. SAFETY AND CONTROL AREA RATING METHODOLOGY

Performance ratings used in this report are defined as follows:

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 and control area or specific area meets requirements and the Canadian Nuclear Safety Commission (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.

The following rating is no longer used by the CNSC. It is defined below for informational purposes only. This rating may appear in historic data.

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 CNSC expectations. Overall, compliance is stable or improving, and any problems or issues that arise are promptly addressed.

E. SAFETY AND CONTROL AREA RATINGS

Table E-1: Safety and control area ratings for Cigar Lake Operation, 2017–21

Safety and control area	2017	2018	2019	2020	2021
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 E-2: Safety and control area ratings for McArthur River Operation, 2017–21

Safety and control area	2017	2018	2019	2020	2021
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 E-3: Safety and control area ratings for Rabbit Lake Operation, 2017–21

Safety and control area	2017	2018	2019	2020	2021
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 E-4: Safety and control area ratings for Key Lake Operation, 2017–21

Safety and control area	2017	2018	2019	2020	2021
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	FS	FS	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 E-5: Safety and control area ratings for McClean Lake Operation, 2017–2021

Safety and control area	2017	2018	2019	2020	2021
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

F. FINANCIAL GUARANTEES

The following tables outline the financial guarantees, as of December 31, 2021, for the uranium mine, mill, historic, and decommissioned sites discussed in this report.

Table F-1: Operating Uranium Mines and Mills – financial guarantees:

Facility	Canadian dollar amount
Cigar Lake Operation	\$61,790,000
McArthur River Operation	\$42,100,000
Rabbit Lake Operation	\$202,700,000
Key Lake Operation	\$222,500,000
McClellan Lake Operation	\$107,241,000
Total	\$636,331,000

G. WORKER DOSE DATA

Table G-1 shows the total number of nuclear energy workers (NEWs) monitored at each of the 5 uranium mines and mills for 2021. 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 millisievert [mSv] in a calendar year).

Table G-1: Number of NEWs at uranium mines and mills, 2021

	Cigar Lake	McArthur River	Rabbit Lake	Key Lake	McClellan Lake
Total NEWs	1047	333	163	676	353

The following table compares the average and maximum individual effective dose for the 5 operating uranium mines and mills.

Table G-2: Radiation dose data for NEWs at uranium mines and mills, 2021

Facility	Average individual effective dose (mSv/year)	Maximum individual effective dose (mSv/year)	Regulatory limit
Cigar Lake Operation	0.32	6.03	50 mSv/year
McArthur River Operation	0.25	3.06	
Rabbit Lake Operation	0.57	2.47	
Key Lake Operation	0.52	3.13	
McClellan Lake Operation	0.79	4.89	

Tables G-3 to G-7 show a 5-year trend (from 2017 to 2021) of the average and maximum effective annual doses to NEWs at the 5 uranium mines and mills. No radiation dose at any facility exceeded the regulatory effective dose limit during 2021. Each of these tables also identifies the maximum 5-year dose to an individual NEW at each uranium mine and mill for the years 2021-2025.

Table G-3: Radiation dose data for NEWs, Cigar Lake Operation, 2017–21

Dose data	2017	2018	2019	2020	2021	Regulatory limit
Total NEWs	1,107	824	875	861	1,047	N/A
Average individual effective dose (mSv)	0.34	0.47	0.57	0.38	0.32	N/A
Maximum individual effective dose (mSv)	3.36	7.28	3.70	2.82	6.03	50 mSv/year
Maximum dose for an individual in current 5-year period (mSv) 2021–2025	6.03					100 mSv/5-year dosimetry period

Table G-4: Radiation dose data for NEWs, McArthur River Operation, 2017–21

Dose data	2017	2018	2019	2020	2021	Regulatory limit
Total NEWs	958	595	136	172	333	N/A
Average individual effective dose (mSv)	0.79	0.15	0.33	0.27	0.25	N/A
Maximum individual effective dose (mSv)	5.73	2.67	2.82	2.94	3.06	50 mSv/year
Maximum dose for an individual in current 5-year period (mSv) 2021–2025	3.06					100 mSv/5-year dosimetry period

Table G-5: Radiation dose data for NEWs, Rabbit Lake Operation, 2017–21

Dose data	2017	2018	2019	2020	2021	Regulatory limit
Total NEWs	153	166	119	128	163	N/A
Average individual effective dose (mSv)	0.4	0.46	0.75	0.70	0.57	N/A
Maximum individual effective dose (mSv)	1.56	1.7	2.73	2.93	2.47	50 mSv/year
Maximum dose for an individual in current 5-year period (mSv) 2021–2025	2.47					100 mSv/5-year dosimetry period

Table G-6: Radiation dose data for NEWs, Key Lake Operation, 2017–21

Dose data	2017	2018	2019	2020	2021	Regulatory limit
Total NEWs	684	481	260	302	676	N/A
Average individual effective dose (mSv)	0.66	0.19	0.27	0.35	0.52	N/A
Maximum individual effective dose (mSv)	5.39	2.02	1.64	2.11	3.13	50 mSv/year
Maximum dose for an individual in current 5-year period (mSv) 2021–2025	3.13					100 mSv/5-year dosimetry period

Table G-7: Radiation dose data for NEWs, McClean Lake Operation, 2017–21

Dose data	2017	2018	2019	2020	2021	Regulatory limit
Total NEWs	334	330	323	369	353	N/A
Average individual effective dose (mSv)	0.91	0.90	0.93	0.67	0.79	N/A
Maximum individual effective dose (mSv)	5.12	5.50	4.70	4.28	4.89	50 mSv/year
Maximum dose for an individual in current 5-year period (mSv) 2021–2025	4.89					100 mSv/5-year dosimetry period

H. RADIOLOGICAL ACTION LEVEL EXCEEDANCES REPORTED TO THE CNSC

CNSC staff reviewed and were satisfied with the remedial actions taken by the licensees for the radiological action level exceedances reporting in table H-1. Table H-1 notes the details of each event, the corrective actions taken by the licensee and the CNSC's associated significance ratings. Table H-2 lists the rating definitions and examples of safety significance across fuel cycle facilities.

Table H-1: Uranium mines and mills – exceedances of radiological action levels in 2021

Facility	Action level exceedance	Corrective action	Significance rating
Cigar Lake Operation	In November, notification was received from the dosimetry provider of an elevated PAD for September, specifically an exposure of 4.28 mSv for radon progeny for a JBS operator. The investigation identified the unexpected exposure likely occurred during non-routine work activities associated with the individual assisting in preparing the underground clarifier for entry by workers to conduct inspections and repairs.	The investigation for this event resulted in corrective actions pertaining to additional negative ventilation installation when clarifier drained of water, installation of a permanent prism location adjacent to the upper clarifier area and implementing radiation work permit requirements when working around the clarifier lid openings when drained. CNSC staff have reviewed and accepted the submitted corrective actions. Corrective actions will be verified through onsite verification activities during regular inspections.	Medium
McArthur River Operation	None reported	N/A	N/A
Rabbit Lake Operation	None reported	N/A	N/A
Key Lake Operation	None reported	N/A	N/A
McClellan Lake Operation	None reported	N/A	N/A

Table H-2: CNSC Radiation protection rating definitions and examples

Radiation protection		
Safety significance	Definition	Fuel cycle facility 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. Examples: <ul style="list-style-type: none"> ▪ nuclear energy worker (NEW) exceeding 50 millisievert (mSv)/year or 100 mSv/5 years ▪ non-NEW exceeding 1 mSv
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 a limited area.	Incident that results in or has reasonable potential to exceed an action level. Example: <ul style="list-style-type: none"> ▪ doses to workers of 1 mSv/week or 5 mSv/quarter
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.

I. REPORTABLE RELEASES TO THE ENVIRONMENT (SPILLS)

Canadian Nuclear Safety Commission (CNSC) staff reviewed and were satisfied with the remedial actions taken by the licensees in response to the spills presented in table I-1 and concluded that these spills resulted in no residual impacts to the environment. Table I-1 notes the details of each spill, the corrective actions taken by the licensee and the CNSC's spill significance ratings. Table I-2 lists the spill rating definitions and gives examples of safety significance across fuel cycle facilities.

Table I-1: Uranium mines and mills reportable releases to the environment, 2021

Facility	Details	Corrective actions	Significance rating
Cigar Lake Operation	On January 1, 2021, maintenance was being performed on generator 7 in the Powerhouse building. As part of the work, antifreeze (ethylene glycol) was removed from the generator and pumped to a holding tank and later re-added back to generator 7. During the refilling, a valve leading to the radiator on generator 2 was open (not part of current work) causing antifreeze to enter generator 2's radiator and overflow through the radiator cap. Approximately 100 litres of antifreeze reported to a concrete pad under the radiators and to the surrounding frozen soil.	Antifreeze and snow from the area were removed and put into containers for appropriate disposal. All filling valves were locked in the closed position after the event and instructions are to be added to the valves for proper filling.	Low
Cigar Lake Operation	On May 17, 2021, while walking to work, a worker noticed the smell of propane when walking past Dry #3. A gasfitter was engaged to investigate and isolate the source of the propane leak. It was identified that the line feeding propane to the building had sagged when the fasteners securing the line to the building had become loose, causing the leak. The leak was greater than 10 minutes induration, classifying the incident as a reportable discharge.	The line was isolated and repaired. The safety department conducted air quality checks in the area to ensure a safe environment.	Low
Cigar Lake Operation	On December 15, 2021, at 14:45, while clearing snow around the condensers at the surface modular freeze plant, an employee noticed an ammonia odour. After investigating, it was identified that the fire valve was bypassing ammonia and venting it from the stack. It is estimated that approximately 400 lbs of ammonia gas bypassed and vented from the relief stack.	The valve seat was tightened, returning it to its normal condition.	Low

Facility	Details	Corrective actions	Significance rating
Cigar Lake Operation	On December 18, 2021, at 19:40, while clearing snow on the East Freeze Pad, a loader operator struck the brine supply hose to a freeze hole, shearing the hose from the wellhead. It is estimated that approximately 17,000 L of brine reported to the ground. The snow impeded the operator's ability to immediately identify that the hose had been compromised. Freeze plant operating staff subsequently identified the leak due to the loss of brine in the system.	The freeze system was shut down and the line was isolated. The brine and affected snow were collected for proper disposal.	Low
McArthur River Operation	No reportable discharges, recordable releases or reportable incidents	N/A	N/A
Rabbit Lake Operation	On May 11, 2021, a breach in the B-Zone ore pad drainage ditch resulted in the release of an estimated 10.3 m3 of spring melt water from the perimeter ditch of the ore pad onto the perimeter road and into the surrounding area.	The eroded section was rebuilt, a vac truck was dispatched to remove water from the ditch to draw down the elevated water level and a pump was placed at the culvert location to transfer water from upgradient to downgradient of the culvert while the culvert was cleared. Impacted soil and roadbed material was removed, and a follow up gamma survey was conducted which verified that impacted material had been effectively removed. The licensee recommended including additional inspections to monitor the berm and assess stability.	Low
Rabbit Lake Operation	On May 26, 2021, at the Warehouse Pad 3 Laydown Area it was discovered that a tote of new engine oil had a cracked drain valve which had caused a leak approximately 1.2 m3 of new oil	The licensee established an earthen berm around the perimeter of the area of downgradient water ponding to prevent any further migration of the released material. Both a vacuum truck and spill pads were deployed to recover as much oil mixed with melted water as possible. Oil was identified at a low point (trench) and recovery in this area involved the use of	Low

Facility	Details	Corrective actions	Significance rating
		<p>clean water to flush the oil along and then recovered using the vacuum truck. The area was backfilled after clean-up activities to reduce erosion concerns. The remaining hazardous materials which were stored outside have been moved to an area with approved secondary containment.</p>	
Rabbit Lake Operation	<p>On May 28, 2021, a separation in the barge line at a fused butt weld at the AGTMF North Pond Surface Water causing a release of an estimated 2.75 m3 of melt water.</p>	<p>Clean up activities were completed, and contaminated soil was excavated. Follow up scanning confirmed that the release area remained similar to background conditions and backfill with clean material was completed.</p>	Low
Rabbit Lake Operation	<p>On August 25, 2021, at the Eagle Point Sand Dryer there was a release of approximately 583 kg of propane.</p>	<p>Upon discovery the licensee's Emergency Response Team (ERT) was dispatched, the area was evacuated, and roadblocks were established to restrict access to the area. The power was shut down to the propane pump and the main propane supply valve was closed, stopping the flow of propane from the tank to the pump. The leaking section of piping was then isolated, thereby stopping further release and the remaining propane was allowed to disperse. The licensee's investigation into this event noted that a failure of the pressure gauge was the cause of the release. A number of corrective actions were identified and assigned, including replacement of the gauge with a higher quality substitute.</p>	Low

Facility	Details	Corrective actions	Significance rating
Key Lake Operation	On February 12, 2021, approximately 3,000 litres of contaminated water was released from a valve shack adjacent to the Deilmann Tailings Management Facility to the ground. A split in a 3-inch pipe occurred as a result of the extreme cold temperatures.	The contaminated water was moved, using a vacuum truck, to the above ground tailings management facility. Additional foam insulation will be used to better seal within the valve shelter around the lateral connection. The 3" elbow was insulated to increase efficacy of the heat tape.	Low
Key Lake Operation	On June 22, 2021, Cameco notified CNSC staff of the discovery of elevated concentrations of constituents of potential concern (COPCs), specifically ammonia and sulfate, were observed in groundwater samples from monitoring well MT-19-01 and MT-19-12 in the 2020 and 2021 sampling program for these wells. These wells were installed as part of the site assessment for the 2018 reportable discharge from the molybdenum plant (refer to CMD 19-M13 [13] and CMD 19-M36 [14]). It was deemed likely that a release to the environment occurred prior to Key Lake going into a state of care and maintenance in 2018 and is not solely the result of previously reported historical discharges or discoveries at Key Lake.	Cameco submitted an assessment report in May 2022 and will be submitting a corrective action plan in the fall of 2022.	Low
Key Lake Operation	On September 13, 2021, an unknown quantity of propane was released from a leak on the propane line outside of the leaching building at the mill. A mill operator reported the smell of propane while conducting their inspection/rounds. The insulation cover on propane piping had deteriorated and corrosion occurred on a pipe which eventually led to the leak.	The valve was closed and the line was isolated. The area was flagged off. Maintenance personnel tested the line and determined that most of the line thickness is close to original specification, with varying thickness along the length of pipe. The corroded section of the pipe was replaced. Maintenance personnel will investigate the option to replace the full length of pipe that runs along the building with corrosion resistant piping and then insulate the line if necessary.	Low

Facility	Details	Corrective actions	Significance rating
Key Lake Operation	On December 27, 2021, over 60 litres of propane was released from the propane storage area near the steam plant. A pressure gauge on the pipe near the propane pump broke resulting in the release. The powerhouse operator was alerted by an alarm and responded.	Maintenance was contacted to isolate the pump and the area was barricaded with red safety tape until the repairs could be completed.	Low
McClean Lake Operation	On January 29, 2021, approximately 1 m ³ of T-Amine 950 reagent was released to the environment while moving the pallet.	The totes of hazardous materials were moved from the loading pad into a Sea-can to prevent snow accumulation and provide clear access. Additionally, a requirement to move totes during daylight hours to ensure adequate visibility was implemented.	Low
McClean Lake Operation	On June 9, 2021, approximately 150 m ³ of partially treated Sue C pit water was released to the environment because of a hole in the pond liner.	The water was removed from under the liner with a vacuum truck and returned into the Sue C pit. The hole was repaired.	Low
McClean Lake Operation	On October 9, 2021, based on the density, approximately 232 Kg of tailings solids were released to the environment because of the tailing's underflow pipeline failed at a valve.	The slurry was cleaned up with a vacuum truck and placed back into the tailings circuit. The affected ground was cleaned up and taken to the JEB Ore Pad for disposal.	Low
McClean Lake Operation	On November 23, 2021, approximately 10 m ³ of reclaim water was released to the environment due to a failed pump rupture disc at the JEB TMF.	The reclaim flow was shut off and the reclaim water removed from the Pumphouse. Work instructions and training materials for restarting the reclaim pump were updated and reviewed with all operators.	Low
McClean Lake Operation	On December 1, 2021, the Calciner scrubber was restarted after routine cleaning of the scrubber ducting. Material had loosened during the cleaning process and was discharged from the Calciner stack. Approximately 0.7 m ³ of material discharged, which settled to the Mill Terrace in the immediate vicinity of the Calciner building.	The material was cleaned up and moved onto the ore pad. The work instruction for restarting the Calciner scrubber was revised to state that the solution flow to the scrubber is to be activated prior to starting the scrubber fan.	Low

Table I-2: CNSC environmental protection spill rating definitions and examples

Environmental protection		
Safety significance	Definition	Fuel cycle facility-specific examples
High	Nuclear or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or that results in significant impact to the environment.	<p>Incident that results in, or has reasonable potential to have, a significant or moderate impact or extensive future remediation.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish bearing water ▪ fish kill
Medium	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that result in impact to the environment outside the licensing basis.	<p>Incident that results in, or has reasonable potential to have, a minor impact or that requires some future remediation.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ effluent action level exceedance ▪ spills to environment (including atmosphere) with short-term or seasonal impacts
Low	Release of hazardous or nuclear substances to the environment below regulatory limits.	<p>Incident that results in, or has reasonable potential to have, a negligible impact.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ effluent administrative level-exceedance ▪ spills to environment (including atmosphere) with no future impacts

J. ENVIRONMENTAL ACTION LEVEL AND REGULATORY LIMIT EXCEEDANCES REPORTED TO THE CNSC

Canadian Nuclear Safety Commission (CNSC) staff reviewed and were satisfied with the corrective actions taken by the licensees for the environmental action level and regulatory exceedances reporting in table J-1. Table J-1 notes the details of each event, the corrective actions taken by licensees and the CNSC's associated significance ratings. Table J-2 lists the rating definitions and examples of safety significance across fuel cycle facilities.

Table J-1: Uranium mines and mills – environmental action level exceedances, 2021

Facility	Action level or regulatory limit exceedance	Corrective action	Significance rating
Cigar Lake Operation	None	N/A	N/A
McArthur River Operation	None	N/A	N/A
Rabbit Lake Operation	None	N/A	N/A
Key Lake Operation	None	N/A	N/A
McClean Lake Operation	On June 1, 2021, Orano reported that a TSS concentration above the action level was measured in the JEB WTP 24-hour discharge composite sample from May 31.	Investigation attributed the result to sample contamination and it was not representative of the discharge. A follow up report was submitted.	Low

Table J-2: CNSC Environmental protection rating definitions and examples

Environmental protection		
Safety significance	Definition	Fuel cycle facility-specific examples
High	Nuclear or hazardous substances being released to the environment exceeding regulatory limits (including public exposure) or that results in significant impact to the environment.	<p>Incident that results in, or has reasonable potential to have, a significant or moderate impact or extensive future remediation.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ impairment of ecosystem functions ▪ effluent licence limit exceedance ▪ spill into fish bearing water ▪ fish kill
Medium	Nuclear or hazardous substances being released to the environment exceeding action levels (including public exposure) or that result in impact to the environment outside the licensing basis.	<p>Incident that results in, or has reasonable potential to have, a minor impact or that requires some future remediation.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ effluent action level exceedance ▪ spills to environment (including atmosphere) with short-term or seasonal impacts
Low	Release of hazardous or nuclear substances to the environment below regulatory limits.	<p>Incident that results in, or has reasonable potential to have, a negligible impact.</p> <p>Examples:</p> <ul style="list-style-type: none"> ▪ effluent administrative level-exceedance ▪ spills to environment (including atmosphere) with no future impacts

K. LOST-TIME INJURIES

A lost-time injury (LTI) is a workplace injury that results in the worker being unable to return to work for a period of time. Table K-1 outlines the LTI's reported in the 2021 reporting period at the 5 operating uranium mines and mills. Table K-2 lists the rating definitions.

Table K-1: Uranium mines and mills – Lost-time injuries (LTIs), 2021

Facility	Incident	Corrective action	Significance rating
Cigar Lake Operation	A worker reported back pain after attempting to close a garbage truck back door that was not closing properly. The worker was placed on restricted work for the remainder of their shift.	N/A	Low
Cigar Lake Operation	A worker misplaced their footing and fell while stepping down from equipment. While attempting to stop their fall, the worker injured their wrist.	N/A	Low
McArthur River Operation	None	N/A	N/A
Rabbit Lake Operation	None	N/A	N/A
Key Lake Operation	None	N/A	N/A
McClellan Lake Operation	July 24, 2021 – Pulled muscles in chest of long-term contractor moving heavy dock plate to unload food truck at the kitchen loading dock.	Orano requires workers to work together to lift heavier objects. The procedure stated that 2 persons are to move the deck plate into place but was specific to kitchen workers. The transport workers have been made aware of the lifting requirement. Signage has been installed as a reminder that 2 persons are required to move the dock plate.	Low

Facility	Incident	Corrective action	Significance rating
McClellan Lake Operation	September 9, 2021 – Worker was walking down incline at the TMF, worker felt pain in knee. Worker was sent off site for assessment which resulted in lost time.	All workers were encouraged to participate in pre-work stretches. This takes place in the morning in addition to as and when the worker feels it necessary.	Low
McClellan Lake Operation	October 29, 2021, Worker caught thumb between a cog and chain on overhead door. The worker received treatment off site for the injury.	Limit stops were to be placed on the overhead door in question, as well as seeking a better tool to do the job.	Low

Table K-2: CNSC Conventional health and safety rating definitions

Safety significance	Definition
High	Fatality or serious injury
Medium	Serious injury or lost-time accident
Low	Minor injury

L. ANNUAL RELEASES OF RADIONUCLIDES TO THE ENVIRONMENT

Introduction

Operating uranium mines and mills in northern Saskatchewan have process waters, which require capture, treatment and release through a final point of control. This appendix represents the total annual release of relevant radionuclides from these facilities from 2017 through 2021.

Releases for total uranium are reported as kilograms (kg) while releases of uranium-238 progeny are reported in megabecquerels (MBq).

CNSC staff have commenced publishing annual releases of radionuclides to the environment from nuclear facilities on the CNSC Open Government Portal.

Liquid releases to surface waters

The uranium mines and mills in northern Saskatchewan have process waters requiring interception, collection and treatment prior to release. Total uranium and a number of uranium-238 progeny are monitored at the operating uranium mines and mills in northern Saskatchewan. CNSC staff publish annual releases of radionuclides to the environment from nuclear facilities on the [CNSC Open Government Portal](#)

M. LINKS TO WEBSITES

Province of Saskatchewan - [Benefits from Northern Mining](#)

[Cameco Corporation](#)

[Cameco Corporation – Cigar Lake Operation](#)

[Cameco Corporation – McArthur River/Key Lake Operations](#)

[Cameco Corporation – Rabbit Lake Operation](#)

[CNSC Fact Sheet on natural background radiation](#)

[CNSC Independent Environmental Monitoring Program](#)

CNSC Indigenous Engagement

[Eastern Athabasca Regional Monitoring Program](#)

Health Canada's Guidelines for Canadian Drinking Water Quality

National Pollutant Release Inventory

[Northern Saskatchewan Environmental Quality Committee](#)

[Orano Canada Inc.](#)

Saskatchewan Environmental Quality Guidelines

N. LIST OF INDIGENOUS NATIONS AND COMMUNITIES

List of Indigenous Nations and communities whose traditional and/or treaty territories are in proximity to the sites covered by this report:

Athabasca Chipewyan First Nation

Birch Narrows Dene Nation

Black Lake First Nation

Buffalo River Dene Nation

Camsell Portage

Clearwater River Dene Nation

English River First Nation

Fond du Lac First Nation

Hatchet Lake First Nation

Lac La Ronge Indian Band

Métis Nation-Saskatchewan

Pinehouse Kineepik Métis

Prince Albert Grand Council

Stony Rapids

Uranium City

Wollaston Lake

O. ACRONYMS


ALARA	As Low As Reasonably Achievable
AREVA	AREVA Resources Canada Inc. (now Orano Canada Inc.)
BE	Below Expectations
Bq/L	Becquerels per litre
Bq/m ³	Becquerels per cubic meter
Cameco	Cameco Corporation
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COPC	Constituents of Potential Concern
EARMPP	Eastern Athabasca Regional Monitoring Program
ECCC	Environment and Climate Change Canada
EPR	Environmental Protection Report
ERA	Environmental Risk Assessments
FS	Fully Satisfactory
HHRA	Human Health Risk Assessment
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEMP	Independent Environmental Monitoring Program
JEB	John Everett Bates
Kg	Kilograms
LCH	Licence Conditions Handbook
LLRD	Long-lived Radioactive Dust
LTI	Lost-Time Injury
mASL	Metres Above Sea Level
MBq	megabecquerels
MDMER	<i>Metal and Diamond Mining Effluent Regulations</i>
mg/L	milligram per litre
Mkg	Million kilograms
mSv	Millisievert
mSv/hr	Macrosievert per hour
NEW	Nuclear Energy Worker

NSCA	<i>Nuclear Safety and Control Act</i>
NPRI	<i>National Pollutant Release Inventory</i>
Orano	Orano Canada Inc.
p-mSv	Person-millisieverts
PAD	Personal Alpha Dosimeter
PFP	Participant Funding Program
REGDOC	Regulatory Document
RnG	Radon Gas
RnP	Radon Progeny
SA	Satisfactory
SCA	Safety and Control Area
SO ₂	Sulphur Dioxide
SpA	Specific Area
SRC	Saskatchewan Research Council
TID-EP	Technical Information Document – Environmental Performance
TMF	Tailings Management Facility
TRIR	Total Recordable Incident Rate
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
U	Uranium
UA	Unacceptable
WTP	Water Treatment Plant

P. REGULATORY OVERSIGHT REPORT OUTREACH

Regulatory Oversight Report (ROR) Dashboard of Uranium Mines & Mills: 2021


This dashboard reports on the safety performance of active Uranium Mine & Mill (UMM) sites and the efforts of the Canadian Nuclear Safety Commission (CNSC) to ensure the safety and protection of people and the environment around these sites in 2021.
For the full ROR (CMD 22-M36) and associated documents, please scan this QR code:



CMD 22-M36

2021 Site Status

X = Operational Site
X = Site in Temporary Shutdown



7

CNSC Inspectors

dedicated to UMM sites

17

CNSC Subject Matter Experts


With direct regulatory effort at UMM sites

Regulatory Conclusion

CNSC staff conclude that all UMM sites operated safely in 2021


3 areas of focus in the ROR

1




Environmental protection

2



Radiation protection

3




Conventional health & safety

Events


- 0 Radiological Action Level Exceedances
- 12 Environmental Action Level Exceedances
- 15 Reportable Releases to the Environment
- 5 Lost-Time Injuries

6,465 hours Compliance work



3,712 hours Licensing work

For more information on CNSC regulatory efforts regarding uranium mines and mills in Canada scan this QR code to visit our website



Activities

- 12 CNSC Compliance Inspections
- 15 CNSC Notices of Non-Compliance (NNCs)

All NNCs and Events were considered low-risk and did not have an impact on safety at UMM sites

Maximum doses

- Regulatory limit
- Effective dose

The Public

Doses to the public from all active mines and mills are negligible. These doses are well below the regulatory limit of 1 mSv/yr.

Nuclear energy workers (NEWs)

6.03mSv

50 mSv/yr

The maximum effective dose received by a NEW in 2021 across UMM sites was at Cigar Lake

Public Outreach & Indigenous Engagement

CNSC staff worked with Indigenous Nations and communities to identify opportunities for formalized and regular engagement throughout the lifecycle of UMM sites. Most of the engagement and consultation in 2021 occurred via remote means due to public health recommendations related to COVID-19.

Independent Environmental Monitoring Program (IEMP)

IEMP sampling campaigns were conducted at 2 UMM sites in 2021: Key Lake and McArthur River. Analysis of samples indicates that the environment is protected. Scan this QR code to see the data.

