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Environmental Protection Framework for Operating Uranium Mines and Mills Under the *Nuclear Safety and Control Act*

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Canadian Nuclear Safety Commission
Canada

Environmental Protection Framework for Operating Mines and Mills Under the *Nuclear Safety and Control Act*

Document availability

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This document outlines the Canadian Nuclear Safety Commission (CNSC) environmental protection framework for operating uranium mines and mills. It also discusses the roles of environmental risk assessment (ERA) and environmental monitoring in federal regulatory oversight of this sector. Lastly, it serves as a backgrounder for a companion data report summarizing modern environmental monitoring data (2000-12) from the four main facilities operating during this time period (McClean Lake, Rabbit Lake, Key Lake and McArthur River).

The CNSC environmental protection framework is based on:

- regulatory instruments: legislation, licences, standards and regulatory documents
- licensing and environmental protection policies, programs and procedures
- compliance verification to ensure that licensees comply with requirements
- regulatory support through conducting research, risk assessment and performance assessment

This framework has evolved since 2000 when the *Nuclear Safety and Control Act* (NSCA) came into force. In June 2000, the CNSC was created to replace the former Atomic Energy Control Board. The NSCA included two fundamental changes with respect to environmental protection. The CNSC was given: 1) the specific responsibility for radiological protection of the environment, and 2) the mandate to manage hazardous substances as well as nuclear substances.

The NSCA obliges the Commission to regulate licensees in order to:

- prevent unreasonable risk to the environment and to the health and safety of persons
- disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission, and the effects on the environment and on the health and safety of persons

Examples are given of how this framework has been applied relative to other risk-based concepts in federal legislation. These principles are presently being applied to uranium mine/mill licences through the implementation of environmental monitoring, effluent monitoring and ERA N288.6 standards jointly developed with the CSA Group (formerly called Canadian Standards Association Group).

A description of the four mines/mills operating since 2000 is provided in the appendix. Details are also provided for the history of key risk management activities at the CNSC under the *Canadian Environmental Protection Act* (CEPA) for control of uranium in effluent, and under the NSCA for control of selenium and molybdenum.

1 INTRODUCTION

This document outlines the Canadian Nuclear Safety Commission (CNSC) environmental protection framework in the context of federal regulatory oversight of operating uranium mines and mills in Canada. This report provides background information for a companion data report summarizing recent environmental monitoring data from this sector. [1] This report describes the role of environmental impact statements and environmental monitoring in the regulatory process in the broader context of environmental risk assessment (ERA).

Environmental assessments (EAs) completed for the CNSC and the Canadian Environmental Assessment Agency (CEAA) contain a wealth of diverse data on the environmental performance of CNSC-licensed facilities. Many ERAs have been performed for existing and proposed projects to interpret these data and to make projections for the future. Examples include the joint federal provincial assessment review panels of the CEAA and the licensing requirements of the *Nuclear Safety and Control Act* (NSCA) of the CNSC. There are also many compliance reports submitted to the Province of Saskatchewan and the CNSC to meet licence requirements. The compliance reports often contain data prior to statistical analysis with minimal interpretation.

Environmental reports are reviewed by CNSC technical specialists and are considered to be public information. However, the overwhelming amount of information and the format of data presentation have limited their use and interpretation by researchers and the public. As a result, environmental performance assessments on data from abandoned mines are often over-emphasized in the public domain. Environmental data from these legacy sites represent historical practices that would be considered unacceptable under modern legislation.

In accordance with the CNSC's commitment to regulatory transparency and its mandate to disseminate objective scientific information on the effects of licensed facilities on the environment and the health and safety of persons, the CNSC has assembled a comprehensive database containing the results of the core environmental monitoring results at operating uranium mines and mills since the coming into force of the NSCA in 2000. [2]

2 ENVIRONMENTAL PROTECTION FRAMEWORK

The CNSC regulates the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to prevent unreasonable risk to the environment. This is done in a manner consistent with Canadian environmental policies, acts and regulations and with Canada's international obligations.

- regulatory instruments: legislation, licences, standards and regulatory documents
- licensing and environmental protection policies, programs and procedures
- compliance verification to ensure that licensees comply with requirements

- regulatory support through conducting research, risk assessment and performance assessment

These four components are used to control releases of nuclear and hazardous substances from nuclear facilities for the protection of human health, safety and the environment.

A feature of the CNSC's licensing process is continuous regulatory oversight. A licence is required to prepare a site, construct a facility, operate the facility and decommission the facility. The granting of a licence requires a hearing with the regulatory decision being made by a quasi-judicial independent Commission. This decision is based on recommendations from CNSC staff, and public presentations from the proponents and diverse stakeholders (First Nations, non-governmental organizations, members of the public). Annual reports on performance of CNSC-licensed facilities are written by CNSC staff and presented to the Commission. At relicensing, technical evaluations and appearances at hearings are also required. Relicensing occurs most typically during the operation of the facility; recently several uranium mines and mills have been granted 10-year operating licences, with renewals required in 10 years. Altogether, in addition to continuous oversight, comprehensive evaluations of a facility's environmental, health and safety performance are required in conjunction with licensing hearings throughout the lifespan of a facility. More information on these processes will be published in REGDOC-3.5.1, *Licensing Process: Class I Facilities and Uranium Mines and Mills* which is currently in development with publication anticipated in December 2014.

3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL RISK ASSESSMENT

The environmental monitoring data that are reported to the CNSC and the provinces by uranium mines and mills are a result of the extensive environmental impact assessment (EIA) history of these operations. In parallel, environmental risk assessment (ERA) has been increasingly important in the development of the CNSC environmental protection framework.

The role of ERA has evolved and it is now being incorporated in regulatory documents and standards for application throughout the lifecycle of nuclear facilities. The emphasis on a facility environmental impact study (EIS) and associated ERA has been driven by practical experience in regulating uranium mines and mills since the 1990s:

- 1990s ERA used as a risk management and assessment tool within the EIAs completed under joint federal-provincial EA legislation for proposed uranium mining activities in Saskatchewan
- 2000 - 6 ERA adopted by the new nuclear regulatory body (CNSC) as a tool for assessing new projects and the adequacy of environmental protection programs for existing facilities
- ~ 2006 + Used independently by CNSC staff to assess facility-specific emerging environmental issues, and where necessary take regulatory action
- ~ 2010 + Progressively being adopted within standards and regulatory documents

The modern concept of ERA for uranium mines and mills was initially applied in the 1990s in support of a series of EIAs submitted to a joint federal-provincial panel[1] conducting public reviews on proposed uranium mining and milling operations in northern Saskatchewan, where ERA was applied as a planning and management tool. ERA was used to identify the potential risks of an activity to the environment and public and to determine appropriate mitigation activities. The ERAs also included a final assessment of residual risk after mitigation, and a determination whether or not the activity could be carried out in a responsible, safe manner.

In 2000, the *Atomic Energy Act* (established in 1946) and the associated federal regulatory body (the Atomic Energy Control Board) were replaced by the NSCA and the CNSC. The NSCA created the CNSC in June 2000; its mission was to protect the health, safety and security of persons and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy.

The NSCA included two fundamental changes with respect to environmental protection. The CNSC was given:

1) the specific responsibility for radiological protection of the environment rather than relying on the paradigm that if humans are protected, the environment is also protected
2) the mandate to manage hazardous substances as well as nuclear substances released by a facility

The NSCA obliges the Commission to regulate licensees in order to:

- prevent unreasonable risk to the environment and to the health and safety of persons
- disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission, and the effects on the environment and on the health and safety of persons

The *General Nuclear Safety and Control Regulations* oblige licensees to:

- take all reasonable precautions to protect the environment and the health and safety of persons
- take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity

Detailed environmental protection elements were incorporated into general requirements of other key regulations (section 3(1) of the *Uranium Mines and Mills Regulations* and in sections 4, 5 and 6 of the *Class I Nuclear Facilities Regulations*). These include:

- the environmental baseline characteristics of the site and the surrounding area
- description of releases of nuclear substances and hazardous substances into the environment

[1] https://ceaa-acee.gc.ca/default.asp?lang=en&n=76C904A0-1

- the effects on the environment and on the health and safety of persons that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects
- the proposed measures to control releases of nuclear substances and hazardous substances into the environment
- the proposed environmental protection policies and procedures
- the proposed effluent and environmental monitoring programs
- the proposed program to inform persons living in the vicinity of the mine or mill of the general nature and characteristics of the anticipated effects of the activity to be licensed on the environment and the health and safety of persons

The CNSC determined that the terms "unreasonable risk" to the environment and the health and safety of persons and "reasonable precaution" to control releases would be interpreted in a manner respecting other Canadian environmental protection legislation such as the *Canadian Environmental Protection Act* (CEPA 1999), [3] the *Canadian Environmental Assessment Act* (CEAA 2012), [4] the *Species at Risk Act, 2002*, the *Fisheries Act* (FA 1995), [5] the *Metal Mining Effluent Regulations* (MMER 2002) [6] and the *Migratory Birds Convention Act, 1994*. [7]

The CEPA principle of "pollution prevention" for hazardous substances was adopted as a counterpart to the as low as reasonably achievable (ALARA) principle applied to nuclear substances (required in the *Radiation Protection Regulations* under the NSCA). ERA was adopted as the logical tool for meeting the NSCA mandate since "unreasonable risk" and "reasonable precaution" are risk-based concepts (see table 1). The CNSC is the only nuclear regulatory body to have environmental protection responsibilities and internationally is the only nuclear regulator to conduct ecological risk assessments to support licensing decisions.

Table 1: Relationship between environmental licensing requirements and an ERA

Licence requirements	Relationship to ERA
Environmental baseline characteristics	Environmental characterization is one of the initial steps and necessary to determine transport and exposure pathways as well as receptors to be assessed/protected
Description of releases of nuclear and hazardous substances: points of release, quantities, concentrations, volumes and flow rates	ERA input parameters; for predictions to be applicable a facility must be assessed and licensed against these predicted releases
Predicted effects on the environment	Predicted effects on the environment are the final output of the ERA
Environmental protection policies, programs and procedures, more commonly referred to as an environmental management system (EMS)	ERA identifies the "environmental aspects" (ISO 14001 parlance) that become the focus of continuous improvement activities for the EMS
Effluent monitoring program (releases to atmosphere, surface and ground waters)	Monitoring program should meet relevant regulations and be designed to demonstrate that releases are within the range of those assessed in the ERA
Environmental monitoring program	Monitoring program should be designed to demonstrate environmental effects are within the range of those predicted in the ERA

4 APPLICATION OF ENVIRONMENTAL RISK ASSESSMENT UNDER THE NUCLEAR SAFETY AND CONTROL ACT

The CNSC uses site-specific ERA as a core EA tool throughout the lifecycle of a nuclear facility. As shown in figure 1, the role of ERA in licensing begins with the initial EA for a new facility or for a new activity at an existing facility. The ERA may be completed as part of a submission under the CEAA or as part of a licence application necessary under the NSCA. The purpose is to determine the potential risks to human health and the environment and to ensure the implementation of adequate mitigation measures. The ERA assists in the systematic identification of necessary mitigation technologies (water treatment systems, filters, liners, covers) or practices (dust control, silt barriers, revegetation). The objective of the ERA is to determine whether the proposed activity can be completed without posing a "likely significant adverse effect" (CEAA) or posing an "unreasonable risk" (NSCA) to the environment and ensuring the health and safety of the public. If this is demonstrated, the facility can be considered for licensing under the NSCA.

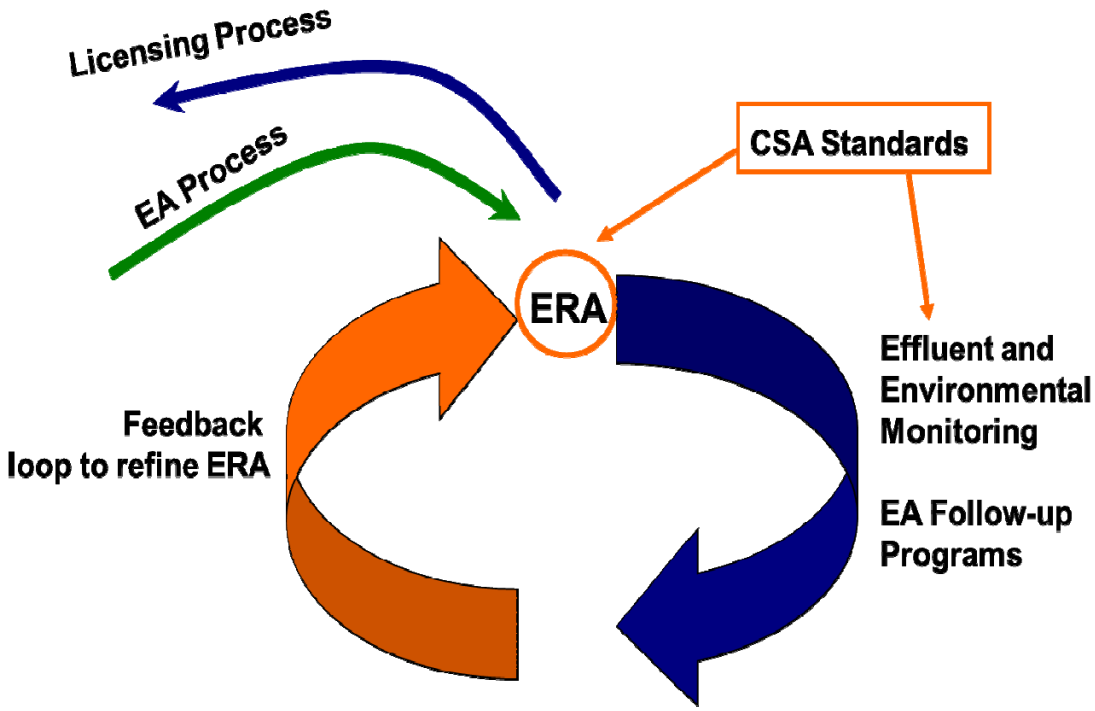
An ERA typically predicts the physical disturbances; releases to the atmosphere, surface water and groundwater; and the changes to the physical environment and any biological effects that may occur as a result of a new facility/activity. It defines both quantitatively and qualitatively the actual environmental envelope within which the facility is expected to perform. This serves as a conceptual "licensing basis" in an environmental context.

The release (gaseous, particulate and liquid) and environmental monitoring programs required by the CNSC are designed by licensees to meet legislated criteria (e.g., MMER limits or NSCA licence-specific conditions). Monitoring programs must be appropriate for testing the facility's performance with respect to its licensing basis. Additional special investigations are also often implemented on an ongoing risk priority basis to decrease "uncertainty" in ERA modelling.

Historically, ERA was applied mainly in a pre-operational context. More recently, the ERA documentation and associated performance predictions are being identified as part of the licensing basis of a facility. This formalizes the ERA predictions as criteria for benchmarking and assessing environmental performance. This encourages the application of a conservative approach to both risk and impact predictions and forms the basis for mitigation. It also emphasizes pre-planning for additional measures, if environmental performance does not meet predicted performance.

In the last few years the CNSC has formally documented this environmental protection framework (figure 1) and continues to develop further guidance. Currently, four core documents are available: REGDOC-2.9.1, *Environmental Protection Policies Programs and Procedures*, addressing environmental management systems [8] and three environmental protection standards with the CSA Group, *N288.4 - Environmental Monitoring Programs*, [9] *N288.5 - Effluent Monitoring Programs* [10] and *N288.6 - Environmental Risk Assessments*. [11] All of these documents are applicable to Class I facilities and uranium mines and mills and are in the process of being incorporated into facility licences as they are being renewed or amended.

Figure 1: Conceptual basis for the CNSC environmental protection framework



The CNSC currently guides licensees to maintain the site-specific ERA as a "living" or "ever-green" document. This concept stems from the periodic updates recommended as part of a typical EMS for continual improvement (a five-year cycle for the relevant CSA standards). Updating the ERA using site-specific data from monitoring programs and incorporating new developments in environmental science and/or modelling are of great benefit to the regulator. These updates test facility performance against predictions and update predictions due to the continued operation of the facility. In this manner the ERA evolves from a conservative one-time predictive performance tool to a powerful site-specific tool for the application of an adaptive management approach to environmental protection.

5 ENVIRONMENTAL MONITORING PROGRAMS

The *Uranium Mines and Mills Regulations* under the NSCA require the following core elements related to environmental protection:

(3) An application for a licence in respect of a uranium mine or mill, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the *General Nuclear Safety and Control Regulation*s:

(c) in relation to the environment and waste management:

(i) the program to inform persons living in the vicinity of the mine or mill of the general nature and characteristics of the anticipated effects of the activity to be licensed on the environment and the health and safety of persons

(ii) the program to determine the environmental baseline characteristics of the site and the surrounding area

(iii) the effects on the environment that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects

(iv) the proposed positions for and qualifications and responsibilities of environmental protection workers

(v) the proposed environmental protection policies and programs

(vi) the proposed effluent and environmental monitoring programs

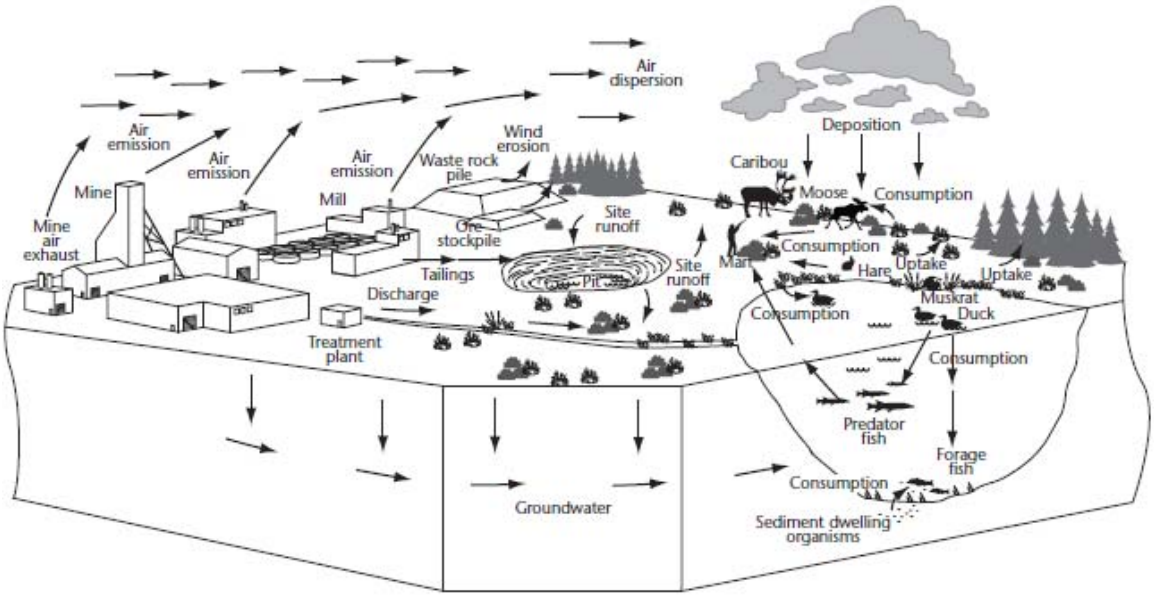
(vii) the proposed location, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous sub-stances into the environment, including their physical, chemical and radiological characteristics

(viii) the proposed measures to control releases of nuclear substances and hazardous substances into the environment

(ix) a description of the anticipated liquid and solid waste streams within the mine or mill, including the ingress of fresh water and any diversion or control of the flow of un-contaminated surface and ground water

These requirements are incorporated in a site's ERA. The release and environmental monitoring programs follow from the ERA and are designed to meet both legislated standards as well as any site-specific needs. The site's ERA addresses all releases of contaminants of potential concern (COPC) to air and water (including groundwater) and the pathways for COPC that may impact biota or members of the public. Figure 2 provides an example of the range of sources, pathways and receptors (biota and members of the public) that should be considered for a generic uranium mining and/or milling operation.

Figure 2: Potential sources of releases and receiving environment pathways and receptors associated with a generic uranium mining and milling operations (from CSA N288.4)



During the operational phase, the most common sources of release, COPCs, and methods of environmental monitoring are illustrated in table 2. Monitoring of other media (including groundwater) and selected biota are also included based on any risks identified to verify that the scope of monitoring is appropriate for all potential environmental impacts.

Table 2: Common sources of releases, associated COPC, primary sources of releases and main methods for environmental monitoring of releases

Type of release	COPC	Primary sources	Monitoring element
Atmospheric Released to air	Radon (gas)	• Tailings management area (no wet cover) • Rock piles (ore, special waste) • Mine ventilation (underground mine) • Mill	Track-etch cups
	Radionuclides, metals and metalloids (particulates)	• Tailings management area (no wet cover) • Rock piles (ore, special waste) • Mine ventilation (underground mine) • Mill	High-volume samplers
Aquatic Released to surface waters	Radionuclides Metals and metalloids Nutrients Suspended solids	• Contaminated water, collected and released from a treatment facility o Mine waters (open-pit or underground) o Leachate and run-off from waste rock piles o Tailings management facility waters (leachate and/or surface) o Mill process water o Dewatering water	Surface water sampling

Release (effluent) monitoring programs are also required to ensure releases meet licensed release limits, but are only briefly discussed here. At present, release monitoring is being aligned to meet the requirements and guidance provided in CSA N288.5. [12] These programs are reviewed and approved by CNSC technical specialists. Licensees are required to immediately report to the Commission any unauthorized release or any failure, abnormal degradation or weakening of a component or system that could result in a serious adverse effect on the environment or risk to the health and safety of persons (section 29.1, *General Nuclear Safety and Control Regulations*). Licence conditions also require the submission of quarterly effluent quality reports for important constituents (monthly statistics). Consolidated release and environmental monitoring data are reported to the CNSC in annual reports, with diverse information also presented at hearings or meetings of the Commission. A key document in this sector that is used to inform the public and the Commission is the integrated staff annual report titled *Report on the Performance of Uranium Fuel Cycle and Processing Facilities*. [13]

In addition to the monitoring programs required of licensees, the CNSC recently began an independent environmental monitoring program that includes uranium mines and mills. The intention is to post results once the program is comprehensively underway. Independent monitoring also occurs under the auspices of two programs based in Saskatchewan: the Eastern Athabasca Regional Monitoring Program (EARMP) and the Athabasca Working Group (AWG). The EARMP technical program monitors 22 COPC at reference and far-field exposure sites (water, sediment and fish chemistry, benthic

invertebrate community structure). It is funded by Saskatchewan, in partnership with Cameco and AREVA. It addresses long-range monitoring and potential cumulative impacts downstream. The EARMP also includes a community-based program to monitor the safety of traditionally harvested country foods by collecting and testing representative water, fish, berry and mammal chemistry. Seven communities in the Athabasca region are participating. The AWG is a separate program that began in 2000 and is funded by Cameco and AREVA. Sampling is done at six communities with a strong emphasis on community involvement. Water, sediments, fish, wildlife and berries are sampled for chemical analysis for selected COPC; radon is also measured in air.

6 DATA REPORT

Environmental monitoring data collected around uranium mines and mills are contained in a companion report. [14] The report presents detailed results of environmental monitoring in air, surface water, fish and sediments by distance from effluent release points at four operating uranium mines and mills in Canada (McClean Lake, Rabbit Lake, Key Lake, McArthur River). A description of these sites is provided in the appendix. Data were not compiled from the Cigar Lake mine, which began operation in March 2014.

The report provides statistics for the period since the coming into force of the NSCA (2000-12), with some additional breakdowns from 2000-09 versus 2010-12. After 2009, levels of a few key COPC in the aquatic environment were reduced following the introduction of new or improved controls on effluent quality. These COPC (uranium, selenium, molybdenum) were identified as posing potential risks to the environment through CNSC regulatory oversight and staff initiatives.

Table 3 provides an overview of the data available for air, water, sediment, fish and soil. These data have been summarized in the report for the period from 2000 to 2012, with the exception of soil data. Soil data were not included, as levels are low, and this pathway is largely captured through particulate air sampling.

The data report reflects only the current status of information that is being submitted to the CNSC as part of environmental monitoring requirements. The data are representative of environmental performance of uranium mines and mills regulated by the CNSC under the NSCA.

Table 3: Environmental monitoring data from uranium mines and mills as required by their respective environmental monitoring programs

Exposure pathway	Nuclear or hazardous substances monitored	Source

Air	Nuclear	U-234, Th-230, Ra-226, Pb-210, Po-210, U-238, Rn	Annual reports Status of the environment reports
	Hazardous	As, Cd, Pb, Ni, U, Se, Cu, Mo, Zn	
Water	Nuclear	Ra-226, Pb-210, Th-230, Po-210	Annual reports Status of the environment reports Environmental effects monitoring reports
	Hazardous	pH, NH_3, TSS, P, Al, As, Ba, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se, V, Zn, U	
Sediment	Nuclear	Ra-226, Pb-210, Th-230, Po-210	Annual reports Status of the environment reports Environmental effects monitoring reports
	Hazardous	Al, As, Ba, B, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se, V, Zn, U	
Fish	Nuclear	Ra-226, Pb-210, Th-230, Po-210	Annual reports Status of the environment reports Environmental effects monitoring reports
	Hazardous	Al, As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se, V, Zn, U	
Soil	Nuclear	Ra-226, Pb-210, Th-230, Po-210	Annual reports Status of the environment reports
	Hazardous	pH, Al, As, Cd, Co, Cu, Fe, Mo, Ni, Pb, Se, V, Zn, U	

The companion data report does not summarize information from release monitoring programs. Core data for releases to surface water are available from Environment Canada (EC) in the annual performance reports for MMER (EC 2006, 2007a,b, 2008, 2009, 2010a,b, 2011, 2012, 2014[2]). [15] These reports have shown that the uranium mining sector has consistently been the best performing metal mining sector with respect to meeting MMER limits for both analyte-specific limits and acute toxicity testing.

For practical purposes, licensees harmonize programs required by the CNSC with the MMER environmental effects monitoring program. Environmental monitoring at uranium mines and mills is also currently being aligned with CSA N288.4. This standard requires that a nuclear facility shall review its ERA to verify its applicability and shall update it, as necessary, consistent with the overall iterative process for ERA. Verification typically involves some additional sampling of plants or animals (currently blueberry plants, lichens, benthic invertebrates), as well as special studies on other organisms (e.g., wildlife). Monitoring for biological effects may also be done on a site-specific basis,

[2] Index at http://publications.gc.ca/site/eng/97848/issues.html, and details of the 2012 report provided in the references list.

depending on predictions and risk. As a NSCA requirement, environmental monitoring data are used in ERA modelling to demonstrate that the public is not exposed to levels of radiation in excess of 1mSv/year above natural background and that doses are ALARA.

In addition to the CNSC's analysis and reporting requirements, the Saskatchewan government has required uranium mines and mills to submit a "status of the environment report" (SOE) on a five-year cycle. These SOE reports have been invaluable in terms of regularly updating a site's environmental performance relative to predictions in the original EIS (its licensing basis). The value of this information was a key factor in the adoption of the "ever-green" ERA concept during the evolution of relevant CSA standards. The SOEs are also of great value to federal regulatory oversight. These reports will be used by licensees to periodically submit updated ERA modelling results to the CNSC. This will help to quantitatively assess present environmental performance relative to EIS and ERA predictions. Updates will also help in predicting future performance based on improved monitoring data and new science. Licensees are doing this either within the formal SOE reporting process and/or in separately maintained ERA documents.

7 REFERENCES

1. Canadian Nuclear Safety Commission, *A Review of Environmental Performance of Operating Uranium Mines and Mills in Northern Saskatchewan* 2000-2012, Presentation to BAPE, September 2014.
2. Ibid.
3. Justice Canada, *Canadian Environmental Protection Act*, laws-lois.justice.gc.ca/eng/acts/c-15.31/
4. Justice Canada, *Canadian Environmental Assessment Act*, laws-lois.justice.gc.ca/eng/acts/c-15.21/
5. Justice Canada. *Fisheries Act*, laws-lois.justice.gc.ca/eng/acts/F-14/FullText.html
6. Justice Canada, *Metal Mining Effluent Regulations*, laws-lois.justice.gc.ca/eng/regulations/sor-2002-222/
7. Justice Canada, *Migratory Birds Convention Act*, laws-lois.justice.gc.ca/eng/acts/M-7.01/
8. Canadian Nuclear Safety Commission, *Environmental Protection Policies, Programs and Procedures, 2013*, nuclearsafety.gc.ca/pubs_catalogue/uploads/REGDOC-2-9-1-Environmental-Protection-Policies-Programs-and-Procedures.pdf
9. CSA Group, *288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*, 2010, shop.csa.ca/en/canada/nuclear/n2884-10/invt/27008222010
10. CSA Group, *N288.5-11, Effluent monitoring program at Class I nuclear facilities and uranium mines and mills*, 2011, shop.csa.ca/en/canada/nuclear/n2885-11/invt/27032642011
11. CSA Group, *N288.6-12, Environmental risk assessment at Class I nuclear facilities and uranium mines and mills*, 2012, shop.csa.ca/en/canada/nuclear/n2886-12/invt/27034162012
12. CSA Group, *N288.4-10, Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*, 2010, shop.csa.ca/en/canada/nuclear/n2884-10/invt/27008222010
13. Canadian Nuclear Safety Commission, *Report on the Performance of Uranium Fuel Cycle and Processing Facilities*, 2014, nuclearsafety.gc.ca/eng/resources/publications/reports/report-on-uranium-fuel-cycle-and-processing-facilities.cfm

14. Canadian Nuclear Safety Commission, *A Review of Environmental Performance of Operating Uranium Mines and Mills in Northern Saskatchewan 2000-2012*. Presentation to BAPE September 2014.

15. Environment Canada. *Summary Review of Performance of Metal Mines Subject to the Metal Mining Effluent Regulations in 2012*. 1/MM/22 – January 2014 Mining Section Mining and Processing Division, Industrial Sectors Directorate, Environmental Stewardship Branch, Environment Canada, 2014, publications.gc.ca/collections/collection_2014/ec/En49-15-22-eng.pdf

8 APPENDIX: OPERATING URANIUM MINES AND MILLS

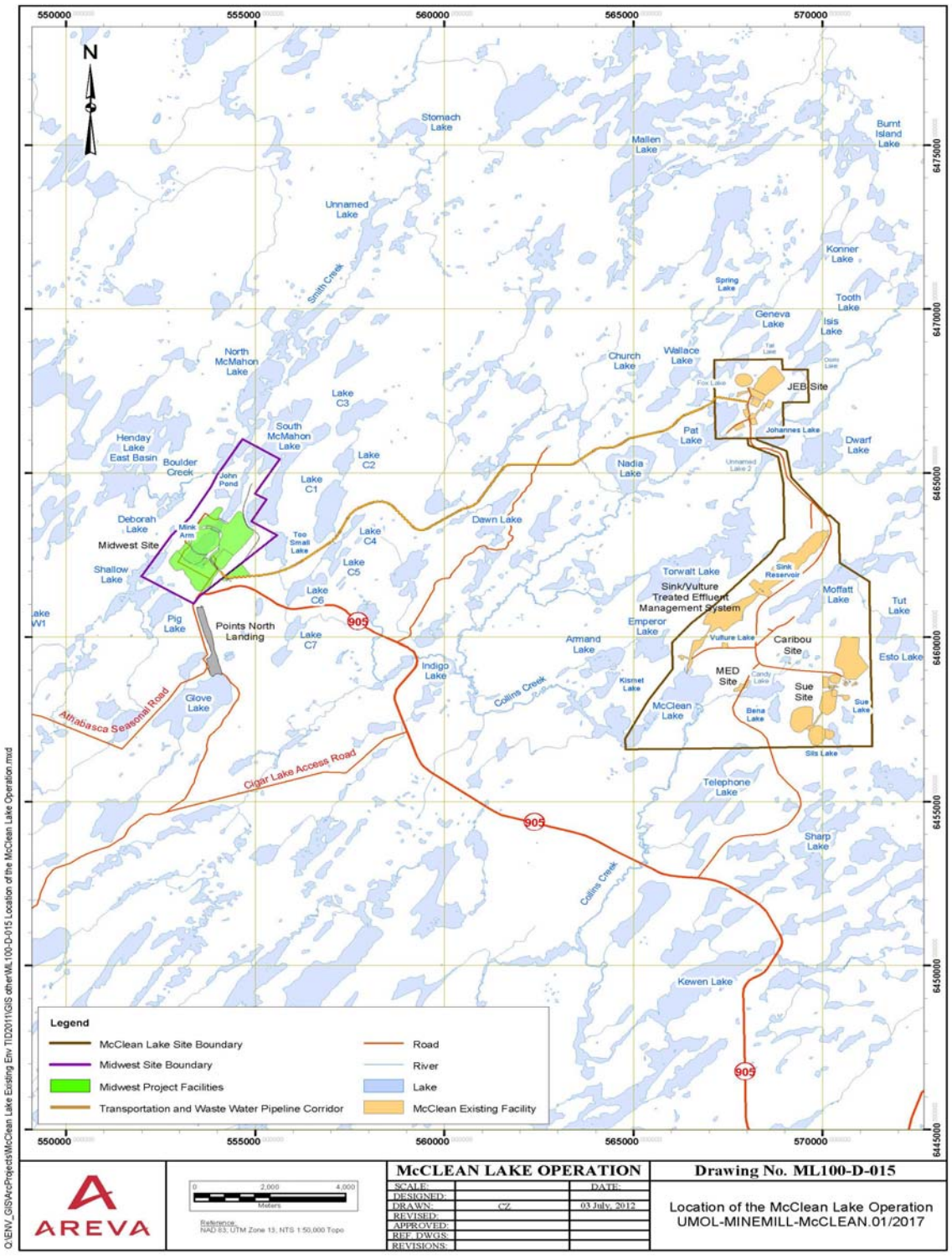
The operating uranium mines and/or mills in Canada for which environmental monitoring data were assembled (McClean Lake, Rabbit Lake, Key Lake, McArthur River) are in the Athabasca Basin of Saskatchewan (figure A1). Other labels on this figure are Cluff Lake (decommissioned), Midwest/Millennium (proposed) and Cigar Lake (operations began 2014).

Figure A1: Location of the operating and other decommissioned or proposed uranium mines and mills in Canada in Northern Saskatchewan

A.1 McClean Lake

The McClean Lake Operation is majority (70%) owned and operated by AREVA Resources Canada. The current licence (UMOL-MINEMILL-McCLEAN.01/2017) expires on June 30, 2017. The site consists of three areas located along a north–south axis joined by a road and pipeline corridor (figure A2).

Figure A2: Map of the McClean Lake Operation



To the north is the JEB site, consisting of the permanent camp, the JEB mill and the mined out JEB deposit, which has since been engineered to manage tailings (JEB in-pit tailings management facility [TMF], figure A3).

Figure A3: Aerial view of the JEB site, north end of the McClean Lake Operation

To the south is the SUE mining area, which includes the mined out SUE A/C, SUE B and SUE E pits as well as two clean waste rock stockpiles. In between and just north of the JEB site is the Sink/Vulture Treated Effluent Management System (S/V TEMS) which consists of Sink Reservoir and its control structure, Vulture Lake, and the effluent diffuser system that discharges to the east basin of McClean Lake.

Process waters and intercepted contaminated waters report to one of the two water treatment plants (WTP) on site, the JEB WTP (process waters and JEB area contaminated waters) and the SUE WTP (SUE area contaminated waters). Both these WTPs release to Sink reservoir. JEB dewatering waters also report to Sink Reservoir with a testing program in place to allow re-routing to treatment if necessary. The S/V TEMS is designed to allow controlled timing of release volumes to ensure that water levels and flows can be maintained in downstream Collins Creek to those within natural fluctuations as well as provide an adequate buffer for extreme precipitation events.

The mill has been temporarily shut down since July 2010. Environmental management activities and maintenance, including the interception and treatment of contaminated waters, continue as the site awaits receipt of ore from the Cigar Lake mine.

A.2 Rabbit Lake

The Rabbit Lake Operation is owned and operated by Cameco Corporation. It is the longest running of the currently operating facilities in northern Saskatchewan. The current licence (UMOL-MINEMILL-RABBIT.00/2023) expires on October 31, 2023. Uranium exploration commenced in the area in 1965 with a 1968 airborne survey identifying several radioactive anomalies. Since then, a total of five different ore bodies

have been discovered: Rabbit Lake ore body (1968), Collins Bay A-Zone ore body (1971), Collins Bay B-Zone ore body (1977), Collins Bay D-Zone ore body (1979) and Eagle Point ore body (1980). The Rabbit Lake and Collins Bay ore bodies were shallow deposits extending beneath local water bodies and were thus amenable to open-pit mining methods. The Eagle Point ore body is deeper and is currently being mined using underground mining methods.

Camp and mill construction commenced in 1972, with exploitation of the Rabbit Lake ore body starting in 1972. Ore production commenced in 1974, with the pit being mined out by 1984. Ore was processed at the mill with tailings deposited to the Rabbit Lake above-ground TMF (AGTMF). Contaminated waters report to the WTP with treated water released to the headwaters of Horseshoe Creek. The mill has been in operation since 1975, with some short-term shut-downs and has also been run on a week-on week-off schedule for a number of years.

The Rabbit Lake site can be sub-divided into three zones (figure A4). The northern zone is associated with Collins Bay and the Harrison Peninsula of Wollaston Lake. This area currently consists of an active underground mine (Eagle Point Mine), one mined-out partially reclaimed flooded pit (B-Zone), and two pits now decommissioned and incorporated back into Collins Bay of Wollaston Lake (A-Zone and D-Zone). The central zone consists of the Mill Hill area containing the operating mill (figure A5), the old Rabbit Lake pit that has now been re-engineered and functions as the Rabbit Lake in-pit TMF (IPTMF), and waste rock storage areas from the Rabbit Pit mine. The southern area consists of the old, partially reclaimed AGTMF and the Rabbit Lake WTP. It currently treats all collected contaminated water from the site as a whole and releases treated water to the Horseshoe Creek system.

Figure A4: Map of the Rabbit Lake Operation

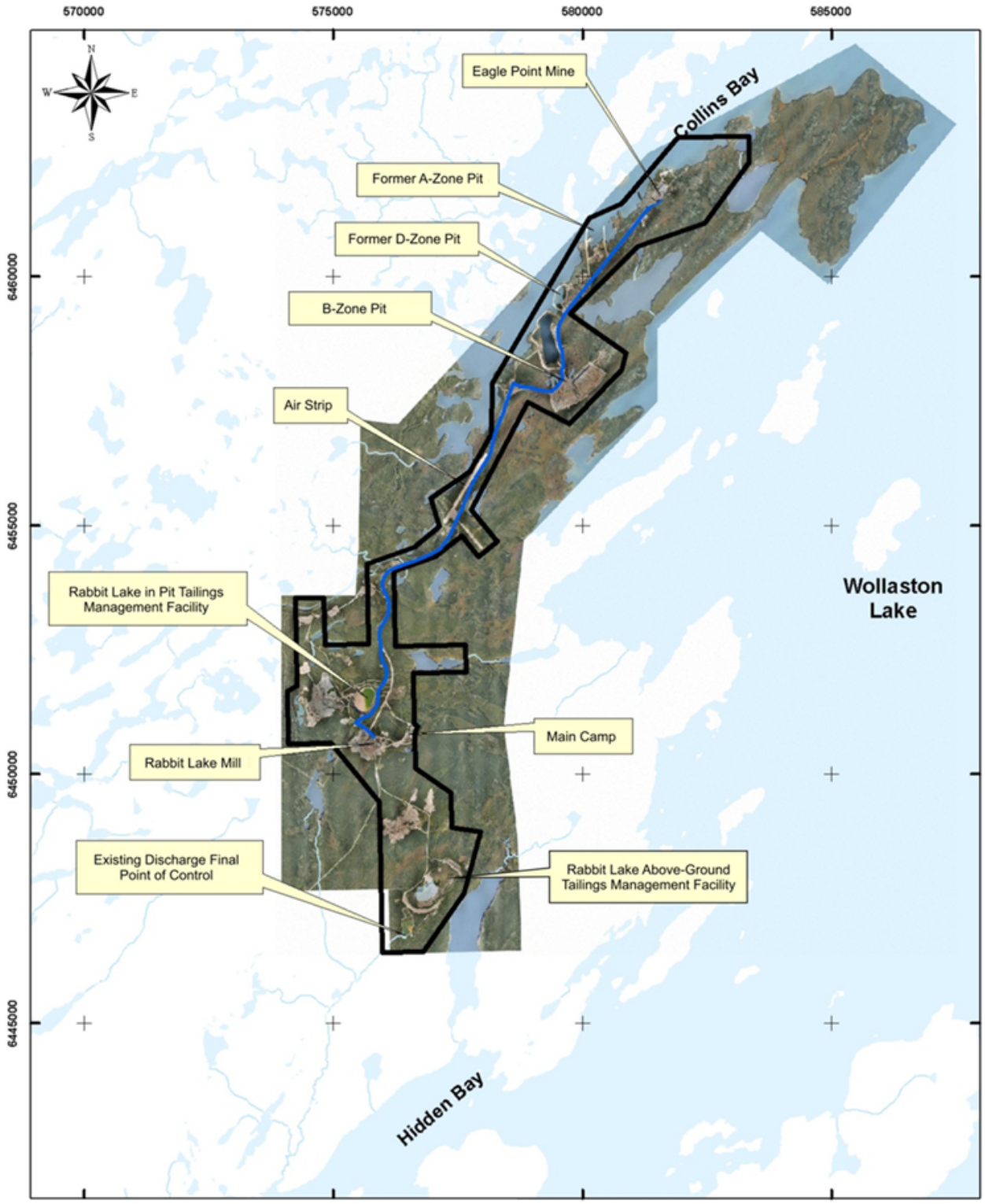


Figure A5: Aerial view of the Rabbit Lake mill

A.2.1 Uranium risk management under the CEPA

Improvements in effluent treatment were undertaken at the Rabbit Lake Operation in response to regulatory efforts by EC and the CNSC. The assessment of releases of radionuclides from nuclear facilities was added to the second Priority Substances List (PSL2) of the CEPA in 2003. The PSL2 assessment was done to determine if such releases pose a significant risk to the environment. The evaluation was produced under the direction of CNSC technical specialists.

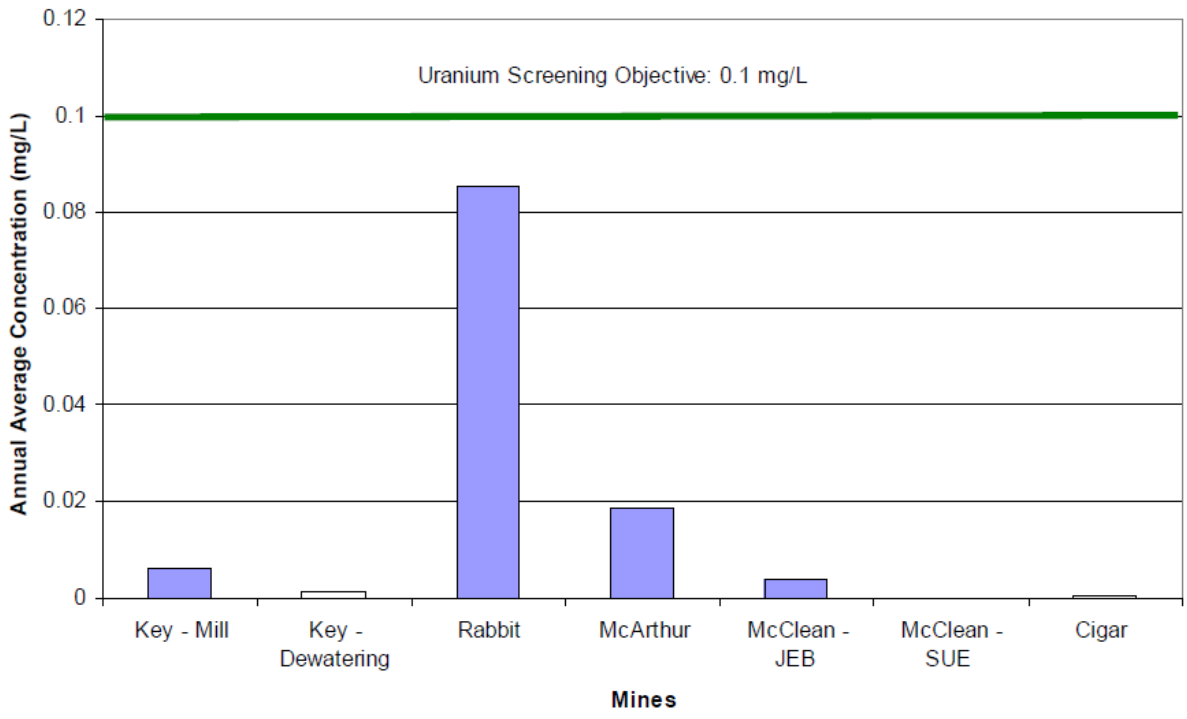
The final report, *Releases of Radionuclides from Nuclear Facilities (Impact on Non-human Biota*, concluded that releases of uranium and uranium compounds contained in effluent from uranium mines and mills are toxic, as defined in section 64 of the CEPA. The toxic determination was related to the releases from specific uranium mines and mills: the Rabbit Lake mine/mill effluent, the Key Lake dewatering water releases and the Cluff Lake mine/mill effluent (now decommissioned). Each uranium mine and mill undertook specific risk management activities to reduce the risk to the environment due to uranium releases.

In April of 2012, the CNSC and EC jointly issued a final annual report on progress of these risk management activities (CNSC, *2010 Annual Report on Uranium Management Activities*). The report concluded that:

- The CNSC and EC are meeting their regulatory commitments and responsibilities associated with the safe regulation and risk management of uranium releases from nuclear facilities.
- The current CNSC-licensed facilities are not releasing uranium in effluent that would result in significant ecological risk.
- Licensees are further expected to "take all reasonable precautions to control releases" and to keep all releases (including hazardous substances) as low as reasonably achievable (ALARA) in accordance with the NSCA and its regulations.

The final review indicated that no facilities exceeded the Saskatchewan licence limit (2.5 mg/L) for uranium effluent discharge concentration. All facilities achieved the CNSC's optimization screening objective of 0.1 mg/L for annual average concentration of uranium in effluent. Results from the report are reproduced below in figure A6. For Rabbit Lake (with the highest loading of any mine/mill), the annual average effluent quality of ~ 0.08 mg/L uranium represents an 84% reduction over the pre-project 10-year baseline of 0.5 mg/L.

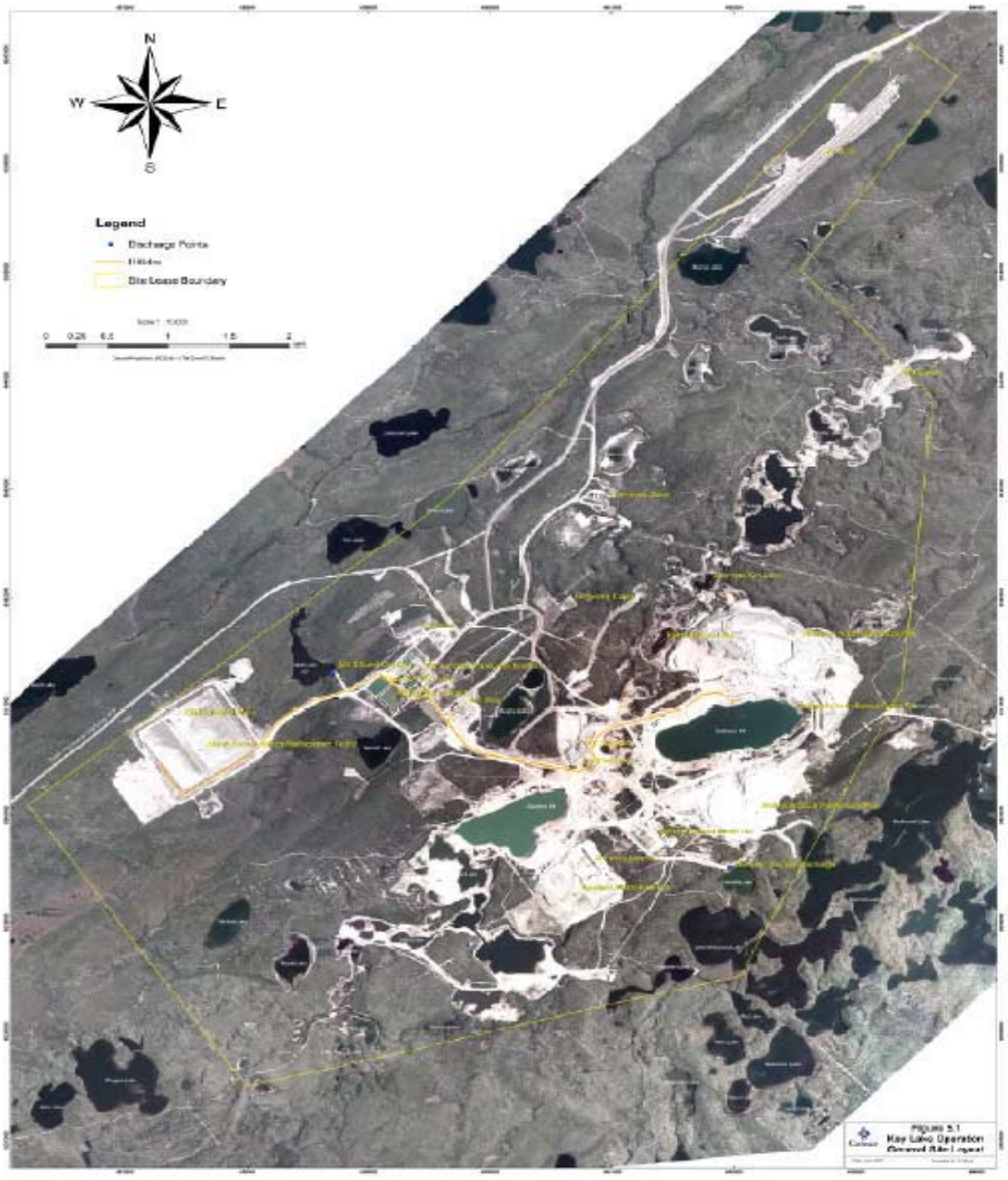
Figure A6: Annual average uranium concentrations in effluent at uranium mines and mills in Canada in 2010



A.3 Key Lake

The Key Lake Operation is operated by Cameco Corporation and co-owned by Cameco (83%) and AREVA (17%). The current licence (UMLOL-MILL-KEY.00/2023) expires on October 31, 2023. The general physical layout is relatively compact (figures A7, A8).

Figure A7: Map of the Key Lake Operation



The Gaertner and Deilmann ore bodies were discovered in 1975 and 1976, respectively. They are now mined out. The site currently consists of the Gaertner open-pit mine, which has been backfilled and flooded. To the northeast is the Deilmann pit, which was engineered to receive tailings and currently serves as the operating Deilmann TMF (DTMF). The AGTMF is found on the west side of the site and received tailings up to 1995 when it was replaced by the DTMF. The AGTMF is currently serving as a storage area for contaminated solid materials from both the Key Lake and McArthur River operations. There is an ore storage area, two special waste storage facilities, three waste rock storage areas and a mill. All of the ore from the Gaertner and Deilmann pits has been milled, and thus the mill currently processes ore slurry transported from the McArthur River mine.

Key Lake operates two water treatment facilities. There is a reverse osmosis plant that processes dewatering water and releases "clean" solvent to Horsefly Lake of the McDonald Lake drainage system. The high concentrate "reject" or solute stream reports to the mill and the chemical WTP. Process waters, the reverse osmosis reject water and all contaminated waters from the site are processed through a two-stage process. Treated waters are released to Wolf Lake and ultimately report to the David Creek drainage system.

Figure A8: Aerial view of the Key Lake Operation

A.3.1 Selenium and molybdenum risk management under the *Nuclear Safety and Control Act*

The original Key Lake Operation EIS was filed in 1979 to develop the Gaertner and Deilmann deposits as open-pit mines, build an AGTMF, and construct and operate a mill. In 1995, a second EIS updated the 1979 analysis, reflecting changes associated with milling McArthur River ore. An updated ERA at the 7.2 M kg-U production rate was next produced in 2005. This targeted assessment of risks from all metals and radionuclides was requested by the CNSC as an aspect of a licence condition for investigation and control of molybdenum in mill effluent. Selenium was also identified as a contaminant of potential concern at this time.

In 2006, CNSC staff completed an independent, peer-reviewed assessment and determination of environmental risk for the present operations' cumulative effects. This was done to determine whether operations remained within the scope of effects anticipated (the 1995 EIS), and whether additional regulatory controls were needed to minimize impacts. A key aspect of this study was the use of a weight of evidence approach to determine if contaminants in the treated mill effluent accumulating downstream posed an unreasonable risk to the environment under the NSCA. Unreasonable risk was interpreted in terms of the definitions of what would constitute a "toxic" substance under the CEPA and a "deleterious substance" under the *Fisheries Act* (FA). Based on seven lines of evidence, CNSC staff's conclusion was that releases of treated effluent from the mill had resulted and may continue to result in an unreasonable risk to the environment, with the likely contributing factors being selenium and molybdenum.

The assessment found that these contaminants had increased and would continue to exceed the 1995 EIS predictions in abiotic and biotic compartments in the David Creek system downstream. Adverse effects had occurred and were predicted to increase. These biological effects covered a wide range of biota (invertebrates, fish, birds, mammals) at multiple trophic levels and levels of ecological organization. The assessment identified selenium and molybdenum as contaminants of potential concern; both had increased in the abiotic and biotic compartments beyond the local project area.

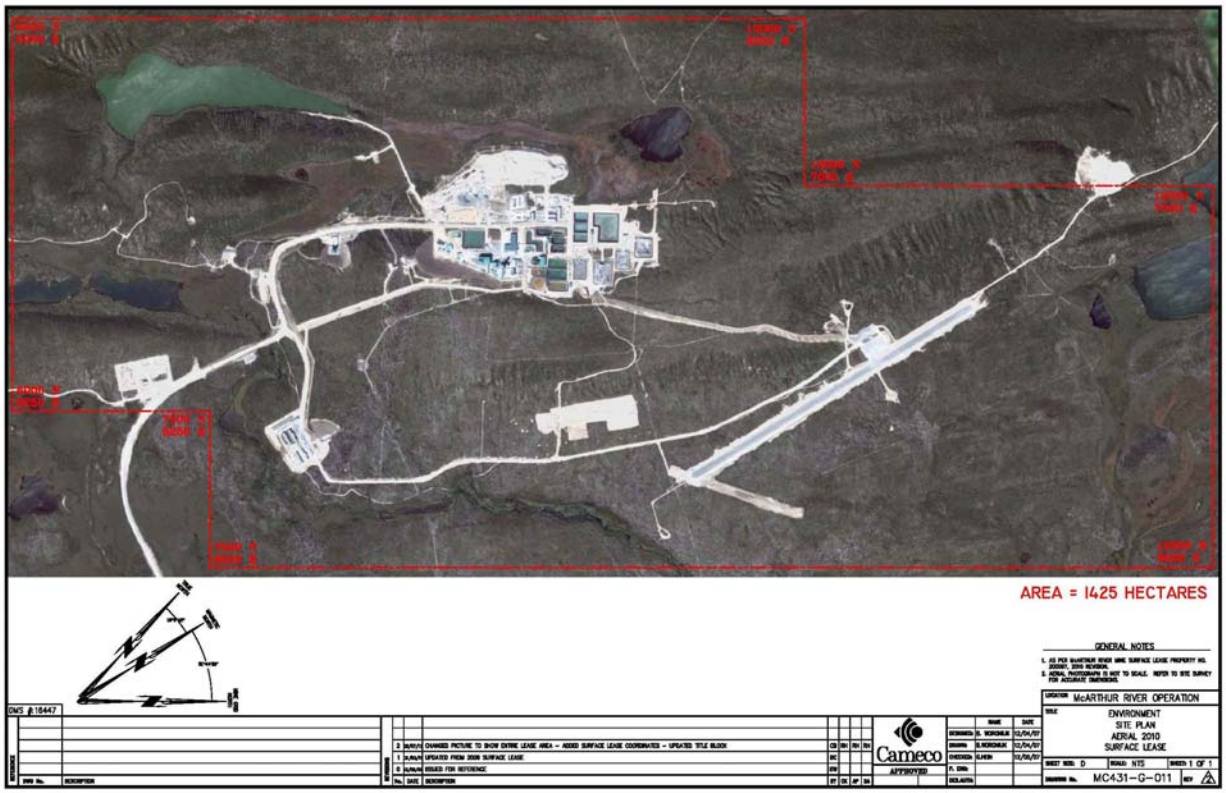
As a result of this assessment, the Key Lake mill added a treatment circuit to control and reduce selenium and molybdenum concentrations in effluent. McArthur mine, Rabbit Lake mine and mill and McClean Lake mill also pro-actively undertook effluent treatment optimization projects to reduce releases of selenium and molybdenum; process improvements were largely in place by 2009. As a further consequence, the CNSC required enhanced biological monitoring focussed on selenium and molybdenum in the David Creek system as a condition of the Key Lake licence renewal. This activity is continuing and has the objective of determining whether a decrease in concentration of selenium and molybdenum in effluent will result in decreased concentrations in abiotic and biotic media in the David Creek watershed, as would be expected. The next report is due in 2015. The CNSC is carefully reviewing results and will require further controls on effluent if the receiving environment becomes further impaired or if recovery does not occur.

At other sites, it is CNSC staff's assessment that the concentrations of selenium and molybdenum in the receiving environment are not at levels that are causing unreasonable risk to the biological environment at this time.

A.4 McArthur River

Cameco Corporation operates the McArthur River Operation, the world's largest high-grade ore uranium mine. The current licence (UMOL-MINE-MCARTHUR.00/2023) expires on October 31, 2023. Facilities include an underground uranium mine, primary ore processing, ore slurry loading and transportation systems, waste management, a WTP, surface freeze plants, administration offices and warehouse buildings (figure A9).

Figure A9: Map of the McArthur River Operation



The mine started production in 2000 and has a licensed capacity of 21 million pounds U_3O_8; average ore grade is 15.8 %. The photograph below displays the main shaft, surface water run-off pond, administrative offices and warehouse (figure A10). The surface water from the run-off pond is treated in the WTP before being released to the environment.

Figure A10: Aerial view of the McArthur River Operation

High-grade uranium ore is mined, then ground and mixed with water in the ball mill to form a slurry that is pumped to surface. The ore slurry is loaded into approved containers and transported to the Key Lake Operation for further processing. Mineralized waste rock is also transported to Key Lake in covered haul trucks, where these materials are milled and blended with high-grade ore slurry to create the mill ore feed.