



**Written submission from
Orano Canada Inc.**

**Mémoire d'
Orano Canada Inc.**

In the Matter of the

À l'égard d'

Orano Canada Inc. – Cluff Lake Project

Orano Canada Inc. – Projet de Cluff Lake

Application for the renewal of the Uranium
Mine Decommissioning Licence for the
Cluff Lake Project

Demande de renouvellement du permis
de déclassement de la mine d'uranium de
Cluff Lake

Commission Public Hearing

Audience publique de la Commission

May 15, 2019

Le 15 mai 2019

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Orano Canada Inc.

Cluff Lake Project

CNSC Commission Member Document

Date Submitted: March 15, 2019

One Day Public Hearing Scheduled for May 15, 2019

Request for a Licensing Decision: Renew and Amend
Decommissioning Licence

UMDL-MINEMILL-CLUFF.01/2019

March 2019

Orano Canada Inc.



Executive Summary

The Cluff Lake Project commenced mining and milling operations in 1980 and over a 22-year operating life mined five ore bodies and produced 28 million kilograms of uranium concentrate (U₃O₈) and 8,000 troy ounces of gold. Following a comprehensive environmental assessment and licensing process, including extensive public engagement, regulatory approval for decommissioning was granted in 2004 with agreed end-state decommissioning objectives. Physical decommissioning works to achieve long-term decommissioning objectives were completed by 2006. Over the last Cluff Lake licence term, the remaining minor physical decommissioning works were completed and the achievement of decommissioning objectives was demonstrated.

Continuous site occupancy ended in 2013 accompanied by a program to decommission infrastructure that had remained in support of on-site monitoring and maintenance crews, and minor remedial works to prepare the site for open public access. In the summers of 2017 and 2018, final earthworks were conducted to ready the site for eventual transfer to the Province of Saskatchewan under the Institutional Control Program (ICP).

The Cluff Lake Project marks an important transition in uranium mining. At the beginning of the operations phase, Cluff Lake did not have the full benefit of decommissioning lessons learned in Canada as no previous uranium mine had been successfully decommissioned and standards for decommissioning were in their infancy. The Cluff Lake Project has benefitted from continuity of ownership throughout its entire life cycle, despite name changes from AMOK to COGEMA to AREVA to Orano. The Cluff Lake Project may be considered the first decommissioned uranium mine site of its era in Saskatchewan.

The Canadian Nuclear Safety Commission Comprehensive Study Report in 2003 described the effects of decommissioning as largely positive. Decommissioning involved the removal or stabilization of constructed structures and the reclamation of disturbed areas. Orano's key objective was to remove, minimize, or control potential contaminant sources and thereby minimize the potential for adverse environmental effects associated with the decommissioned property. Decommissioning was designed to minimize the need for care and maintenance activities and long-term institutional controls taking into consideration socio-economic factors. The objectives for decommissioning have been achieved.

Orano has requested that the Commission amend and renew the Cluff Lake Licence for a 5-year term. While retaining CNSC regulatory oversight, the requested amendments administratively prepare for transfer of the Cluff Lake site to the Provincial ICP. The requested amendments reduce the licenced activity, eliminate aspects no longer necessary, acknowledge completion of decommissioning activities, delineate the remaining area requiring future administrative controls, and adjust the required financial guarantee. Although Orano intends to progress quickly towards transferring the Cluff Lake property into the ICP, we acknowledge that additional time is needed for responsible parties to review and accept the long-term monitoring and maintenance plans and associated establishment of institutional control funds prior to transfer into the ICP.

Orano has a strong record of public engagement extending to the pre-mining period. Throughout the decommissioning and post-decommissioning periods, Orano has engaged with local stakeholders to understand their needs and is proud to have been able to achieve mutually beneficial outcomes with key land users. The sufficiency of the Tailings Management Area engineered cover is an important aspect of the successful decommissioning of the site and has been a topic of sustained interest of a community member. Consequently, Orano contracted a review of the studies and evaluations used to both select the Tailings Management Area cover design and assess the current and anticipated long-term performance of the facility. The review is provided as an appendix to this Commission Member Document.

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Acronyms and Abbreviations

Term	Definition
ACFN	Athabasca Chipewyan First Nation
AECB	Atomic Energy Control Board
ALARA	As Low As Reasonably Achievable
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COPCs	Constituents Of Potential Concern
CSD	Comprehensive Study For Decommissioning
CSR	Comprehensive Study Report (CNSC)
CWRP	Claude Waste Rock Pile
DDP	Detailed Decommissioning Plan
DJN	Dominique-Janine North
DJX	Dominique-Janine Extension
DP	Dominique-Peter
DPDP	Detailed Post-Decommissioning Plan
DSWQO	Decommissioning Surface Water Quality Objectives
EA	Environmental Assessment
EARPGO	Environmental Assessment Review Process Guidelines Order
EMLS	Environmental Monitoring Locations and Schedule
EMP	Environmental Monitoring Program
EQC	Environmental Quality Committees
FUP	Follow-Up Program
IC	Institutional Control
ICP	Institutional Control Program
IMS	Integrated Management Systems
LLRD	Long Lived Radioactive Dust
LTMP	Long Term Monitoring Plan
NAD	Northern Administrative District
NGO	Non-Governmental Organization
NSCA	Nuclear Safety And Control Act
NSEQC	Northern Saskatchewan Environmental Quality Committee
ORANO	Orano Canada Inc.
PIP	Public Information Document
RnP	Radon Progeny

Term	Definition
RPR	Radiation Protection Regulations
SCAs	Safety And Control Areas
SEQG	Saskatchewan Environmental Quality Guidelines
SMHI	Saskatchewan Ministry of Highways and Infrastructure
SMOE	Saskatchewan Ministry of Environment
SMOE	Saskatchewan Ministry of Environment
SSWQO	Saskatchewan Surface Water Quality Objective
STS	Secondary Treatment System
TMA	Tailings Management Area
TRU	Traditional Resource User
TSS	Total Suspended Solids

1 Introduction

1.1 Purpose

Orano Canada Inc. (Orano) holds Uranium Mine Decommissioning Licence (UMDL-MINEMILL-CLUFF.00/2019) expiring July 31, 2019 authorizing Orano to: decommission a nuclear facility; possess, manage, and store nuclear substances; possess and use prescribed equipment and prescribed information; and modify the facility as described in the Detailed Decommissioning Plan.

Over the licence term (August 1, 2009 to July 31, 2019), the remaining physical decommissioning works outlined in the Cluff Lake Detailed Decommissioning Plan (V3; AREVA 2014) were completed, the achievement of decommissioning objectives has been demonstrated through transition-phase monitoring, and the site has been readied for transfer to the Province of Saskatchewan under the provincial Institutional Control Program (ICP).

On September 17, 2018, in accordance with Section 24 of the *Nuclear Safety and Control Act* and Sections 5 and 6 of the *General Nuclear Safety and Control Regulations*, Orano applied to the Canadian Nuclear Safety Commission (CNSC) to renew and amend the Cluff Lake Project Uranium Mine Decommissioning Licence (UMDL-MINEMILL-CLUFF.00/2019). In the application, Orano requested the Commission to:

- renew the Cluff Lake Decommissioning Licence for a five year term;
- amend the Cluff Lake Decommissioning Licence to:
 - replace Appendix A – Location of Licensed Areas
 - replace the reference in Appendix B from the Detailed Decommissioning Plan with the Detailed Post-Decommissioning Plan,
 - remove Appendix C – Authorized Effluent Discharge Limits;
 - modernize the Cluff Lake Decommissioning Licence to reflect the Cluff Lake Project's post-closure status; and
- accept a revised financial guarantee.

The Commission acknowledged receipt of the application on November 22, 2018 and determined in accordance with CNSC Rules of Procedure that this application would be heard in a one-part public hearing process on May 15, 2019 in Ottawa, Ontario.

In accordance with Section 18(1)(b) of the CNSC Rules of Procedure, this Commission Member Document (CMD) provides documentary information as a written submission that Orano will present to the Commission at the public hearing. With a request to transition the Cluff Lake site status from *decommissioning* to *post-decommissioning*, content within this CMD provides an overview of decommissioning (1998 to 2019) with a focus on the current licence term from 2009 to 2019.

1.2 Decommissioned Cluff Lake Project Overview

The Cluff Lake Project is a former uranium mine and mill site located in the Athabasca Basin of northern Saskatchewan. The mine site is located approximately 900 km north of Saskatoon, SK, approximately 75 km south of Lake Athabasca, and approximately 264 km north of the community of La Loche, Saskatchewan (Figure 1.1). Orano Canada Inc. (Orano) owns the Cluff Lake Project.

The Cluff Lake Project commenced mining and milling operations in 1980. Over the 22-year operating life of the mine, five ore bodies were extracted using either underground or open pit techniques. The Cluff Lake Project produced 28 million kilograms of uranium concentrate (U₃O₈) and 8,000 troy ounces of gold over its operational period and produced its final barrel of yellowcake in December 2002. Operational facilities at the Cluff Lake Project included open pit and underground mines, a mill, a Tailings Management Area (TMA) with a two-stage liquid effluent treatment system, a residential camp area, and various other support and site infrastructure facilities.

The Cluff Lake Project is the first decommissioned uranium mine site of its era in Saskatchewan. With the end of successful operations in 2002, the decommissioning of the site underwent a decommissioning environmental assessment (Comprehensive Study for Decommissioning (CSD), (COGEMA 2000) and Comprehensive Study Report (CSR), (CNSC 2003). The decommissioning objectives, and timeframes for accomplishing them, were established in consultation with federal and provincial authorities and through the public engagement process.

After receiving federal and provincial environmental assessment, licensing, and permitting approvals, decommissioning of the Cluff Lake Project commenced in 2004. The majority of physical decommissioning was completed by 2006 including demolition and disposal of the mill complex buildings, covering the TMA and Claude Waste Rock Pile, moving the DJN waste rock to the Claude Pit, completion of backfilling the Claude Pit, flooding the contiguous DJN and DJX pits (referred to collectively as the DJX Pit post-decommissioning), grading, and revegetation. Underground mine raises and declines were closed at the cessation of underground mining. Minor physical undertakings were completed in 2013 to prepare for the end of an on-site presence, included the demolition of a small residential camp which included potable water and sewage treatment plants, two steel outbuildings, and the Secondary Treatment System. The Cluff Lake site has been in *post-decommissioning* monitoring since 2006. Full time on-site presence ended in 2013 with some accompanying earthworks. Most recently, in 2017 and 2018, the final physical works outlined in the Detailed Decommissioning Plan (DDP; AREVA 2014, V3) were completed and the site was readied for transfer back to the province through the ICP. Figure 1.2 shows locations of past mining and milling activities that have been decommissioned or remediated.

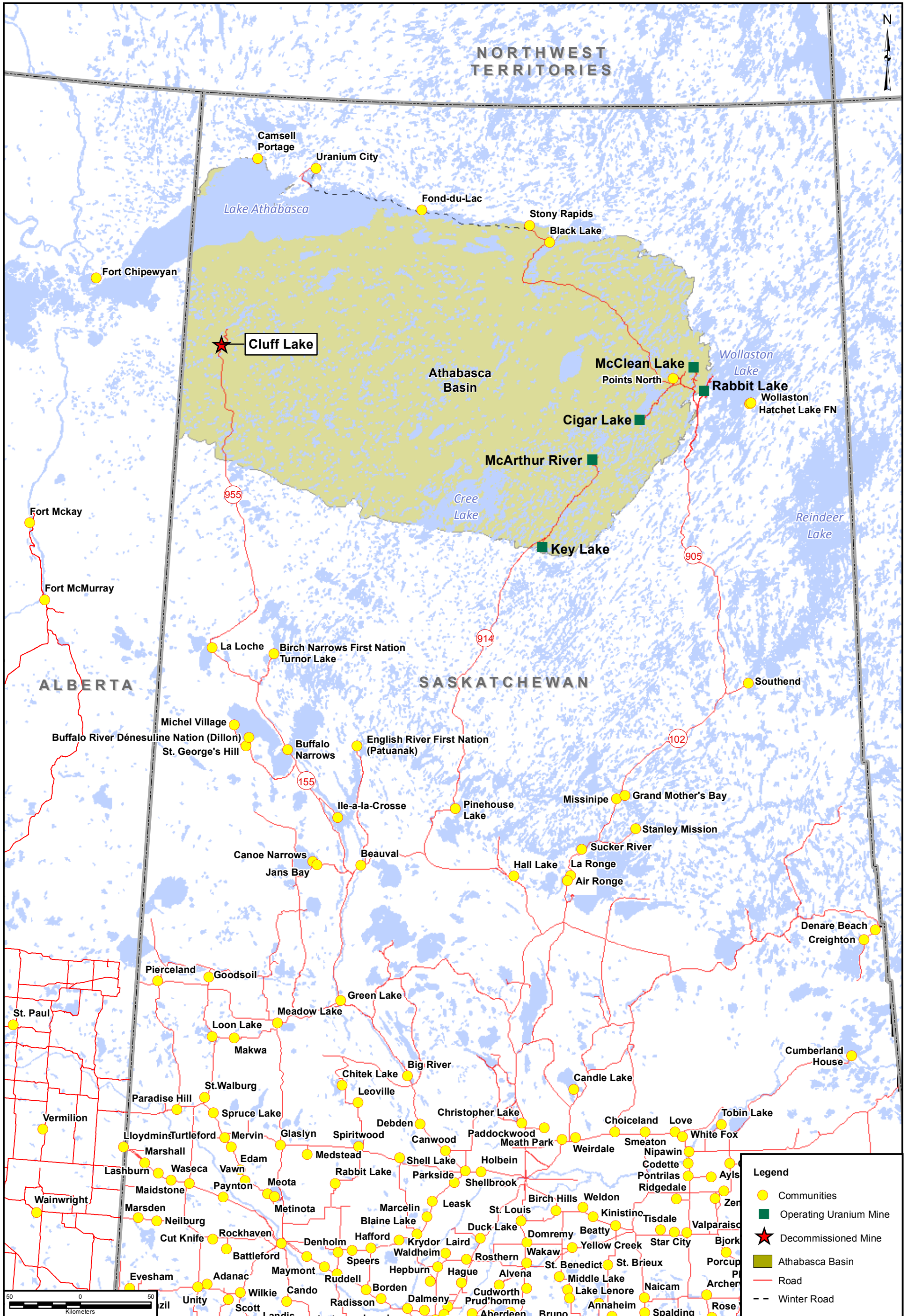
1.2.1 Decommissioning Milestones during Current Licence

Over the period of the current CNSC licence (UMDL-MINEMILL-CLUFF.00/2019 - valid from August 1, 2009 to July 31, 2019) the following the milestones have been achieved:

- 2009 - Revision of the Detailed Decommissioning Plan to reflect project progress

- 2011 - Optimization of the Environmental Monitoring Program;
- 2013 - Physical decommissioning of remaining surface infrastructure including camp and secondary water treatment plant, minor earthworks, discontinuation of continuous site occupancy;
- 2013 - site transitions to unrestricted access, given demonstrated site safety and stability;
- 2014 - Further revision of the Detailed Decommissioning Plan to reflect project progress;
- 2014 - Optimization of the Environmental Monitoring Program schedule to facilitate quarterly monitoring campaigns;
- 2015 - Closure of the Follow-up Program;
- 2015 - Submission of environmental risk assessment documents demonstrating current and long-term achievement of decommissioning objectives;
- 2015 - Re-classification of the entire provincial lease area to the category 'undeveloped';
- 2016 - Mid-term update to Commission;
- 2017 - CNSC conducts Independent Environmental Monitoring Program at Cluff Lake;
- 2017 - Optimization of the Environmental Monitoring Program and transition to annual campaign monitoring;
- 2017/2018 - final minor works under Detailed Decommissioning Plan completed; and
- 2019 - Detailed Decommissioning Plan replaced by the Detailed Post-Decommissioning Plan.

With decommissioning completed, it is expected that the Detailed Post-Decommissioning Plan (DPDP) and Environmental Monitoring Plan will evolve into the End-State Report and a Long-Term Monitoring and Maintenance Plan respectively for management of the Cluff Lake property by the Province of Saskatchewan under the ICP.



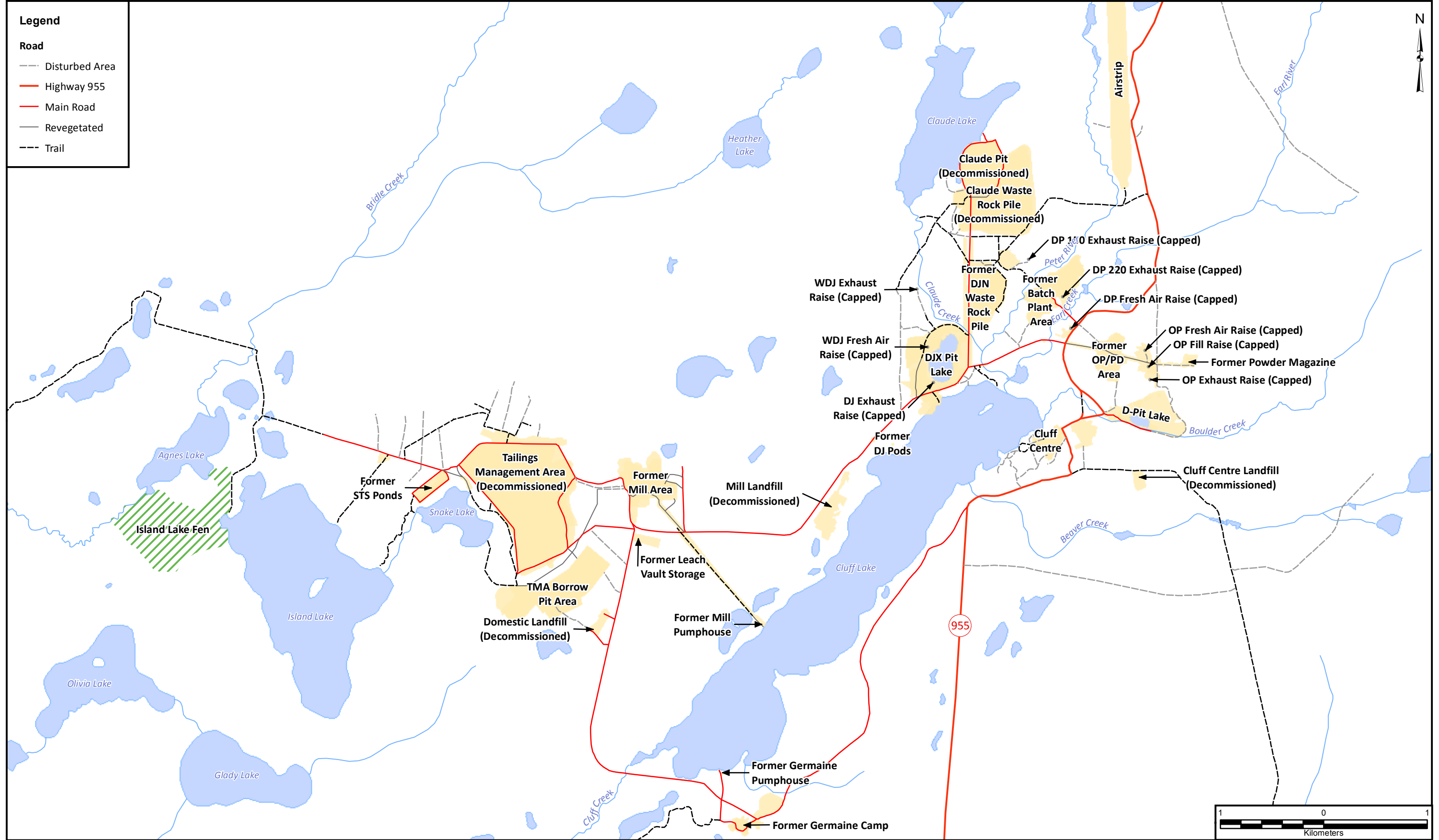
Projection: NAD 1983 UTM Zone 13N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/11/19 Scale: 1:2,500,000
 Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, ORANO Canada Inc.

FIGURE 1.1
 LOCATION OF CLUFF LAKE PROJECT

CLUFF LAKE PROJECT

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019





Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/08/19 Scale: 1:35,000
 Data Sources: Natural Resources Canada, Geobase® Nation
 Topographic Database, ORANO Canada Inc.

FIGURE 1.2
 GENERAL SITE LAYOUT

CLUFF LAKE PROJECT

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



1.3 Licence History

Following the delineation of D-Pit (the first ore body to be mined at Cluff Lake) and at the request of the Department of Environment Saskatchewan, an initial Environmental Assessment and Safety Report (AMOK 1976) for the development of a uranium mine and mill (Phase I) was submitted that met the requirements of the *Atomic Energy and Control Regulations* (1974). The Minister of Environment asked the Lieutenant-Governor-in-Council for a public inquiry to review the Environmental Assessment and Safety Report, and to “contemporaneously study what have been termed the “broader implications” and “global implications” of expanding the uranium mining industry in Saskatchewan” (Bayda 1978). The Cluff Lake Board of Inquiry, commonly referred to as the Bayda Commission, reviewed the expansion of uranium mining in northern Saskatchewan and recommended that development of the Cluff Lake Project proceed and that the uranium industry be allowed to expand in northern Saskatchewan (Bayda 1978). The Atomic Energy and Control Board (AECB) used the inquiry findings and recommendations to proceed through the AECB licensing process.

Throughout the mine life, additional reserves were discovered and delineated including Claude, N, N40, OP, and Dominique-Peter (DP) ore bodies (Cluff Mining 1982). These developments were assessed under the Saskatchewan Environmental Assessment Policy (1978) with AECB review. Mining of the Dominique-Janine (DJ) ore body subsequently underwent similar review (AMOK 1992).

The proposed extension of the DJ mining operation occurred at the same time as numerous other proposed uranium projects in northern Saskatchewan at Midwest, McArthur River, Cigar Lake, and McClean Lake. In response to these development proposals, the governments of Canada and Saskatchewan, under their respective legislation, appointed a Joint Federal-Provincial Environmental Assessment Review Panel (Joint Panel) to study uranium mine developments in northern Saskatchewan. The Joint Panel, based on its terms of reference to review the environmental, health, safety, and socio-economic impacts including the benefits of the proposals, recommended to the governments of Saskatchewan and Canada that these projects should be allowed to proceed (Joint Panel 1993 and 1997). The preliminary decommissioning plans arising from the DJ extension (DJX) environmental assessment and subsequent licensing requirements formed the basis of what would become the Detailed Decommissioning Plan for the Cluff Lake Project. The first Decommissioning Plan was submitted in June 1999 in fulfilment of a commitment under the Cluff Lake Project AECB Licence. Some aspects of decommissioning remained conceptual within the 1999 submission as investigations and environmental impact modelling were still on-going.

In parallel with the Joint Panel review from 1992 to 1997 under EARPGO, the federal government moved to strengthen the environmental assessment process in Canada, replacing the federal Environmental Assessment Review Process Guidelines Order (“EARPGO”) with the *Canadian Environmental Assessment Act* (CEAA 1992). The Atomic Energy Control Act and its regulations were replaced by the Nuclear Safety Control Act, when the former Act received royal assent in 1997. The AECB was replaced by the Canadian Nuclear Safety Commission in May 2000.

In April 1999, a project description for the Cluff Lake Decommissioning Project was submitted to regulators and in May 1999, the AECB/CNSC advised COGEMA that they had determined a comprehensive study level environmental assessment (EA) was required under CEAA, 1992, with the CNSC as the Responsible

Authority. Saskatchewan Ministry of Environment (SMOE) required approval of the Cluff Lake Detailed Decommissioning Plan prior to its implementation but did not require a decommissioning environmental assessment under the *Saskatchewan Environmental Assessment Act*. The Saskatchewan Ministry of Environment agreed to participate as technical reviewers in the federally-led EA process.

The Cluff Lake Project Comprehensive Study for Decommissioning (CSD, COGEMA 2000) was prepared to meet the requirements of the Canadian Environmental Assessment Act (CEAA 1992). The CSD was submitted to regulatory agencies, including the CNSC, Environment Canada, Health Canada, Natural Resources Canada, SMOE, and Saskatchewan Labour in 2000. The CSD and subsequent regulatory comments and company responses provided much of the basis of the CNSC-authored Comprehensive Study Report (CSR; CNSC 2003) that was submitted to the federal Minister of Environment and Canadian Environmental Assessment Agency in January 2004. The Minister of Environment approved the decommissioning environmental assessment on April 15, 2004. The CNSC held a hearing with Day 1 in Ottawa on April 29, 2004 followed by Day 2 on June 9, 2004 in La Ronge, Saskatchewan and subsequently issued the Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.00/2009, effective July 23, 2004 and expiring July 31, 2009, revoking the Uranium Mine and Mill Operating Licence UMLOL-MINEMILLCLUFF.05/2004. The Cluff Lake Decommissioning Licence was renewed in 2009 with a one-day public hearing for a 10-year term effective August 1, 2009 to July 31, 2019. A midterm report, as requested by the Commission with the Record of Decision, was provided in conjunction with the annual Regulatory Oversight Report for Uranium Mines and Mills in December 2016.

1.3.1 Summary of Commission Decisions

Related specifically to the decommissioning phase, the Commission has approved the following:

- July 20, 2004, issued Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.00/2009, effective July 23, 2004 and expiring July 31, 2009 (public hearing date in Ottawa April 29, 2004 and in La Ronge June 9, 2004)
 - DDP V01; COGEMA 2003 and associated financial assurance estimate
- May 19, 2006, re-issued Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.01/2009 to reflect name change from COGEMA Resources Inc. to AREVA Resources Canada Inc.
- June 10, 2009, renewed Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.00/2019, effective August 1, 2009 and expiring July 31, 2019 (public hearing in Ottawa June 10, 2009)
 - DDP V02; AREVA 2009a and associated financial assurance estimate
- August 1, 2018, re-issued Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.01/2019 to reflect name change from AREVA Resources Canada Inc. to Orano Canada Inc. and amend the financial guarantee value.
 - DDP V03; AREVA 2014 and associated financial assurance estimate

1.4 Socioeconomics, Community, Land Use

Over its operating life, the Cluff Lake Project was the largest industrial employer on the west side of northern Saskatchewan providing a stable base of employment for over 20 years, generating about 4,000 person years of staff employment. Employees averaged around 200 at any given time and, with on-site contractors, indirect, and induced employment this number is estimated to have been as high as 958 individuals employed in 1996. Approximately 52% of company staff were northern residents and approximately 80% of northerners were from the west side of the province. The training and experience gained by individuals throughout the project life provided transferable skills for subsequent employment.

In 1999, as part of decommissioning planning, Orano designed a decommissioning-specific Public Involvement Plan (PIP) with the following objectives:

- to engage early with the public,
- to provide useful information to the public, and
- to provide a means for the public to voice their concerns and views.

This early decommissioning-specific PIP consisted of three major stages. Prior to conducting the CSD, two of the three stages of public involvement had been completed (pre-June 1999). During the initial two stages of public involvement, information was provided to the public regarding the rationale, schedule, and methods for decommissioning and plans for monitoring in the longer term. These public discussions assisted in refining the scope and methods for ongoing public involvement and clarified issues associated with decommissioning. The first stage involved a tour and workshop with the west side sub-group of the Environmental Quality Committee (EQC). The second stage included a series of meetings in west side communities to discuss the decommissioning plan with local residents. The third stage of the plan occurred following the submission of the DDP, to communicate key aspects of the plan to interested stakeholders and inform them about how their concerns had been dispositioned.

Over the current licence term, engagement focused on environmental monitoring data; site safety, stability, and land use; and future plans. From 2009 to 2013 Orano continued with an on-site staff managing site access, environmental monitoring, and minor remediation works. This on-site staff ranged from 63% to 81% of the small workforce of employees and contractors (<35) being from Saskatchewan's north. 2014 was the first full year with unrestricted access to the Cluff Lake site and communication at this time focused on the transition to campaign monitoring and emphasizing that travel on-site should be taken with similar precautions to other remote wilderness travel. In addition to letters, meetings, phone calls, and site tours with individual stakeholders and groups over the licence term, Orano hosted open house community meetings in west side Saskatchewan communities in October 2012, June 2013, October 2015, and November 2018.

The Cluff Lake Project is considered to be one of the first modern uranium mines decommissioned in Canada. As such, planning for decommissioning took place before operations ceased and the closure end-state was intentioned to demonstrate that, properly managed, mining and milling can be a temporary use of

the land. At the height of operations, the provincial surface lease for the site was approximately 4,139 hectares (or ~40 km²), with about 634 hectares (or ~6 km²) considered to be developed. Public access to these developed areas was controlled for safety reasons but traditional activities were undertaken in areas that did not pose safety concerns. For example, an Indigenous trapper and his family, who maintained a commercial trap line in the local area, seasonally accessed the site. The trapper also hunted and fished for personal consumption. Throughout the Cluff Lake Project history, this same trapper continued to trap within the Cluff Lake area. The trapper's family maintains cabins at both Cluff and Sandy lakes. With the decommissioning, reclamation, and remediation largely completed in 2013, remaining primary gates and barriers to the site were removed and members of the public have been able to freely cross the former mine site as it is safe for casual traditional land use by a visitor.

The primary historic and current land users of the area are the local cabin owners mentioned above, a lodge owner/outfitter established on the shore of Carswell Lake (about 20 km north of Cluff Lake), and members of the N22 trapping block of northern Saskatchewan within which Cluff Lake is located. The N22 trapping block of northern Saskatchewan has five members, three of whom own the cabins mentioned above. It is also Orano's understanding that former Orano employees have and may continue to visit the site to harvest in areas that have become familiar to them through their time employed at Cluff Lake or simply to visit the site.

1.5 Licence Documentation

1.5.1 Licensee

Orano Canada Inc., with headquarters in Saskatoon, is the sole owner and operator of the Cluff Lake Project. Orano Canada Inc. is a wholly owned subsidiary of Orano Group, a world leader in nuclear energy and components.

The business address is:

Orano Canada Inc.
817 - 45th Street West
Saskatoon, SK S7L 5X2

1.5.2 Current Licence and Approval

The Cluff Lake Project operates under an approval issued by the SMOE and a decommissioning licence issued by the CNSC, currently:

- Approval to Operate Pollutant Control Facilities; PO18-025 (February 28, 2018 – February 28, 2023)
- UMDL-MINEMILL-CLUFF.01/2019 (August 1, 2019 – July 31, 2019), issued under Section 24 of the *Nuclear Safety and Control Act*

2 Licence Renewal and Amendment Application

On September 17, 2019, Orano applied to the CNSC to renew and amend the Cluff Lake Project Uranium Mine Decommissioning Licence UMDL-MINEMILL-CLUFF.01/2019 that will expire on July 31, 2019.

2.1 Licence Renewal for Five-Year Term

In 2007, the Province of Saskatchewan enacted the *Reclaimed Industrial Sites Act* and the *Reclaimed Industrial Sites Regulations* to establish an ICP. The ICP legislation allows for the transfer of responsibility for a decommissioned site, or portions of the site, to the Province of Saskatchewan and details the funding requirements to be provided by the owner/operator to the Province, to maintain a long-term monitoring and maintenance program, and to provide contingency funds for unforeseen events. The ICP was developed to ensure the health, safety, and wellbeing of future generations, to provide greater certainty and closure for the mining industry broadly, and, specific to uranium mining, meet provincial, national, and international obligations for the storage of radioactive materials.

Within the proposed five-year licence term, Orano intends to apply to transfer responsibility of the Cluff Lake property to the Province of Saskatchewan under the ICP. The renewal of the Cluff Lake Decommissioning Licence for a 5-year term provides Orano and provincial and federal regulators time to develop, review, and approve a long-term monitoring and maintenance plan and establish funds required under ICP. Transfer of the Cluff Lake Project to ICP will be the subject of a future application to the Commission.

Orano's performance over the current licensing period is provided in Section 3 demonstrating that Orano remains a qualified operator. A summary of Orano's engagement efforts and results over the current licensing period is provided in Section 4.

2.2 Licence Amendment – Modernize

2.2.1 Licensed Activities

Orano requests an update to the Licence to describe the ongoing activities at the decommissioned Cluff Lake site. Decommissioning Licence UMDL-MINEMILL-CLUFF.01/2019 authorizes the following licensed activities: decommission a nuclear facility; possess, manage, and store nuclear substances; possess and use prescribed equipment and prescribed information; and modify the facility as described in the DDP.

Over the past licence term, physical works outlined in the Cluff Lake DDP were completed, the achievement of decommissioning objectives was demonstrated through transition-phase monitoring, and the site was readied for transfer to the Province of Saskatchewan under the provincial ICP. The proposed licensed activities are to: possess, manage, store nuclear substances while maintaining the facility as described in the DPDP.

Similar to a transition in mine life phase from *operations* to *decommissioning*, Orano is requesting an amendment to the Licence to recognize a transition from *decommissioning* to *post-decommissioning*. Completion of decommissioning works recognizes the completion of decommissioning design; maintenance activities are expected and planned to occur during the post-decommissioning phase as described in the document *Detailed Post-Decommissioning Plan, Version 4, Revision 1* to be referenced by the CNSC Licence or Licence Conditions Handbook.

2.2.2 Operational and Active Decommissioning Sections

The current licence references activities that are relevant for an operating or active decommissioning site and are therefore no longer relevant for the Cluff Lake site in the post-decommissioning phase. Orano requests the Licence be updated to reflect the current site status.

2.3 Licence Amendment - Authorized Effluent Discharge Limits

Given the absence of effluent treatment and the absence of the need for contingency water storage, Orano requests the removal of 'Authorized Effluent Discharge Limits' from the amended licence. The Cluff Lake Project is a Recognized Closed Mine under the *Metal Mining Effluent Regulations* as of January 16, 2006.

The secondary effluent treatment system had been maintained as a contingency for treating tailings pore water resulting from tailings consolidation. The system was demolished and disposed of in 2013 after further use was deemed unnecessary. The associated B2 pond was preserved as contingency in the event that water storage or treatment was required. In the event that water treatment capability had been required the pond could have been lined, portable treatment facilities or an in-pond treatment could have been used, and the monitoring requirements for water quality outlined in Appendix C of the Licence would have been undertaken and achieved. Without a need to maintain a contingency water storage location, the B2 was decommissioned in 2018.

2.4 Licence Amendment – Detailed Post-Decommissioning Plan

Orano requests that the Detailed Post-Decommissioning Plan (DPDP) Version 4, Revision 1, replace the DDP in support of the Licence. The DDP has contained the overall work plans, schedule, and costs for decommissioning and it has been regularly updated to reflect decommissioning progress and associated changes in financial assurance values, with updates in May 2004 (V01), February 2009 (V02), and December 2014 (V03).

With the achievement of decommissioning objectives demonstrated, the title for Version 04 has been changed to Detailed Post-Decommissioning Plan (V04) and the content has shifted to describe post-decommissioning monitoring and administrative work until the site is returned to the Province of Saskatchewan. Costs associated with remaining monitoring, administration, and transfer to the Provincial ICP are estimated and proposed as the appropriate financial guarantee (see Section 2.6).

DPDP Version 4 was provided to CNSC staff and the Saskatchewan Ministry of the Environment in December 2018 outlining completion of works and achievement of decommissioning objectives. CNSC staff provided comments to Orano on January 30, 2019 and Saskatchewan Ministry of Environment provided comments on February 14, 2019. Revisions to address comments received from both agencies have been incorporated in DPDP Version 04 Revision 01.

2.4.1 Decommissioning Works Completed in Licence Term

The physical decommissioning of mine and mill facilities was completed by 2006. Certain infrastructure remained from 2006 until 2013 in order to support the post-closure monitoring phase and to control site access during the initial monitoring period. Two minor earthworks programs took place during the current licence period in 2013 and 2017/18, thereby completing all decommissioning design works.

2.4.1.1 2013 Works Summary

The 2013 earthworks program took place from April 11 to September 7, 2013. The program marked the end of an on-site presence and transition to campaign monitoring. Infrastructure which supported the on-site presence, such as the camp accommodations and shop buildings, were demolished and disposed of and, with no further need to maintain water treatment contingency measures, the secondary water treatment plant was similarly decommissioned. Completed works are summarized below.

At the TMA decommissioning works included the removal of culverts within roads crossing the north and south diversion ditches used to access the TMA borrow pits and Secondary Treatment System (STS). The STS building was decommissioned with isolation of electrical, pneumatic, mechanical, and fuel sources; removal and disposal of reagents (off-site); demolition and disposal in former B1 pond; perforation of concrete floor with hydraulic hammer; placement of 1 meter thick glacial till over STS foundation; re-vegetation of disturbed area and the remaining settling pond was decommissioned with the folding and perforation of the pond liner; placement of 1 m of glacial till; and seeding the disturbed area. A few maintenance activities also took place including placement of glacial till in low lying areas of the TMA cover (primarily in the former liquids pond and lower solids areas) and re-grading the TMA north diversion ditch and fresh water diversion dam to improve overall surface water management.

At the Claude pit decommissioning works included the demolition and disposal of a small steel building. Maintenance and optimization works at the Claude pit included the installation of three horizontal drains through former ring-dyke road to lower the local water table and minimize the occurrence and duration of surface ponding on the Claude pit cover.

With the end of an on-site presence, the Germaine Camp was demolished. There was demolition and disposal of five residences, the kitchen, recreational hall, water treatment and sewage plants, office trailers, and ancillary structures (e.g. generator, storage). Following demolition there was minor re-grading for aesthetics.

With a reduced need to facilitate access across the site, numerous culvert crossings were decommissioned. Excavation, culvert removal, streambed and streambank rehabilitation, and sediment control took place at the following crossing locations: Boulder Creek (downstream), Earl Creek (airport), Earl Creel (batch plant), Earl Creek (main road), Peter River (main road), Claude Creek, Lost knife Creek.

Other miscellaneous decommissioning works included the demolition of the warehouse including breaking the concrete floors and covering the area with glacial till; fuel storage containers were emptied, flattened, disposed of in a landfill, and subsoils were excavated and transported to the hydrocarbon landfarm (confirmation testing completed); and demolition of the main communication tower at mill, airport beacon tower, and former communication tower near south gate.

2.4.1.2 2017/18 Works Summary

The earthworks program in 2017 and 2018 was undertaken to complete outstanding physical decommissioning works detailed in planning envelopes within the DDP, improve site aesthetics, and capitalize on opportunities for targeted optimizations and improvement with heavy equipment to site. Dates of the program were from September 4-16, 2017 and August 23 to October 5, 2018. Completed works are summarized below.

With mine and mill facilities decommissioned by 2006 and accommodation and ancillary facilities decommissioned in 2013, the 2017/18 program was minor and contained the remaining four decommissioning items: TMA cobble dam removal, removal of culverts at two remaining on-site locations, removal of a small building and runway lights at the abandoned airstrip, and decommissioning of groundwater monitoring wells.

During previous decommissioning and remedial works in 2006, a spillway was constructed at the north end of the TMA to manage runoff from the TMA. A temporary cobble dam was constructed within the spillway alignment to reduce solids from entering Snake Lake until vegetation on the TMA cover had been adequately established. Total suspended solids (TSS) were successfully reduced. The cobble dam, having served its purpose and no longer required, was removed in 2017.

Two culvert crossings, that were left in place in 2013 to facilitate on-site travel for campaign monitoring, were removed in 2018. Consistent with the approved approach used in 2013, the crossings were excavated, culverts removed, and streams rehabilitated.

Minor works were completed at the airstrip with a small building and runway lights demolished and disposed in a landfill.

Groundwater monitoring wells that were previously removed from monitoring programs and that are no longer required were decommissioned by grouting the well and removing the casing belowground so that water cannot flow and there is no surface safety hazard.

Additionally, maintenance of the domestic landfill required localized settling repair. General tidying across the site took place, e.g. demolition of a temporary campaign monitoring camp.

2.4.2 Status of Decommissioning Planning Envelopes

For the purpose of decommissioning planning, the Cluff Lake site was divided into key areas described as “planning envelopes”. Table 2.1 provides the status of each of these planning envelopes starting at the 2009 Licence renewal (AREVA 2009b; CNSC 2009) and tracking progress following the two subsequent earthworks campaigns in 2013 and 2017/18.

Given that primary decommissioning works have been presented and contemplated by the Commission during the 2009 licence renewal, the discussion within this section will focus on parcels with decommissioning completed between 2009 and 2019.

Table 2.1: Status of Cluff Lake Decommissioning Planning Envelopes

Planning Envelope	Parcel	Site Status at 2009 Licence Renewal (AREVA 2009b, CNSC 2009)	Remaining Works Listed in the 2014 DDP following 2013 Earthworks	2019 Site Status (DPDP) following 2017/18 Earthworks
D-Mining Area	D-Pit	Decommissioning complete	Decommissioning complete	Decommissioning complete
	D-Waste Rock Pile	Decommissioning complete	Decommissioning complete	Decommissioning complete
Claude Mining Area	Claude Pit	Decommissioning design complete; maintenance as required (e.g. potential erosion control) until a stable, self-sustaining cover established	Vegetation cover established Claude Pit Horizontal drains installed in 2013. Results of monitoring and inspections will determine if any further mitigation will be required for the Claude Pit	Cluff Lake Project – Claude Pit Horizontal Drain Closure Study concludes no further works required Decommissioning complete
	Claude Waste Rock Pile	Decommissioning design complete; maintenance as required (e.g. potential erosion control) until a stable, self-sustaining cover established	Vegetation cover established Decommissioning complete	Decommissioning complete
DJ Mining Area	DJN/DJX Pit	Decommissioning design complete; pumping from Cluff Lake to expedite flooding of the DJX pit completed in January 2006 and water levels then allowed to equilibrate naturally	The water level in DJX pit gradually increases from 2006 to 2014 and then stabilize, as predicted, at about 320 mASL Decommissioning complete	Decommissioning complete
	DJN Waste Rock Pile	Decommissioning complete	Decommissioning complete	Decommissioning complete
	DJ Underground	Decommissioning complete	Decommissioning complete	Decommissioning complete
	DJX Overburden Pile	Decommissioning complete	Decommissioning complete	Decommissioning complete
OP/DP Mining Area	OP/DP Underground	Decommissioning complete	Decommissioning complete	Decommissioning complete
Mill Complex Area	Mill Complex Area	Decommissioning design complete; maintenance as required (e.g. potential erosion control, surface grading)	Decommissioning complete	Decommissioning complete

Table 2.1: Status of Cluff Lake Decommissioning Planning Envelopes (cont'd)

Planning Envelope	Parcel	Site Status at 2009 Licence Renewal (AREVA 2009b, CNSC 2009)	Remaining Works Listed in the 2014 DDP following 2013 Earthworks	2019 Site Status (DPDP) following 2017/18 Earthworks
Tailings Management Area	Cover and Main Dam	Decommissioning design complete; maintenance as required (e.g. potential erosion control, surface grading)	Decommissioning design complete; minor maintenance works conducted in 2013 including filling settled areas (i.e. surface grading)	TMA Water Management Study and a Risk Assessment of the Presence of Poned Water on the Decommissioned Tailings Management Area conclude cover and main dam performing as designed Decommissioning is complete
	Storm Water Management	Decommissioning design largely complete; temporary cobble dam placed at entrance of TMA outlet channel to reduce TSS while vegetation across cover establishes	Vegetation cover established; temporary cobble dam remained in place	Vegetation cover remains established and temporary cobble dam removed in 2017. Decommissioning complete
	Buildings and Surface Infrastructure	The Secondary Treatment System (STS) along with settling ponds remained in the TMA area. The STS was a radium removal plant and was retained as a contingency measure should the need have arisen to treat radium contaminated water.	STS demolished and area decommissioned in 2013 Decommissioning complete	Decommissioning complete
Ancillary Buildings and Services	Germaine Camp	A portion of the camp remained and supported on-site staff for Cluff Lake decommissioning and also exploration staff working at the Shea Creek site. Request and Commission acceptance (S53) to remove Germaine camp from area of CNSC licensed activities.	Remaining Germaine camp demolished and area decommissioned in 2013 Decommissioning complete	Decommissioning complete
	Cluff Center	Decommissioning complete	Decommissioning complete	Decommissioning complete
	Southgate Entrance	Security building and gate as the primary location for controlling site access	Security building and gate was removed in 2013 after the site was determined to be safe for access by the general public Decommissioning complete	Decommissioning complete
	Airstrip	Continued use with an above ground aviation fuel storage tank and two small buildings	Fuel tank and buildings decommissioned in 2013 Final fate of the runway to be determined through discussions with federal and provincial agencies	Decision to abandon airstrip; runway light infrastructure removed in 2018 Decommissioning is complete
	Site Roads	On-site roads continued to be used by on-site staff	Majority of culvert crossings removed in 2013; two on-site culvert crossings remained to facilitate campaign monitoring	Remaining on-site culvert crossings removed and on-site roads considered sufficiently decommissioned Decommissioning is complete
	Highway 955	The Saskatchewan Ministry of Highways and Infrastructure (SMHI) may choose to maintain, abandon or decommission the highway. Orano to decommission the portion of the highway within the surface lease agreement or transfer responsibility	The SMHI may choose to maintain, abandon or decommission the highway. Orano to decommission the portion of the highway within the surface lease agreement or transfer responsibility	Responsibility of three crossing locations on the portion of road between the end of highway 955 and the airstrip will be transferred to the Province or local lodge owner (permit pending) Decommissioning is complete

Claude Pit:

Three horizontal drains were installed in 2013 to reduce the frequency, duration, and extent of groundwater expression to surface on the Claude Pit cover. Five years of monitoring and two targeted field studies in the fall of 2017 and the spring of 2018 support that the 2013 performance optimization was achieved: I) localized groundwater levels at the edge of the former Claude Pit have been lowered by about 0.5 m and II) the incremental contaminant loading is limited and bounded by the flow through the drains. No further mitigation is required.

Decommissioning is complete.

TMA Cover and Main Dam:

The TMA engineered cover was designed to minimize surface ponding but not necessarily eliminate the presence of ephemeral ponding. Ephemeral ponding, a few centimeters in depth, are observed primarily on the former liquids pond where the thickest amount of glacial till was placed during decommissioning (1 to 5 m) and adjacent to the internal TMA berm at the boundary of the lower solids areas where about 2 m of till was placed. The presence of ponded water does not undermine design. Positive drainage is maintained across the TMA towards the spillway contributing to the overall capacity to route higher precipitation events, including a probable maximum flood.

A risk assessment of TMA ponded water was completed to evaluate potential impacts and to alleviate community concern. Ponded water, sediment, and vegetation samples were collected on the TMA over the years 2010 to 2016 and the associated ecological risk was evaluated using a consistent approach and assumptions as presented the Cluff Lake ecological risk assessment. From an ecological perspective, should ephemeral ponding on the TMA exist, I) no adverse effects are expected for terrestrial wildlife or species-at-risk that may use the TMA and II) other than a small potential for nickel concentrations to be an issue for individual toads, no adverse effects are expected from an aquatic perspective.

Decommissioning is complete.

Airstrip: The airstrip was closed in 2013 and is listed as abandoned on air navigation charts and in the Canada Flight Supplement. The airstrip will be left in its current condition and will remain listed as abandoned. Abandoned airstrips serve as important, potential landing strips for aircraft and the west side of Saskatchewan has limited alternate landing locations.

The Cluff Lake airstrip is well positioned as an emergency landing strip - the closest active aerodrome is Fort Chipewyan, 100 km to the northwest. There is another abandoned aerodrome, Keane Tower, about 45 km west of Cluff Lake and located in Alberta. The closest active aerodromes in Saskatchewan are the private strip with no winter maintenance at Axe Lake, 126 km to the south and Camsel Portage and Uranium City at 137 and 139 km to the north. There are other examples of abandoned airstrips in Saskatchewan and across Canada located on active mineral claims including Hidden Bay and Otter Lake abandoned airstrips.

Decommissioning is complete.

Site Roads: The culvert crossings at Cluff Creek and Unnamed Creek at Germaine Camp, were removed in the fall of 2018. On-site roads are determined to be sufficiently decommissioned and obligations under the 2014 DDP are closed.

The Cluff Lake site has about 28 km of onsite roads and an additional 22 km of trails. Traffic on roadways at Cluff Lake reduced considerably in 2002 at the end of operations, again in 2006 following the end of the main decommissioning, and reduced further when continuous on-site presence ended in 2013. Current traffic on Cluff Lake roads includes a small crew of about four workers travelling the site for approximately two week monitoring campaigns, mineral exploration activities, and travel by traditional land users - mainly by members of the Flett family to visit their cabins on Cluff and Sandy lakes.

The roadways at the Cluff Lake site are in various stages of natural revegetation that began when grading and regular use of the roads stopped. Berms have been placed before stream crossings to slow potential traffic. Over time, access roads and trails used for mining activity are fading into the wilderness.

Decommissioning is complete.

Highway 955: Prior to mining at the Cluff Lake Project, highway 955 transitioned into an ice road servicing Uranium City. Over time with the increased traffic due to mining activities, the route overlapping the Cluff Lake surface lease was upgraded including installation of culverts. Highway 955 largely bypasses the decommissioned mine site and provides continued public access north to Carswell Lake where there is an established business. Culverts are located at the Beaver, Boulder, and Earl Creek crossings on the portion of Highway 955 overlapping with the current Cluff Lake Project provincial surface lease.

Given:

- I. the known and documented public use of this route prior to, during, and post mining operations,
- II. the demonstrated public interest in maintaining the road,
- III. stated concerns from the Carswell Lake business owner that culvert crossings are required for reliable truck and trailer access to the business,
- IV. with the understanding that removal of the Beaver and Boulder Creek crossings would materially affect public access north to Carswell Lake and also to established Traditional Resource User (TRU) parcels (including cabins) on Cluff and Sandy lakes,
- V. the high potential for improper installation of culverts in the future where adequate culverts are currently in place, and
- VI. interest in decommissioning that minimizes adverse effects and considers benefits;

Orano will maintain responsibility for the three culvert crossings until they are successfully transferred to the Ministry of Highways (public) or potentially to the TRU holders and/or Carswell Lake business owner

(private). Should the culverts be successfully transferred to a private owner, the infrastructure will be permitted under a provincial Miscellaneous Use Permit.

The Cluff Lake site can remain recognized as decommissioned with a provincially or privately maintained road bypassing the site. Decommissioning is considered complete.

2.4.3 Uncertainties Resolved by Follow-up Program

One of the key outcomes of the CSR was the Follow-up Program (FUP). The FUP detailed in the CSR identified key uncertainties inherent in environmental assessment that required additional monitoring or study to provide improved confidence that the decommissioning objectives will be sustainably achieved.

A progress report on the identified FUP items was submitted by AREVA in 2009. At the time of the Licence renewal in 2009, the FUP was well advanced with some studies completed. In 2015, within the last Licence term, the final FUP report was submitted to regulators and the knowledge gained was integrated into the Cluff Lake ecological risk assessment that predicts long-term environmental performance. The outcomes of the FUP are summarized as Appendix B.

2.4.4 Decommissioning Objectives

As described in the CSR, the effects of decommissioning are largely positive. Decommissioning involves the removal or stabilization of constructed structures and the reclamation of disturbed areas. Orano's key objective was to remove, minimize, or control potential contaminant sources and thereby minimize the potential for adverse environmental effects associated with the decommissioned property. Decommissioning was designed to minimize the need for care and maintenance activities and long-term institutional controls (i.e. prioritize passive care) taking into consideration socio-economic factors.

To evaluate the success of the decommissioning program for the Cluff Lake Project, site-specific objectives were established which, when achieved, indicate the site has been successfully decommissioned. The decommissioning objectives, and associated locations and time-frames for accomplishing the objectives, were established in consultation with federal and provincial authorities and with public engagement through the CSR process.

The Cluff Lake decommissioning objectives are to:

- achieve Decommissioning Surface Water Quality Objectives (DSWQO) and other accepted decommissioning objectives at surface water and flooded pit locations;
- achieve levels of gamma, radon, and long-lived radioactive dust which pose no unacceptable risk to traditional land use, and which are consistent with application of the As Low As Reasonably Achievable social and economic factors considered (ALARA) principle;
- establish a stable, self-sustaining landscape;

- reduce infiltration rates around the TMA and the Claude waste rock pile to levels that adequately restrict contaminant movement in groundwater and are suitably protective of downstream surface water receptors; and
- return the site to an aesthetically acceptable state, similar in appearance and land capability as that which existed prior to mining activities, and that poses no unreasonable risk to humans or the environment.

The decommissioning objectives must be achieved currently and also in the future. Monitoring data is used to evaluate the achievement of objectives in the short-term and numerical modelling is used to predict future, sustained achievement of the objectives.

2.4.4.1 Achievement of Decommissioning Objectives

The decommissioning objectives, agreed to during the CSR, are to be achieved currently and also in the future. Monitoring data is used to evaluate the achievement of objectives in the short-term and numerical modelling is used to predict future, sustained achievement of the objectives. The completion of FUP and revised numerical modelling has improved confidence that the decommissioning objectives will be sustainably achieved in the future.

Surface Water Quality

Objective: Achieve Decommissioning Surface Water Quality Objectives (DSWQO) and other accepted decommissioning objectives at surface water and flooded pit locations.

DSWQO were based on the 1997 Saskatchewan Surface Water Quality Objectives (SSWQO) and site-specific surface water quality objectives developed by Orano in the absence of provincial surface water quality objectives (i.e. uranium, molybdenum, and cobalt) or specific natural conditions prevailing in the area (i.e. iron). These decommissioning objectives were described in the CSR.

Locations chosen to meet the DSWQOs for key surface waterbodies were identified by consideration of the locations and the distances of potential constituents of potential concern (COPC) sources in relation to potentially impacted natural surface waterbodies, and in consultation with federal and provincial authorities. As presented in the CSR, selected locations and DSWQOs are listed in Table 2.2.

Table 2.2: Summary of Post-Decommissioning Surface Water Quality Objectives

Parameter	Unit	Snake Lake	Island Lake	Claude Lake	Claude Creek	Peter River	Earl Creek	Cluff Lake	Flooded Pits ⁽¹⁾
As	µg/L	50	50	50	50	50	50	50	50
Ba	mg/L	1	1	1	1	1	1	1	1
Cd	µg/L	1	1	1	1	1	1	1	1
Cr	µg/L	20	20	20	20	20	20	20	20
Cu	µg/L	10	10	10	10	10	10	10	10
Fe ⁽²⁾	mg/L	3.2	1	7.3	7.3	1	5.2	1	7.3
Pb	µg/L	20	20	20	20	20	20	20	20
Hg	µg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ni ⁽³⁾	µg/L	-	-	-	-	-	-	-	-
Se	µg/L	10	10	10	10	10	10	10	10
Ag	µg/L	10	10	10	10	10	10	10	10
Zn	µg/L	50	50	50	50	50	50	50	50
Ra ²²⁶	Bq/L	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
U ⁽⁴⁾	mg/L	-	-	-	-	-	-	-	-
Mo ⁽²⁾	µg/L	73	500	73	73	73	73	73	500
Co ⁽⁵⁾	µg/L	20	20	20	20	20	20	20	20

(1) Flooded Pits – Objectives apply to upper 50% of the water column only

(2) Fe and Mo are waterbody specific objectives

(3) Nickel values are hardness related; values range from 25 µg/L when [Hardness] <100 mg/L and 100 µg/L when [Hardness] >100 mg/L at the site in question

(4) Uranium DSWQO was calculated as 0.002 [Hardness in mg/L] at the site in question. The current CCME surface water quality guideline for uranium is 0.015 mg/L. The CCME guideline is used as a screening tool for the environmental risk assessment.

(5) Cobalt objective was set as a site specific decommissioning objective

Status: Achieving DSWQO currently and predicted to continue to achieve DSWQO in the long-term. For key COPC, Figures 2.1 and 2.2 present achievement of DSWQO and also comparison to Saskatchewan Environmental Quality Guidelines (SEQG) published by the Government of Saskatchewan (current to 2019). For the six key COPCs presented, the SEQG is the same value or smaller than the SSWQO. Surface water quality performance is presented currently (using measured field data), at future peak concentration (modelled), and in the long-term (modelled). Decommissioning surface water quality objectives have been achieved.

Surface water quality at key waterbodies will continue to be monitored by Orano and following successful transfer of the property into Provincial Institutional Control, the long-term monitoring of surface water quality will be administered by the Province of Saskatchewan. On-going monitoring will be used to validate the continued applicability of the ground and surface water modelling.

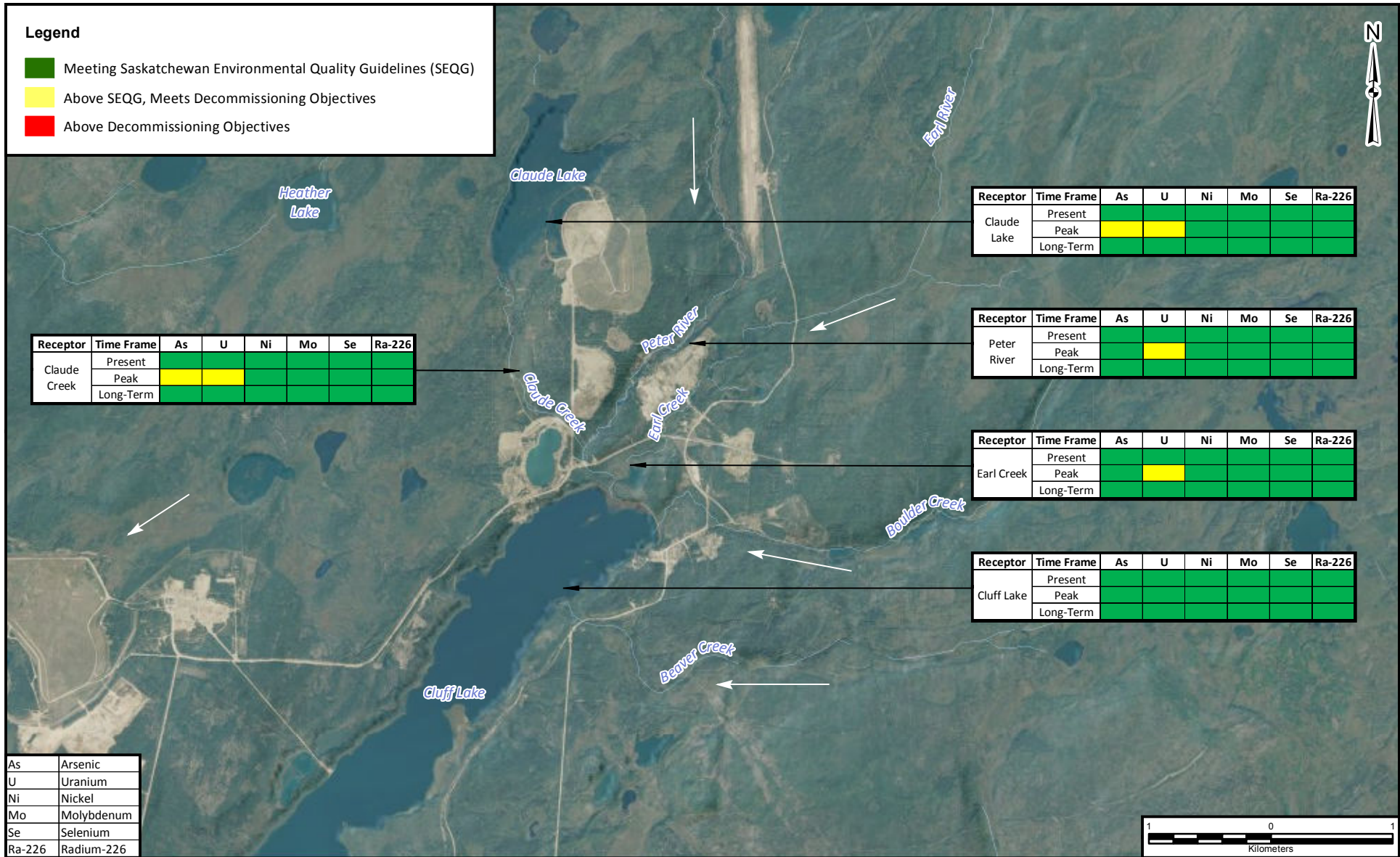


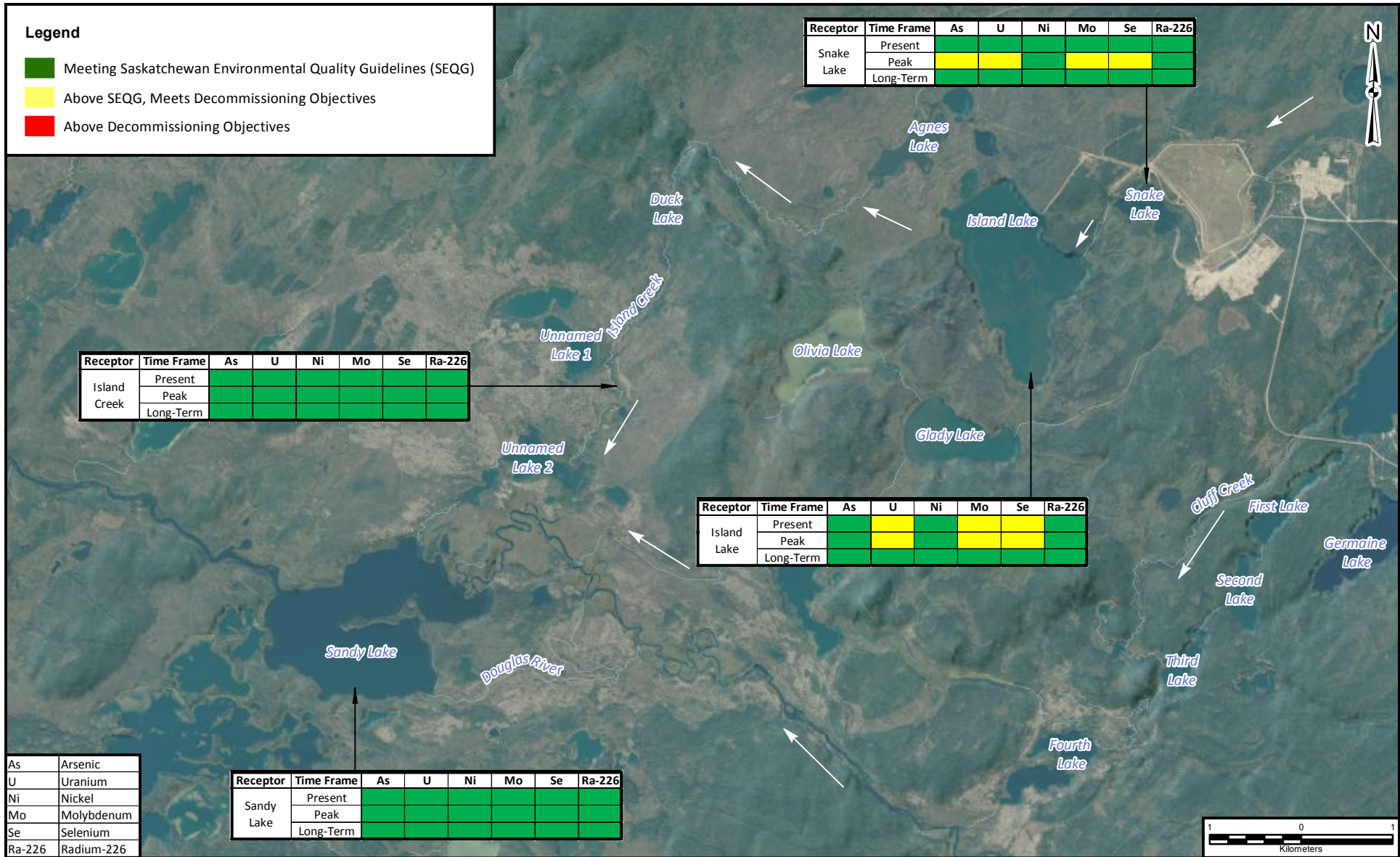
FIGURE 2.1
ACHIEVEMENT OF DECOMMISSIONING SURFACE WATER QUALITY OBJECTIVES OVER TIME - MINING AREA

Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/11/19 Scale: 1:45,000
 Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, ORANO Canada Inc.

CLUFF LAKE PROJECT

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Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/11/19 Scale: 1:60,000
 Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, ORANO Canada Inc.

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FIGURE 2.2
 ACHIEVEMENT OF DECOMMISSIONING SURFACE WATER QUALITY OBJECTIVES OVER TIME - TAILING MANAGEMENT AREA

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



Radiological Objectives

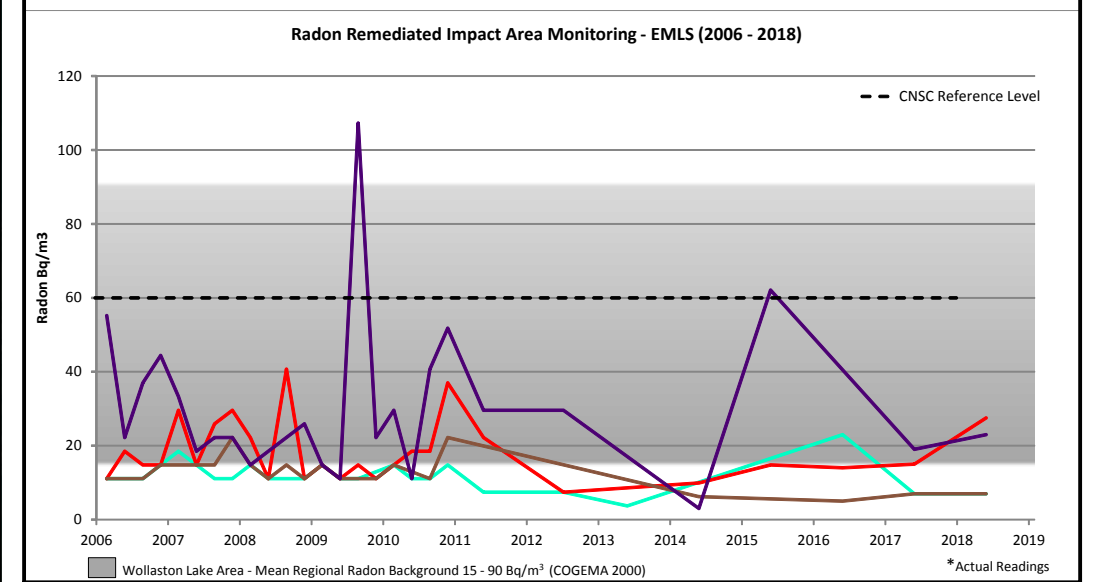
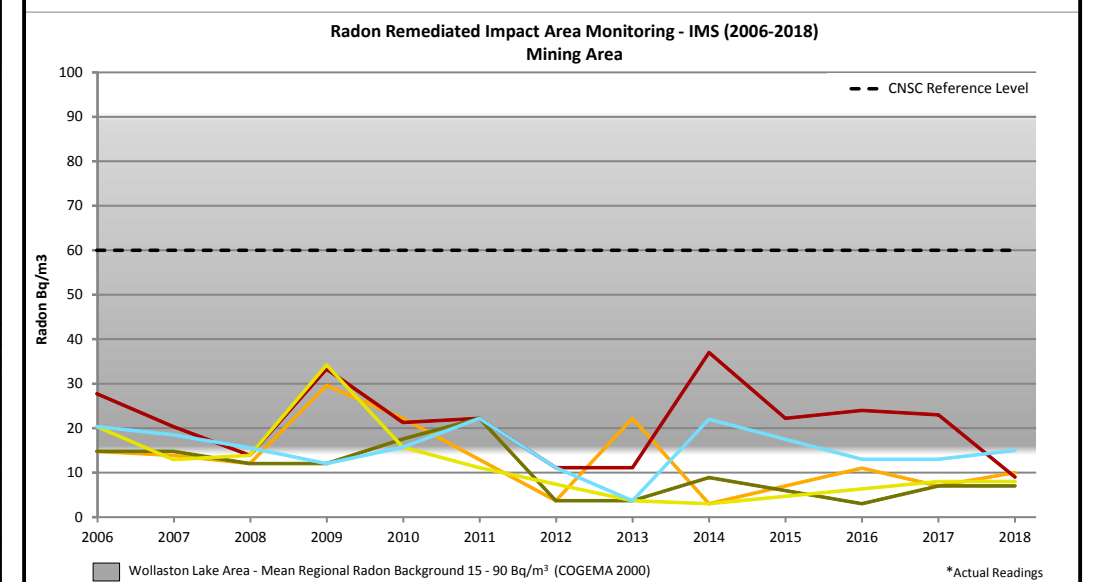
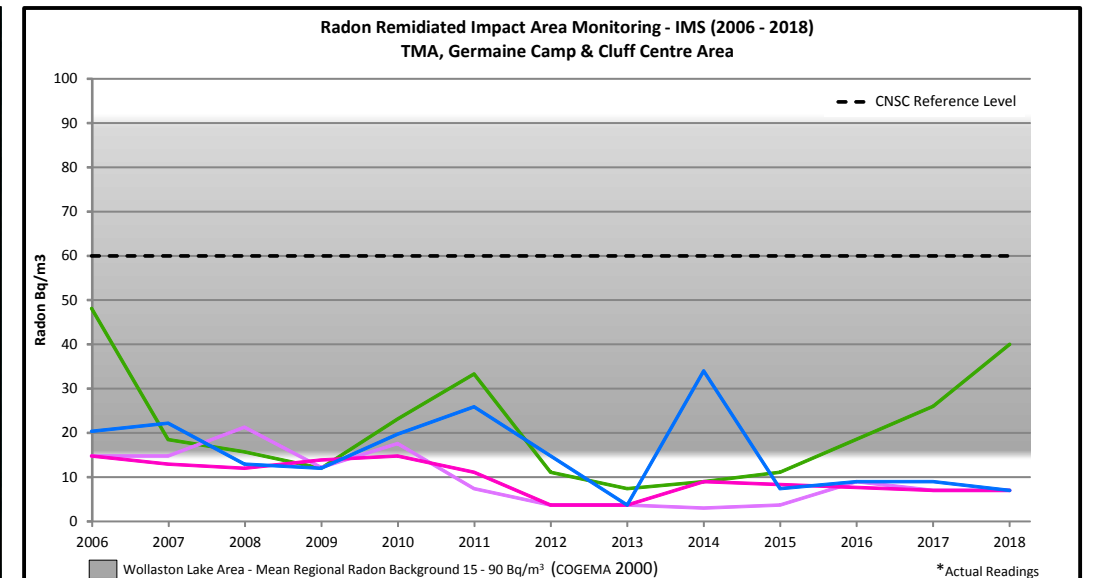
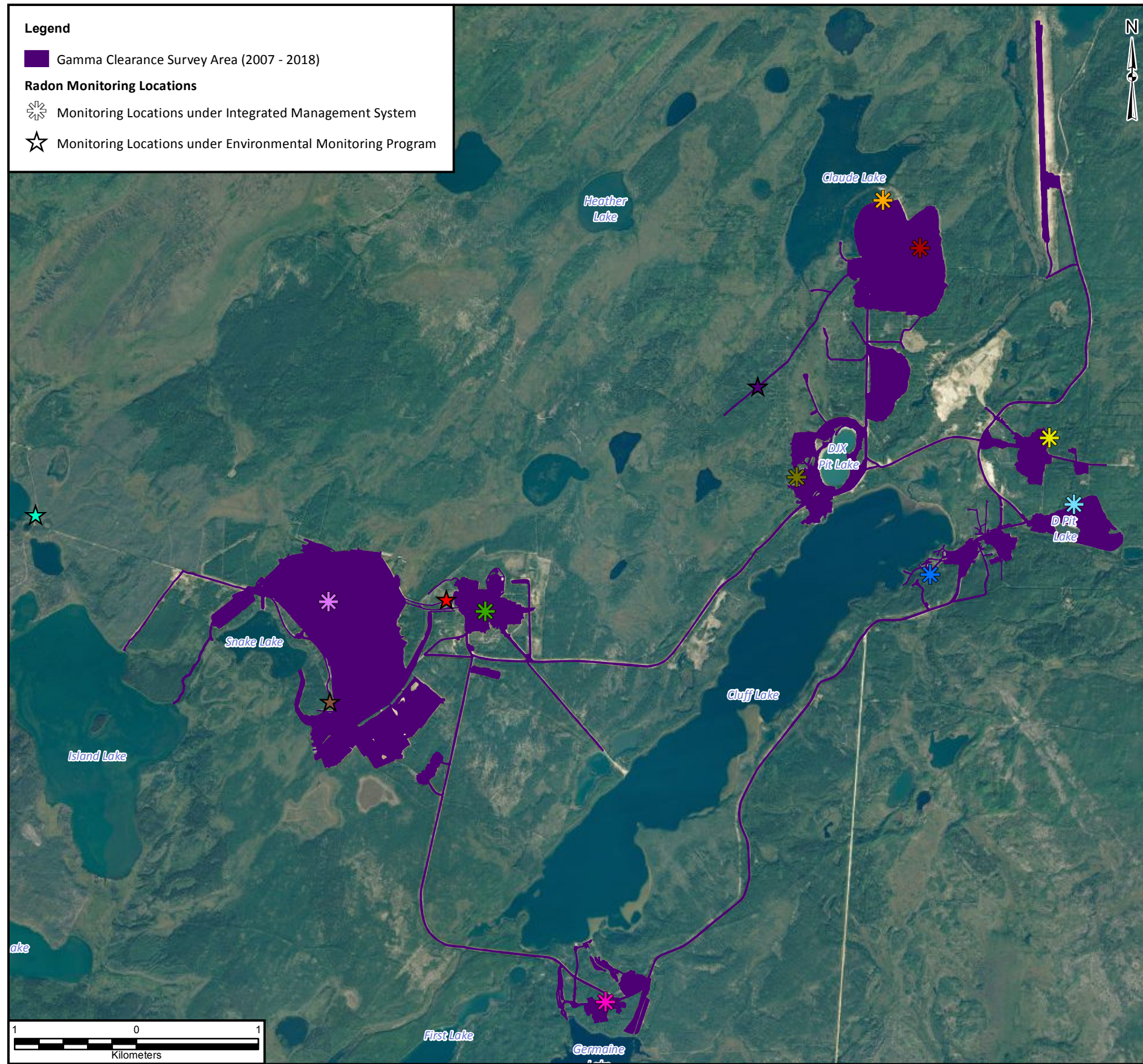
Objective: Achieve levels of gamma radiation, radon, and long-lived radioactive dust (LLRD) which pose no unacceptable risk to traditional land use, and which are consistent with application of the ALARA principle.

The decommissioning radiological objectives are based on a need to keep radiation doses to the general public below the regulatory limits and as low as reasonably achievable, social and economic factors considered (ALARA) through the final decommissioning and post-decommissioning phases.

The limit on annual effective dose to a member of the public under the CNSC's *Radiation Protection Regulations* (RPR) is 1 mSv per year above natural background levels. The regulations specify that the limit includes contributions from external sources, inhalation of radon progeny, and ingestion and inhalation of radioactivity according to the sum rule provided [subsection 13(2) of the *RPR*].

Radon and LLRD levels were reduced through removal of source material or by covering with clean soil material. Sufficient cover materials were applied to eliminate LLRD, and to reduce radon levels to near background conditions, where source terms existed. Post-decommissioning LLRD and radon levels are near background and did not require specific decommissioning objectives. The potential exposure to gamma radiation is the primary exposure pathway and was addressed through surface gamma clearance surveys with associated remediation as necessary. Exposure to ambient gamma radiation is included in a comprehensive human health risk assessment (AREVA 2015).

Status: Levels of gamma radiation, radon, and long lived radioactive dust pose no unacceptable risk to traditional land use and are consistent with application of the ALARA principle. Radiological levels achieved protect public health by maintaining doses to future users well within regulatory limits for members of the public. Radiological objectives have been achieved. Having confidently achieved this decommissioning objective, radon monitoring was removed from the environmental monitoring program in late 2017 with regulatory approval. Figure 2.3 shows the areas of the site surveyed and meeting gamma surface clearance as well as radon monitoring results over the licence period compared to the regional mean radon values and to the CNSC reference level of 60 Bq/m³. The value of 60 Bq/m³ was derived from Publication 65 of the International Commission on Radiological Protection, *Protection Against Radon-222 at Home and at Work*, as referenced in the *Radiation Protection Regulations*.



Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/15/19 Scale: 1:37,500
 Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 2.3
 CLUFF LAKE GAMMA CLEARANCE AND RADIOLOGICAL MONITORING

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



Site Stability and Landscape

Objective: a stable, self-sustaining reclaimed landscape

Decommissioning of the site included works to stabilize the landscape and minimize public safety hazards, e.g. backfilling or flooding mined out pits. Of particular interest are the decommissioning of underground mine workings, rehabilitation of the TMA dam, and landscaping of the Claude Waste Rock Pile (CWRP), as summarized below.

- DJ Underground was mined using an undercut and fill mining method. DJU fresh air raises were entirely backfilled from the bottom of the raise to the raise collar elevation in 2002. The DJU decline backfilled from about 181m down the ramp to the portal opening with reinforced concrete caps placed over all backfilled raises and a concrete plug poured over the former DJU portal opening.
- OP/DP Underground was mined using undercut and fill mining method. Similar to DJU, backfilling of raises was completed in 2002. The OP/DP decline was backfilled from about 176m down the ramp to the portal opening with reinforced concrete caps placed above backfilled raises and a concrete plug was poured over the former OP/DP portal opening.
- The TMA dam was stabilized prior to decommissioning and has achieved a passive state that does not require regular surveillance. The dam is considered physically, chemically, ecologically, and socially stable. Stabilization and surface water management features include:
 - spillway established to passively release water from surface,
 - engineered cover with grading for positive drainage towards spillway,
 - installation of toe drain,
 - construction of the south division ditch and north diversion ditches,
 - main dam buttressed with a downstream slope of 4H:1V, and
 - potentially erodible slopes vegetated.
- CWRP: for aesthetics and erosion control, the CWRP was re-contoured in 2005 from approximate 2.5H:1H side slopes to a maximum side slope of 4H:1V, the re-graded waste rock surface was compacted to design specifications, a 1 m glacial till cover was installed to reduce net infiltration and provide a growth medium for vegetation, storm water management channels were constructed to provide additional erosion control for the regraded and covered pile, and the cover then seeded with native grasses and legumes.

Revegetation of the Cluff Lake site was undertaken to accelerate reclamation and additionally served to improve site aesthetics. The revegetation approach for the Cluff Lake Project included two different strategies: seeding soil covers with grasses and forbs (addressed in following section on covers); and planting trees in other disturbed areas. Tree seedlings were propagated from local seed and cutting sources including a mixture of six native woody species: green alder, balsam poplar, white birch, trembling aspen, willow, and jack pine. Over 600,000 seedlings were planted across 129 ha from 2005 to 2007. In general,

good survival and density of trees has been observed. Some small disturbed areas were not seeded but rather regraded to allow indigenous vegetation to establish naturally.

Status: The former mine site is stable, self-sustaining, and reclaimed. Decommissioning works are complete. Periodic geotechnical inspections will continue to be contracted by Orano and following successful transfer of the property into Provincial Institutional Control geotechnical inspections will continue to be part of the long-term monitoring program conducted by the Province of Saskatchewan. Though landforms are expected to stable over the long-term, funding for future minor works has been considered in the maintenance costs of the site, appropriately addressed under the IC Program.

Engineered Covers

Objective: Reduction of infiltration rates around the TMA and the CWRP to levels that adequately restrict contaminant movement to groundwater and are suitably protective of downstream surface water receptors

The purpose of covers for the TMA and CWRP is to promote surface runoff, minimize infiltration, and thus minimize the release of contaminants to groundwater. Between 2001 and 2006, a minimum 1 m thick glacial till cover was placed on the TMA. The CWRP was overlain with a 1 m thick till cover in 2005 to 2006. A cover monitoring program was implemented following final grading of these areas in 2006. Monitoring stations were installed at select locations to monitor soil and weather conditions to gauge the success of the cover systems.

The TMA and CWRP covers were seeded in 2006 with grasses and forbs. These types of vegetative covers increase erosional stability, fix nitrogen in the soil, provide root establishment quickly until successional state of vegetation establishes, and better ensure the integrity of the covers for the long-term. As other native vegetation progressively invades, the soil binding capabilities of the grass/forb understory persists and is supplemented by the rooting systems of the other native vegetation species. The vegetation community has shifted over time with both the TMA and CWRP achieving equilibrium following cessation of fertilization in 2009 and on a slow natural trajectory towards successional states.

Status: The cover systems are performing predictably and consistently since 2011 despite some annual variation ; they are expected to continue to be stable. The covers are self-sustaining and effective in controlling erosion. Engineered cover objectives have been achieved. Long-term monitoring for erosion and potential minor repair to covers is appropriate under the ICP.

The sufficiency of the TMA engineered cover is an important aspect of the successful decommissioning of the site and has been a topic of sustained interest of a community member. Consequently, Orano contracted a review of the studies and evaluations used to both select the TMA cover design and assess the current and anticipated long-term performance of the facility. The review, SNC Lavalin, 2019, is provided as Appendix A

Aesthetics and Absence of Unreasonable Risk

Objective: Return the site to an aesthetically acceptable state, similar in appearance and land capability as that which existed prior to mining activities, and that poses no unreasonable risk to humans or the environment

Re-vegetation efforts (as summarized above) focused on the re-establishment of native species of grasses, forbs, and woody species to accelerate the process of natural ecological succession and result in a forested environment similar to that which existed prior to mining. With forest establishment comparable to pre-mining and sound decommissioning, wildlife species can reclaim the mine footprint. The site is safe, reclaimed, and allows for hunting and trapping land uses that existed prior to site development.

Aerial photographs of key areas which show operational, decommissioned, and recent conditions are presented in Figures 2.4 to 2.9.

A comprehensive ecological and human health risk assessment for the Island Creek and Cluff Creek watersheds was submitted in 2015. The assessment was completed to comply with applicable components of the N288.6 Standard for Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills (CSA 2012). Potential risk was characterized both temporally and spatially within an integrated probabilistic framework to address uncertainties in the assessment of effects.

A weight-of-evidence approach was used combining the results of the predictions and risk evaluations with biological monitoring carried out at the Cluff Lake Project. The weight-of-evidence suggests that in the Island Creek Watershed I) there are elevated levels of some COPCs but the aquatic system is recovering and will continue to improve in the future and II) there is some potential risk to mink, muskrat, otter, yellowlegs, and the nighthawk. Potential risks are limited to Island Lake and Island Lake fen with negligible risk downstream at Island Creek at the Dolomites. The weight-of-evidence suggests that in the Cluff Creek Watershed there are no significant effects on the health of the aquatic communities present and there are no predicted effects on terrestrial species. The results are comparable to those predicted in the CSR stating recovery of the Island Creek watershed over time and potential effects on biota considered not significant as effects are restricted locally with full recovery expected.

The results of the human health assessment indicated that a casual visitor to the site who hunts, fishes, and traps over a lifetime as well as his/her family who would consume the food harvested at the Cluff Lake Project will not experience adverse effects from exposure to radionuclides or non radionuclides.

Status: There is an absence of unreasonable risk. The site has unrestricted access and public health and safety does not rely on controlling human behaviours (e.g. fences, signs, fish advisories). Ecological integrity is maintained. Aquatic and terrestrial systems are recovering and they are expected to continue to do so in the future. Aesthetic and risk objectives have been achieved.



1999



2008



2014



2017

Projection:
Compiled: T.Lohman Drawn: T.Lohman
Date: 3/11/19 Scale:
Data Sources: ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 2.4
AERIAL PHOTOGRAPHS OF D MINING AREA

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019





1999



2008



2014



2017

Projection:
Compiled: T.Lohman
Date: 3/11/19
Data Sources: ORANO Canada Inc.

Drawn: T.Lohman
Scale:

FIGURE 2.5
AERIAL PHOTOGRAPHS OF CLAUDE MINING AREA

CLUFF LAKE PROJECT

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019





Projection:
 Compiled: T.Lohman
 Date: 3/11/19
 Data Sources: ORANO Canada Inc.

Drawn: T.Lohman
 Scale:

FIGURE 2.6
 AERIAL PHOTOGRAPHS OF DJ MINING AREA

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019

CLUFF LAKE PROJECT





2001



2008



2014



2017

Projection:
Compiled: T.Lohman Drawn: T.Lohman
Date: 3/11/19 Scale:
Data Sources: ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 2.7
AERIAL PHOTOGRAPHS OF MILL COMPLEX AREA

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



orano



Projection:
 Compiled: T.Lohman
 Date: 3/11/19
 Data Sources: ORANO Canada Inc.

Drawn: T.Lohman
 Scale:

CLUFF LAKE PROJECT

FIGURE 2.8
 AERIAL PHOTOGRAPHS OF TAILINGS MANAGEMENT AREA (TMA)

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019





2004



2008



2014

Projection:
Compiled: T.Lohman
Date: 3/11/19
Data Sources: ORANO Canada Inc.

Drawn: T.Lohman
Scale:

CLUFF LAKE PROJECT

FIGURE 2.9
AERIAL PHOTOGRAPHS OF GERMAINE CAMP AREA

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



2.5 Licence Amendment –Location of Licensed Activities

Orano requests that the area delineated under Appendix A of the Licence be narrowed to include parcels of land contemplated for future transfer into the provincial ICP. A separate request has been submitted to the Province of Saskatchewan to reduce the area of land leased by Orano to those areas where land-use controls will be assured under the ICP. A subset of parcels identified for future IC include land where the licenced activity of ‘possess, manage, store’ a nuclear substance is conducted.

Throughout decommissioning, Appendix A of the Cluff Lake Licence has referenced or closely resembled the provincial surface lease. With the completion of decommissioning activities, the area of provincial and CNSC interest has narrowed over time. From 1992 to 2004, the provincial surface lease totalled 4139 hectares; following a partial surface lease surrender effective July 1, 2004, the provincial surface lease totalled 1631 hectares. In 2009, the Germaine Camp was removed from reference under the Licence although it remained part of the provincial surface lease. The Germaine Camp was determined to have no previous or planned nuclear substance exposure, the area passed radiological clearance, and the CNSC accepted that their on-going oversight of that area was not required, as detailed in Section 53 of the CNSC Record of Proceedings, Including Reasons for Decision for the hearing date of June 10, 2009. Given the differing regulatory oversight, mandates, and authority, it is reasonable for the area on which CNSC licensed activities are conducted to differ from the area encompassed by the provincial surface lease.

2.5.1 Parcels of Land Included

Parcels contemplated for future transfer into ICP: Parcels with completed decommissioning contemplated for future transfer to provincial IC are proposed to remain delineated within the CNSC Licence. These decommissioned parcels that, in consequence of development and use, require long-term administrative controls and, in certain circumstances, maintenance are outlined in Figure 2.10 and include:

- D Mining Area: D-pit, D waste rock pile;
- Claude Mining Area: Claude pit, Claude waste rock pile, Claude peat trenches;
- DJ Mining Area: DJN/DJX pit, DJ underground mine;
- OP/PD Mining Area: OP/DP underground mine;
- Mill Complex Area;
- Tailings Management Area: decommissioned tailings area including the cover, dam, diversion ditches, spillway;
- Landfills: Domestic, Industrial (within the boundary of the TMA parcel), Mill Landfill, Cluff Center Landfill, Secondary Treatment System Ponds (A1, A2, B1, and B2 ponds); and
- Lakes: Snake Lake and the portion of Claude Lake currently under lease. These lakes are recommended for continuation under the provincial surface lease and contemplated for future institutional control to protect sediment attenuating properties important in groundwater contaminant transport and downstream surface water quality; and

- Former location of the DJN waste rock pile and former location of the leach vault storage:
 - The DJN waste rock pile was relocated to Claude pit in 2004 and 2005 and area subsequently regraded and revegetated
 - The leach vault storage area was decommissioned and remediated in 1989 and 1990.

The former location of the DJN waste rock pile and former location of the leach vault storage have no known ecological or public safety risks, both areas passed surface gamma clearance in 2007, there are no remaining decommissioning structures, and there is no need for future administrative controls or maintenance. Members of the public have raised concerns over the adequacy of the leach vault area remediation during the CSR and verification monitoring was added to the FUP. Field sampling of soil and vegetation and a gamma survey were conducted in 2005 to confirm the adequacy of the earlier remediation. The FUP studies concluded that the area does not pose a risk and decommissioning is complete. These two areas, former locations of the DJN waste rock pile and leach vaults, are proposed to remain under Licence until a final determination on IC inclusion is made.

Buffers around potential, future institutional control parcels have been advised by the Ministry of Energy and Resources. Parcels for underground mine workings and pits include a minimum 25 meter buffer and remaining parcels include a minimum 10 meter buffer.

The requested licensable activities under Section 26 of the *Nuclear Safety and Control Act* - management, storage, disposal of mine and mill waste containing nuclear substances - occurs within a subset of the land parcels intended for transfer to the ICP. The following parcels may be defined as decommissioned nuclear facilities containing mine and mill wastes (i.e. disposed nuclear substances) with a radioactive inventory of 10^{15} Bq or more (*NSCA S.2 and NSCR S.19(a)*):

- Waste Rock: the Claude Waste Rock Pile, Claude Pit, DJX Pit; and
- Tailings: the Tailings Management Area.

Figure 2.11 identifies the parcels where proposed CNSC licensed activities - possess, manage, store nuclear substances - occur.

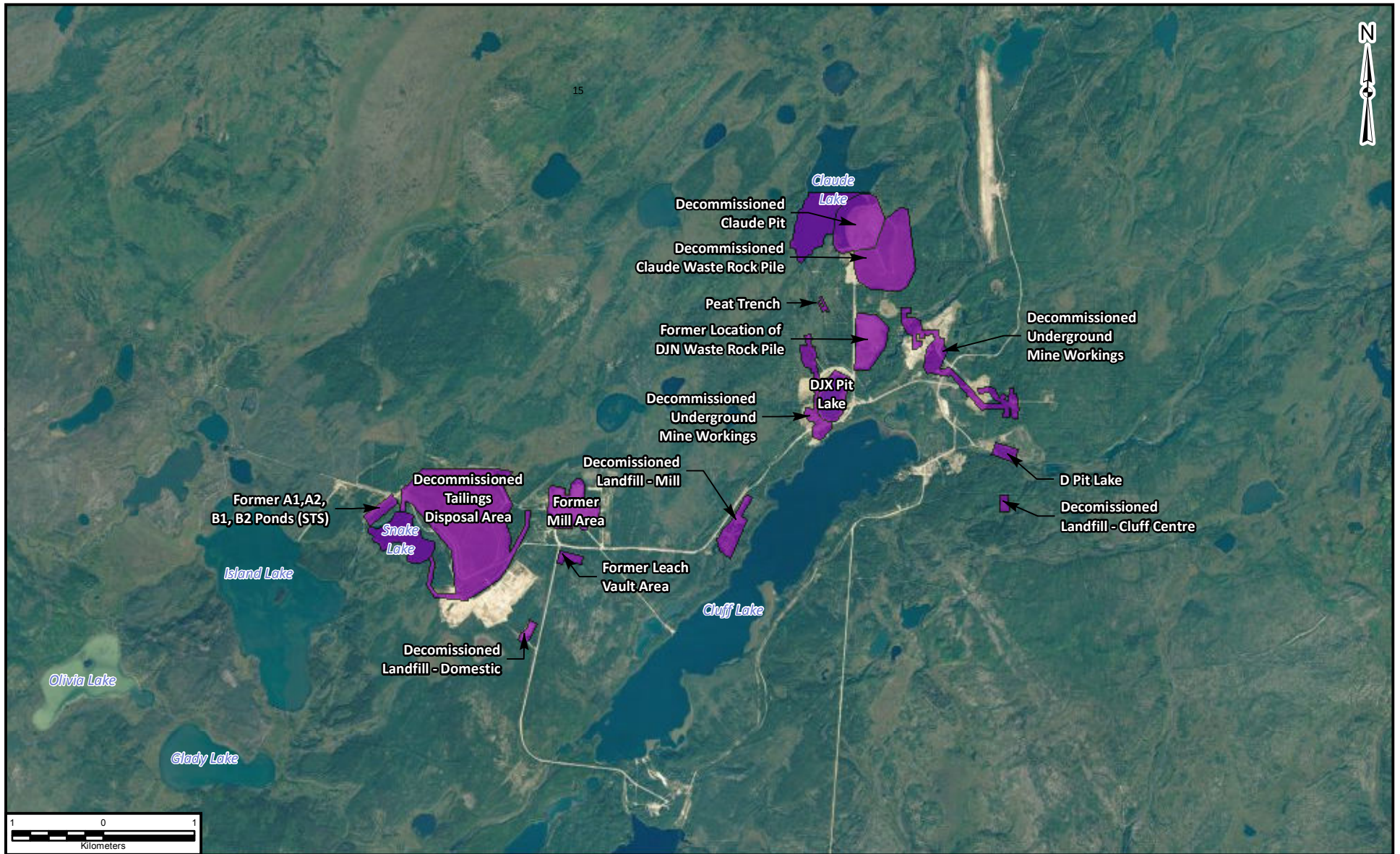
2.5.2 Parcels of Land Removed

Parcels of land referenced in Appendix A of the current CNSC Licence that are proposed for removal from the Licence include: decommissioned site roads, the abandoned airstrip, Cluff Center, locations of former buildings and infrastructure, and borrow pits and quarries.

On-site roads are decommissioned. Infrastructure is removed from on-site roads and trails, streambeds rehabilitated, and routes are expected to continue to naturally reclaim over time. Three stream crossings extending from Highway 955 (Boulder, Beaver and Earl creeks) have remaining infrastructure (i.e. culverts) that will be managed under the Provincial permitting system.

Parcels removed that were the location of former infrastructure include: locations of maintenance buildings, laydown areas, batch plant, powder magazine, surface infrastructure for underground mine workings, pump house, and the Germaine Camp area. In these areas, surface structures have been removed; radiological clearance (if required) has been passed; areas were seeded, planted or allowed to naturally revegetate as approved; and areas are absent of public safety hazards beyond what is expected of a remote wilderness site.

Cluff Lake and Island Lake are requested for removal from reference under the Licence as they are no longer areas of licenced activities and do not require long-term controls or maintenance. These lakes are safe, stable or recovering, and available for unrestricted access.



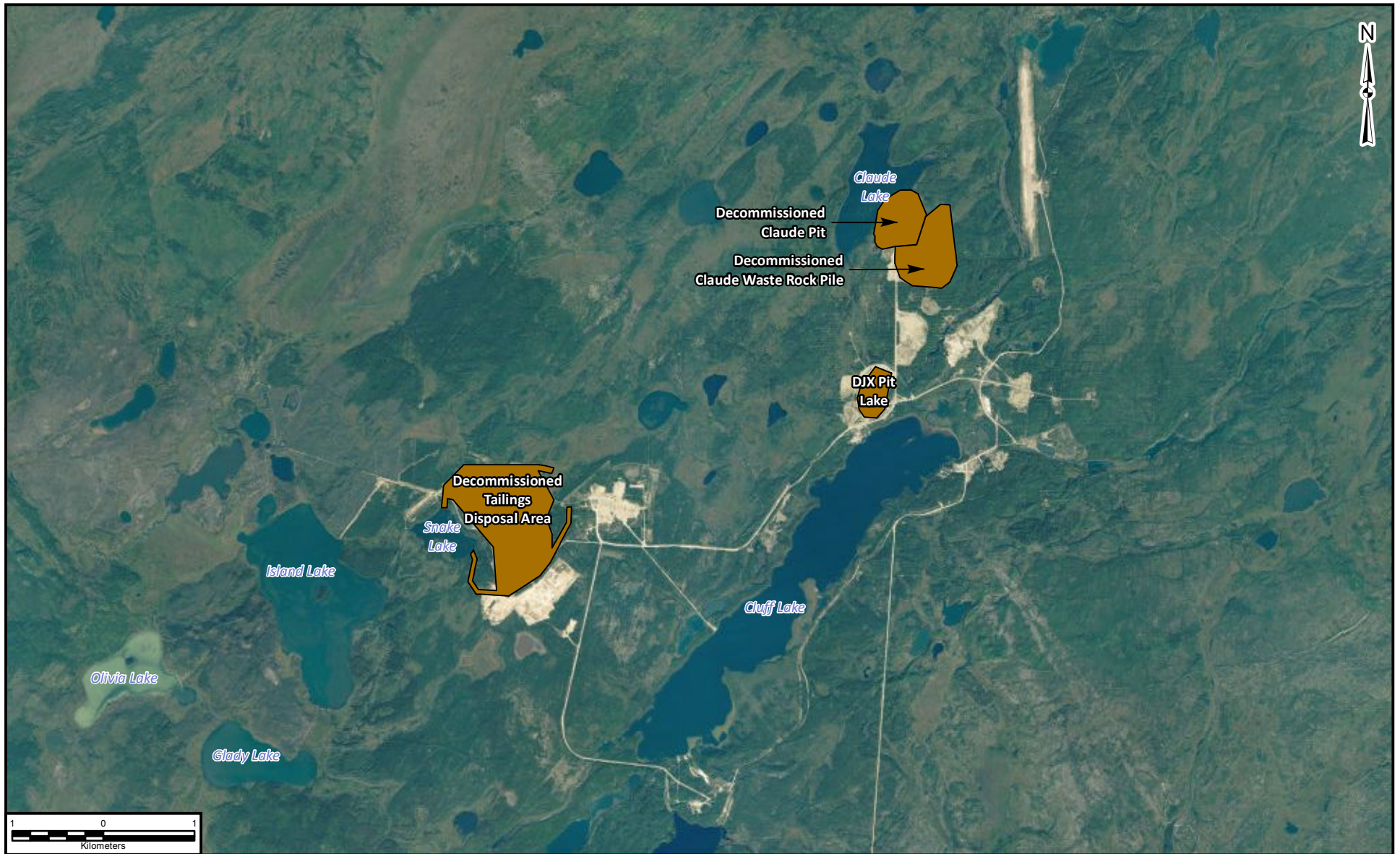
Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/15/19 Scale: 1:60,000
 Data Sources: Natural Resources Canada, Geobase®, Nation
 Topographic Database, ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 2.10
 CLUFF LAKE DECOMMISSIONED MINE AND MILL SITE

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Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/15/19 Scale: 1:60,000
 Data Sources: Natural Resources Canada, Geobase®, Nation
 Topographic Database, ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 2.11
 CLUFF LAKE DECOMMISSIONED NUCLEAR FACILITY -
 DECOMMISSIONED NUCLEAR FACILITIES WITH
 RADIOACTIVE INVENTORY >10¹⁵ Bq

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



2.6 Commission Acceptance – Financial Guarantee

The current financial guarantee associated with the Cluff Lake Decommissioning Licence is in the form of an irrevocable letter of credit issued to the Government of Saskatchewan in the amount of \$26.8M (CDN). This value was accepted by the Ministry of Environment (MOE 2015), and the CNSC Commission (CNSC 2018b).

With reclamation and decommissioning work completed, a financial guarantee of \$3.5M (CDN) is proposed.

The decommissioned end-state objective was to achieve a stable and self-sustaining site under perpetual passive care. Engineered structures including the CWRP and the TMA dam have been designed to require no routine ongoing maintenance. Underground mine workings were backfilled as part of routine operations, vent raises were backfilled completely before capping, and declines were substantially backfilled before closure. Replacement of decommissioned features is not anticipated at Cluff Lake, e.g. there are no shaft caps to replace. Monitoring of the site will include geotechnical monitoring to ensure landforms are stable, and water quality monitoring to ensure continuous achievement of decommissioning objectives. Estimated costs of monitoring and maintenance are based on Orano's post-decommissioning site management experience.

The Province of Saskatchewan's *Reclaimed Industrial Sites Act* and its regulations require provision of a fund sufficient to pay for the perpetual monitoring and maintenance of the site, and an additional contribution of 20% of the monitoring and maintenance amount to an unforeseen events fund. Until such time as the provincial unforeseen events fund is self-sufficient, new entries into the ICP are requested to provide an additional financial assurance for repair of a potential low-probability, worst-case failure event.

The current cost estimation indicates a cost of \$3.5M (CDN). Orano believes this estimation adequately funds monitoring activities until the transfer of the Cluff Lake site into the Province of Saskatchewan's ICP and establishment of ICP funds.

The components of the Cluff Lake Project total cost to completion include:

1. payment of CNSC cost recovery fees for the 5-year licence term, based on the average fees for the past five years;
2. environmental monitoring program costs for up to three years while Orano, the Province of Saskatchewan, and the CNSC confirm requirements for post-closure monitoring and transfer to ICP;
3. an estimated cost of repair to a low-probability failure event (e.g. surface erosion due to a unlikely maximum flood event); and
4. the lump sum cost to establish the Long Term Monitoring and Maintenance Plan and an Unforeseen Events Fund.

The calculation of funds to establish the IC monitoring and maintenance fund (i.e. cost to conduct the long-term monitoring and maintenance plan) as well as an unforeseen events fund have been estimated according to guidance provided in the provincial ICP document (SMER 2009). Future costs are based on escalation of present costs using a 10-year average Bank of Canada inflation rate of 1.7%. The calculation of the net present value of an annuity that would support future site expenses assumes a conservative rate of return of 3.7%, i.e. inflation plus 2%. The present value of a cash payment sufficient to support monitoring and maintenance in perpetuity is estimated at \$1.6M (CDN). The actual value for IC fund establishment will be guided by the regulatory accepted long-term monitoring and maintenance plan (future submission); the values presented here are estimates for financial assurance purposes.

In correspondence received from the SMOE (Moulding to Huffman, February 14, 2019), the SMOE accept that the reduced financial assurance presented in the DPDP (Orano 2019) is adequate.

3 Performance during Licence Period

Section 3 discusses the performance of the Cluff Lake site relative to relevant Safety and Control Areas (SCAs) for a decommissioned site consistent with SCAs presented for decommissioned sites in the CNSC Regulatory Oversight Report.

3.1 Management System

Orano maintains a Cluff Lake Integrated Management System (IMS V12, 2016). The IMS for the Cluff Lake Project follows the CNSC quality assurance elements, requirements, and principles and the internal requirements of Orano.

With the reduced project activities, the Cluff Lake Project IMS has been revised to include campaign monitoring activities, as well as environmental, health and safety, and emergency preparedness and response requirements. In this way, the IMS has incorporated the information that was previously contained in licensing documents and manuals such as the Environmental Code of Practice, Radiation Code of Practice, and the Emergency Response Manual. As the Project progresses, AREVA will update the IMS as required.

The IMS specifies the requirements applicable to personnel who manage and perform work affecting the post-closure environmental monitoring phase of the Cluff Lake Project. It focuses on activities or processes that could have an effect on the health and safety of people at/or around the site and potential effects on the surrounding environment. The activities associated with campaign monitoring and inspection campaigns, generally conducted by third-party consultants, are guided by the application of the IMS to ensure the continued adherence to company standards.

3.2 Safety and Control Areas

The availability and presence of workers and licensee staff onsite determines the degree of applicability of each SCA. Consistent with the CNSC Regulatory Oversight Reporting (CNSC 2016), most SCAs are not applicable to decommissioning activities leaving three relevant SCAs: Radiation Protection, Conventional Health and Safety, Environmental Protection. In the last two Regulatory Oversight Reports that included decommissioned mine sites (CNSC 2016 and 2018), Cluff Lake received satisfactory ratings for each SCA evaluated.

3.2.1 Radiation Protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the Radiation Protection Regulations. This program must ensure that contamination, and radiation doses received, are monitored (if required), controlled, and maintained as low as reasonably achievable, economic and social factors considered (ALARA).

Radiation sources that once existed on site have either been removed or managed as part of the decommissioning activities, leaving the site at background levels of radiation exposure. Worker exposure to radiation had been at background levels for several years before Radon and LLRD personnel monitoring ceased in 2006 and gamma dosimetry ceased in 2013. Table 3.2-1 presents dosimetry monitoring results within the licence period. Decommissioning radiological objectives are based on a need to keep radiation doses to the general public below regulatory limits and consistent with the ALARA principle.

Procedures are in place to evaluate the need for worker radiological monitoring during earthwork campaigns. Radiological monitoring is required when a predicted dose to workers may be >0.1 mSv. Works completed in 2017 and 2018 were evaluated and potential doses fell well below the threshold for monitoring.

Table 3.1: Annual Incremental Gamma Dose Summary

	Number of Workers	Average Worker Dose (mSv)	Maximum Worker Dose (mSv)
2009	12	0.005	0.03
2010	10	0.002	0.01
2011	6	0.008	0.05
2012	6	0.005	0.03

3.2.2 Conventional Health and Safety

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

The primary Health and Safety Program activities associated with the Cluff Lake Project campaign monitoring include:

- health and safety orientation at the start of the work,
- pre-campaign drug and alcohol testing,
- risk management through creation of safe work plans and job hazard analysis,
- accident prevention through the use of the 5-point safety system,
- communication through daily tool box meetings,
- current first aid trained workers on site during campaigns,
- an Emergency Response Plan, and
- record keeping and reporting.

Prior to the initiation of campaigns, training verification is performed for campaign crew members in relation to the activities that are being performed. Examples included verification of training for:

- First-aid
- Spill Response
- WHMIS
- Driver's Licence
- Pleasure Craft Operator's Licence
- Wildlife Awareness
- All-Terrain Vehicle Safety
- Snowmobile Safety

Injuries reported and occupational lost-time injuries at Cluff Lake over the licence period are presented in Tables 3.2 and 3.3 below.

Table 3.2: Injuries Reported

Injuries	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Orano		0	0	0	0	0	0	0	2	3	1
Contractor		0	0	0	0	0	0	9	7	6	5
Total		0	0	0	0	0	0	9	9	9	6
Illnesses Reported at Medical Centre	n/a	n/a	n/a	n/a	n/a	n/a	n/a	17	16	17	16

Table 3.3: Occupational Lost Time Injuries

	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009
Number of Injuries		0	0	0	0	0	0	0	0	0	0
Hours Lost		0	0	0	0	0	0	0	0	0	0

3.2.3 Environmental Protection

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

The Cluff Lake Project is a Recognized Closed Mine under the Metal Mining Effluent Regulations as of January 16, 2006.

Environmental sampling and monitoring data for the Cluff Lake Project is collected in accordance with the approved environmental monitoring programs included in the Saskatchewan Ministry of Environment operating approval. Sampling locations, parameters, and frequencies are outlined in the Environmental Monitoring Locations and Schedule (EMLS) program document.

A reportable spill is defined by the Provincial *Spill Control Regulations*. Other events such as accidental releases of contaminated materials from primary containment areas into secondary containment areas, or releases of volumes less than those defined in the Provincial *Spill Control Regulations*, are deemed “incidents” and are non-reportable as spills. Spill control measures are implemented for spills and incidents. Hydrocarbon contaminated soil was taken to the hydrocarbon landfarm until it was closed in 2013. Testing at the hydrocarbon landfarm and at the fuel storage facilities decommissioned in 2013 indicated that the criteria for hydrocarbons industrial and commercial land was met. Contaminated soil since 2013 was taken to appropriate facilities offsite, e.g. contaminated soil from a hydraulic fuel spill in 2018.

Table 3.4: Reportable and Non-Reportable Environmental Incidents

Year	Reportable Spills	Non Reportable Environmental Incidents	
		Number	Summary
2009	0	3	2 litres of coolant leaked from a generator 5 litres of transformer oil was spilled when transformers were removed from a decommissioned power pole 5 litres of hydraulic fluid leaked from a hydraulic line on a packer at the airport.
2010	0	5	1 litre of oil leaked onto the ground from a punctured 4 litre oil can in the back of a half-ton truck 1 litre of gasoline leaked onto the ground from a jerry gasoline can used for boating that was on a cargo box on an ATC. Approximately 56 litres of diesel overflowed from a containment sump full of water at the fuel tank for a generator. A small of transmission fluid from a gravel truck was found on the snow.
2011	0	4	12 litres of transmission oil leaked onto the ground from the 880 loader when the rear driveshaft broke. 5 litres of diesel spilled on the concrete pad when an automatic shutoff failed during the filling of a 500 gallon fuel tank on the back of a drillers truck. 0.5 litres diesel spilled onto the ground from a truck slip tank 5 litres of differential oil leaked onto the ground from a failed differential on a gravel truck.
2012	0	1	10 litres of diesel spilled from an Envirotank during refueling.
2013	0	0	
2014	0	0	
2015	0	0	
2016	0	0	
2017	0	0	
2018	0	1	20 litres of hydraulic fluid leaked on the ground from the failure of a hydraulic hose on a tandem dump truck.

3.2.4 Other Items of Regulatory Interest

Waste Management: Wastes generated during monitoring activities are removed from the Cluff Lake Project site with each campaign for disposal in the appropriate facility. Efforts are made to deliver waste materials to the appropriate recycling facilities in Saskatoon. Waste management practices are outlined in the Cluff Lake Integrated Management System (IMS) manual which is provided to campaign monitoring personnel, and also reviewed in an environment orientation that is provided to personnel working at Cluff Lake.

Emergency Management: Campaign crews are required to provide an acceptable Emergency Response Plan in advance of campaigns. If an emergency occurs at the Cluff Lake Project site that is unable to be handled with the on-site resources available, the Orano Crisis Management Plan will be activated. The Orano Crisis Management Plan is a corporate level document that describes the roles and responsibilities of the crisis management organization within Orano and the corresponding activities during a crisis. The Cluff Lake site has a registered STARS Air Ambulance landing location should evacuation be required.

Safeguards and Non-Proliferation: The site has been decommissioned and the risk for intervention is very low. Orano is required to provide reasonable services and assistance to the International Atomic Energy Agency (IAEA) inspectors to carry out their duties and functions. During the licence period, there were no requests by IAEA inspectors to inspect Cluff Lake.

4 Community and Stakeholders

Orano is committed to conducting our activities in a socially responsible, environmentally sustainable, and profitable manner. In keeping with our commitments, Orano's overarching communication program considers the exchange of information with neighbouring communities, the general public, and key interest groups who express interest in our operations. The methods of communication vary in an effort to match purpose and to optimize effectiveness. Communication methods may be oral, written, or video based, and disseminated using a variety of media including online channels.

Communication and engagement is undertaken with the following overall objectives:

- provide opportunity for sharing of information on the Cluff Lake Project;
- engage with key interest groups in a manner that recognizes their interest in the Project and with the intent to understand concerns and respond to questions related to the Cluff Lake Project;
- communicate key Orano business decisions as it relates to the Cluff Lake Project; and
- ability to provide feedback from Orano's Program to regulators to assist their assessment of public interest or concern.

Over the licence term there have been three periods that, coinciding with changes in Project status, have shifted the focus on communication and engagement. From 2009 to 2013 communication was focused on completion of physical decommissioning; from 2014 to 2017 communication focused on the end of an on-site presence, on-site safety, and safe land uses; and from 2018 to 2019 communication focused on the achievement of a stable, safe end-state and preparation for institutional control.

4.1 Geographical Context

The Cluff Lake Project is located in northwestern Saskatchewan within the Northern Administrative District (NAD), an administrative area defined by the Saskatchewan Provincial Government. Northern Saskatchewan poses a particular challenge in terms of public information as it features low populations spread across a vast geographic region. The NAD is comprised of approximately half of Saskatchewan's land area but less than four percent of the province's population or roughly 37,000 people. The communities encompassed within the NAD include First Nation, Métis, and other municipalities. The closest community to Cluff Lake is Fort Chipewyan, Alberta. By all-season road, the closest community is La Loche, Saskatchewan located more than 250 km away.

When Cluff Lake first commenced operations, it was one of the only mining operations in the NAD, and as such, much of the NAD was interested in the activities occurring at the site. As time has progressed, a number of other mining and milling operations have started in other regions within the NAD. Far field communities generally have an interest and actively participate in their neighbouring economic opportunities. Engagement efforts during decommissioning reflect an increased focus on the western side of

the NAD, which reflects a reasonable narrowing of the NAD to address current interest in the Cluff Lake Project.

4.2 Interest Groups

In 1999, as part of decommissioning planning, Orano (then named COGEMA Resources Inc.) designed a decommissioning-specific Public Involvement Plan (PIP) that involved the following primary interest groups:

- Communities – Indigenous and Non-Indigenous (leadership and members)
- Northern Saskatchewan Environmental Quality Committee (EQC)
- Business sector
- Community Groups and Non-Governmental Organizations

Although Orano continues to work and communicate with the business sector, following transition from active operations and then active decommissioning there is a diminished need to engage with the business sector. The other primary interest groups identified in 1999 remain primary interest groups. In-person meetings, open houses, and site tours are highlighted for each group below. These in-person interactions are in addition to hundreds of phone calls, text messages, emails, and letters over the 10-year licence term as well as social media and local advertisements used to share information.

Communities – Indigenous and Non-Indigenous: The nearest community is Fort Chipewyn, Alberta at about 100 km from Cluff Lake. The nearest community with all-season road access is La Loche, Saskatchewan more than 250 km away from the site. The next nearest communities with all-season road access are Buffalo Narrows at 351 km, Ile a la Crosse at 414 km, and Beauval at 463 km away from the Cluff Lake Project.

Although the main communities, both Indigenous and municipal, are located quite far from the Cluff Lake Project, these communities and their leadership have a long-standing history with the Cluff Lake Project as the Project served as the largest employer on the northwest side of the Province during its lifetime. As representatives of the community members, Orano considers leadership of the various communities as a key interest group.

Over the course of the Cluff Lake Project the primary Indigenous communities that Orano engages with are the Clearwater River Dene First Nation, the La Loche local Métis President, the Regional Métis President, and the Athabasca Chipewyan First Nation (ACFN). The primary municipal communities Orano engages with are Beauval, Buffalo Narrows, La Loche, and Ile a la Crosse.

Community members (or local residents) within these communities also comprise an interest group for Orano because it is important for potential land users to have a general understanding of the site, anticipated environmental effects, and continuing recovery. Respecting the organizational structure of

communities, ACFN member representation occurs through the Industrial Relations Committee and the Métis of La Loche is represented by a single Local President (who is also currently the Mayor of la Loche).

The ACFN has two separate families that have each had an interest in Cluff Lake or Carswell Lake, and as such, the ACFN Industrial Relations Committee (now Dene Lands and Resource Management) has actively sought information regarding the activities at Cluff Lake on behalf of their members.

A summary of in-person community events is provided below.

- 2009 – 2013: open house tours in 2012 and 2013 in the communities of Beauval, Buffalo Narrows, Ile a la Crosse, and La Loche; three site tours and one meeting with ACFN; seven in-person meetings with community groups or leadership including Beauval, Birch Narrows (2), Clearwater, Ile a la Crosse, La Loche, Metis Local 39.
- 2014 – 2017: open house tour in 2015 in the communities of Beauval, Buffalo Narrows, and La Loche; one meeting with ACFN; nine in-person meetings with community groups or leadership including Birch Narrows, Buffalo Narrows, Buffalo River, Canoe Lake, Clearwater, Ile a la Crosse (2), La Loche, Metis Local 39,
- 2018 – 2019: open house tour in 2018 in the communities of Clearwater, Beauval, Buffalo Narrows, Ile a la Crosse, and La Loche; site tour and one meeting for ACFN; 6 in-person meetings with community groups or leadership including Clearwater, Beauval, Birch Narrows, Buffalo Narrows, Ile a la Crosse, and La Loche.

Northern Saskatchewan Environmental Quality Committee: The Northern Saskatchewan Environmental Quality Committee (EQC) was created in 1995 by the Saskatchewan provincial government to assist northern Saskatchewan residents in understanding the various facets of uranium mining and milling. In 2000, the original three separate NSEQC committees were combined into a single entity with three regional subcommittees, the Athabasca Subcommittee, the West Side Subcommittee, and the South Central Subcommittee. In total, the NSEQC represents 35 communities. The Indigenous and municipal communities of the West Side Subcommittee are:

- Northern Village of Beauval
- Birch Narrows First Nation (Turnor Lake)
- Northern Hamlet of Turnor Lake
- Northern Village of Buffalo Narrows
- Buffalo River Dénesuline Nation (Dillon)
- Northern Village of La Loche
- Clearwater River Dénesuline Nation
- Northern Hamlet of Jans Bay
- English River First Nation (Patuanak)
- Canoe Lake Cree Nation (Canoe Narrows)
- Northern Village of Green Lake
- Northern Village of Ile a la Crosse
- Northern Hamlet of Michel Village
- Northern Hamlet of Patuanak
- Northern Hamlet of St. George's Hill

A summary of in-person events with the EQC is provided below.

- 2009 – 2013: two site tours; two meetings
- 2014 – 2017: four meetings
- 2018 – 2019: site tour; three meetings

Community Groups and NGOs: The non-governmental organization (NGO) community can be active participants in regulatory process. The Saskatchewan Environmental Society (SES), in particular, has an interest in the Cluff Lake Project. The SES has partnered/collaborated with the ACFN for various regulatory milestones during the licence term, as well as with an individual from Ile a la Crosse. Orano hosted two SES representatives, a former employee, and an interested community member for a site tour in 2017 given their sustained interest in the Cluff Lake decommissioning and active regulatory participation. Additional intermittent meetings have been held with SES from 2016 to present.

4.3 Cabin Owners and Known Local Land Users

Of particular importance are historical and current land users comprised of three co-owners of a cabin on Cluff Lake (Flett family members who also hold trapping licences), a Carswell Lake lodge owner, a Sandy Lake cabin owner, and two individuals with trapping licences. Carswell Lake is located in a different watershed than the Cluff Lake Project but is accessed by the road extending from Highway 955 by Cluff Lake. Figure 4.1 shows the historical and current land use and watersheds in relation to the Cluff Lake decommissioned mine site.

Former employees and contractors that worked at Cluff Lake have and may continue to visit the site to harvest in areas that have become familiar to them through their time employed or simply to visit the site. In addition, with unrestricted access other individuals may choose to travel to site. Although there may be local land use by numerous individuals, company engagement efforts focus on near-by cabin and lodge owners and individuals with trapping licences within the N22 region.

Flett Family: Orano has a long history of working collaboratively with the Flett family. In the late 1970s, the late Mr. Alex Flett was trapping in the exploration area for Cluff Lake. As the Cluff Lake mine was constructed, Mr. A. Flett maintained his trapping residence on the surface lease, and he continued traditional land use activities (hunting, fishing, trapping) throughout the mine life. He and his sons were employed at Cluff Lake and, in the mid-2000s, the company built him a permanent cabin on the shores of Cluff Lake where he spent significant time until he passed away in 2012.

Three members of the extended family remain active trappers within the N22 region and are therefore entitled to own and use a cabin within N22 for trapping purposes. The cabin on the shore of Cluff Lake was given to A. Flett in the mid-2000's but the cabin remained on the company provincial surface lease. Orano and A. Flett could not hold surface rights for the same location at the same time so, throughout the mine life, we worked collaboratively while the area was included in a comprehensive surface lease held by Orano. In 2018 to 2019, Orano concluded a process with the Province of Saskatchewan whereby about 0.1 hectares

of the Cluff Lake surface lease was surrendered to enable the establishment of a Traditional Resource User cabin lease for the Flett family cabin to provide the family with greater ownership and control. We see this parcel transfer as an important and respectful progression of the site's overall decommissioning.

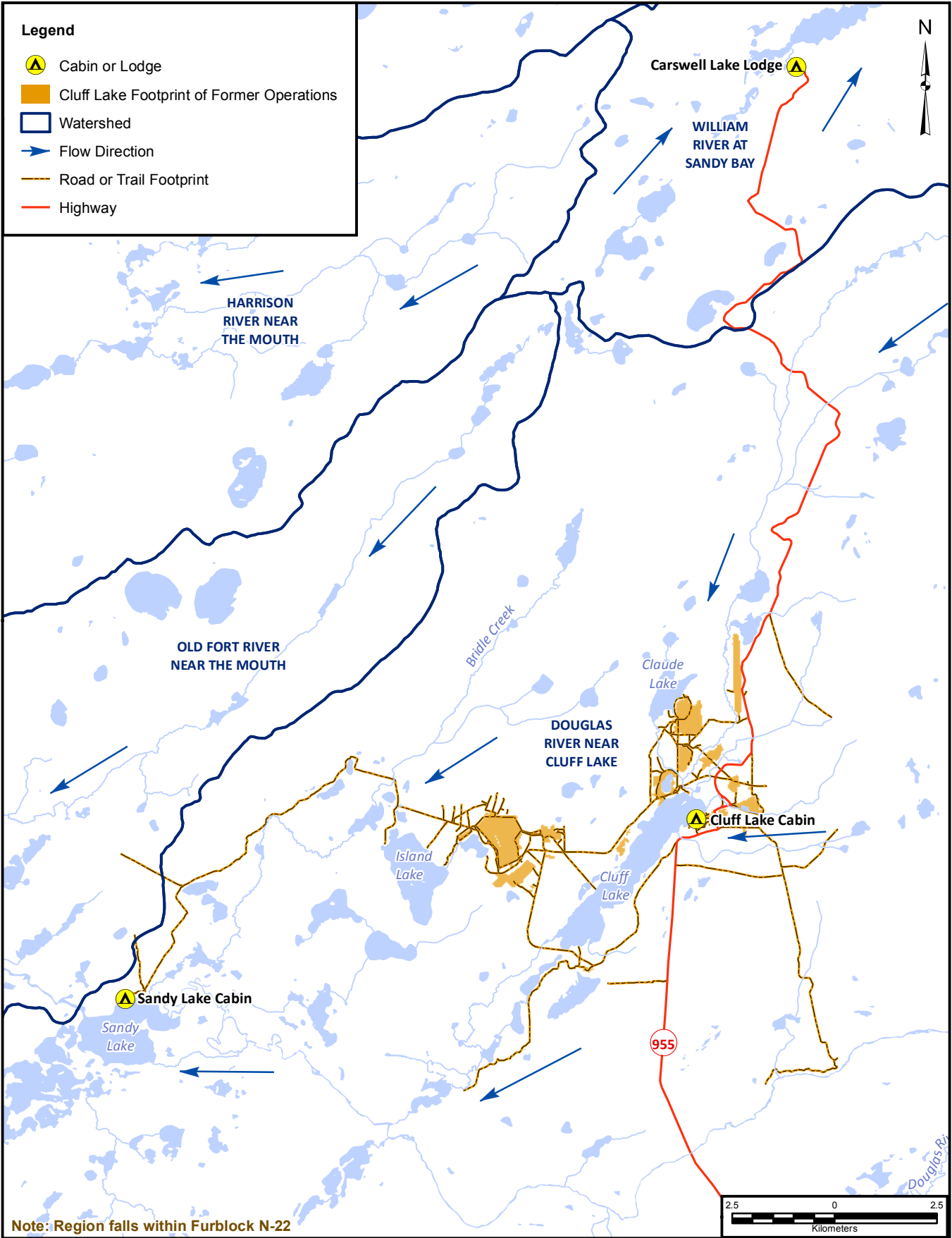
Orano staff have met members of the Flett family at Cluff Lake in 2013 to celebrate our working relationship and mark the end of the company's on-site presence and again in 2018 to provide a comprehensive tour of the decommissioned site. In 2018, with heavy equipment on site, Orano tidied the area immediately around the Flett cabin and installed security gates as mutually agreed. It has been a pleasure being neighbors throughout the years and we hope that members of the Flett family continue to view their cabin, with a backdrop of a decommissioned mine, as Shangri La (Flett 2006).

Lone Wolf Lodge Owner at Carswell Lake: Prior to the development of Cluff Lake, the road travelling north transitioned into an ice road servicing Uranium City. In the early years of mine development when the ice road was operating, the Ministry of Highways built a few seasonal bypass trails through the Cluff Lake surface lease so that road traffic would not interfere with mine operations. Over the life of the mine the portion of the provincial route overlapping with the mine surface lease was upgraded and during the operational life of the mine site access was controlled with north and south gates with escorted public access. In 2013, the security gates were removed when the site was approved for unrestricted access.

The Lone Wolf Lodge, a commercial fishing and hunting lodge, is established on the shores of Carswell Lake north of the Cluff Lake site. The lodge owners and their guests use this road to provide reliable access to Carswell Lake. There are also a few ACFN families with ties to Carswell Lake who value continued reliable access.

In addition to letters and phone calls, Orano representatives met with the lodge owner twice in 2013 prior to earthworks. In 2017, Orano representatives toured the lodge owner around Cluff Lake site and discussed options regarding the culvert infrastructure (three stream crossings) along road extending from Highway 955 to Carswell Lake. Removal of these culverts would make the route north to Carswell Lake largely impassable, certainly to truck and trailers. In 2018 and early 2019, Orano worked with the Province of Saskatchewan and lodge owner to find a collectively agreeable path forward for the long-term ownership of the culverts at three stream crossings. The company is currently in the process of gifting the culverts, surrendering a portion of the provincial surface lease, and facilitating the acquisition of the culverts by the lodge owner to be held under a Provincial Miscellaneous Use Permit (approval pending).

Furblock N22 Trappers: The additional two individuals with N22 trapping licenses do not have cabins near Cluff Lake. Most communication is through letters, phone calls, and opportunistic meetings. As an outfitter, one of the trappers has communicated to Orano that he is susceptible to perceived risk and negative Cluff Lake publicity as this can influence client confidence.



Projection: NAD 1983 UTM Zone 12N
 Compiled: T.Lohman Drawn: T.Lohman
 Date: 3/11/19 Scale: 1:130,000
 Data Sources: Natural Resources Canada, Geobase®, Nation
 Topographic Database, ORANO Canada Inc.

CLUFF LAKE PROJECT

FIGURE 4.1
 NEIGHBORING HISTORICAL AND CURRENT LAND USES

CLUFF LAKE COMMISSION MEMBER DOCUMENT 2019



5 Conclusions

The Cluff Lake Project realized a return on investment while contributing to the economic development of Saskatchewan without compromise to ecosystem integrity, health, or safety. Mining operations include decommissioning as a phase in the overall project life and the Cluff Lake Project may be considered the first decommissioned uranium mine site of its era in Saskatchewan. Coinciding with the end of successful operations in early 2002, the decommissioning of the site underwent a Comprehensive Study environmental assessment. The general decommissioning objectives and appropriate locations and timeframes for accomplishing the objectives were established in consultation with federal and provincial authorities, and through the company's public engagement process.

Over the licence term (August 1, 2009 to July 31, 2019), the remaining physical decommissioning works outlined in the Cluff Lake Detailed Decommissioning Plan were completed and the achievement of decommissioning objectives was demonstrated through transition-phase monitoring, modelling, and risk assessment. The site is safe and stable under passive care. Similar to a transition in mine life phase from *operations* to *decommissioning*, Orano is requesting recognition that the site has successfully transitioned from *decommissioning* to *post-decommissioning*. Monitoring and maintenance activities are expected and planned to occur during the post-decommissioning phase as recognized in the primary CNSC licensing document – the DPDP.

The licence amendments requested acknowledge completion of decommissioning, retain CNSC regulatory oversight, and administratively ready the site for future transfer to the provincial ICP. Orano anticipates successful transfer of the property to the Province will occur within two to five years. Should that not be the case, Orano will continue as the licensee. A separate, future licensing request will be submitted for the Commission to approve a release from licensing to enable a successful transfer of the Cluff Lake Project to the Provincial ICP.

6 References

- Amok Ltd. (AMOK), 1976. Environmental Assessment and Safety Report.
- Amok Ltd.. (AMOK), 1992. Environmental Impact Statement Dominique-Janine Extension February, 1992.
- AREVA Resources Canada Inc. (AREVA) 2009a. Cluff Lake Project - Detailed Decommissioning Plan, Version 2. February 2009.
- AREVA Resources Canada Inc. (AREVA) 2009b. Submission to the Canadian Nuclear Safety Commission: Application to renew and Amend Decommissioning Licence UMDL-MINEMILL.CLUFF.01/2009, April 9, 2009
- AREVA Resources Canada Inc. (AREVA) 2014. Cluff Lake Project, Detailed Decommissioning Plan, Version 3, December 2014.
- AREVA Resources Canada Inc. (AREVA) 2015. Hydrogeology and Groundwater Modelling Technical Information Document. June 2015.
- AREVA Resources Canada Inc. (AREVA) 2015. Cluff Lake Project-Environmental Performance Technical Information Document – Volume 1, September 2015.
- AREVA Resources Canada Inc. (AREVA) 2015. Cluff Lake Project-Environmental Performance Technical Information Document – Volume 2, September 2015.
- AREVA Resources Canada Inc. (AREVA) 2015. Cluff Lake Project Follow-up Program – Version 3. October 2015.
- Atomic Energy Control Board (AECB). 1974. Regulation of Uranium Mining and Milling in Canada
- Bayda, E.D., McCallum, K.J. and Groome, A.J. (Bayda). 1978. The Cluff Lake Board of Inquiry Final Report. Regina, Saskatchewan. May 1978.
- Canadian Environmental Assessment Agency (CEAA). 1992. *Canadian Environmental Assessment Act*. S.C. 1992, c.37.
- Canadian Environmental Assessment Agency (CEAA). 2012. *Canadian Environmental Assessment Act*. 2012.
- Canadian Nuclear Safety Commission (CNSC) 2003. Comprehensive Study Report Cluff Lake Decommissioning Project. December 2003.

- Canadian Nuclear Safety Commission (CNSC), 2009. Record of Proceedings, Including Reasons for Decision in the Matter of Application to Renew the Cluff Lake Uranium Mine Decommissioning Licence, June 10, 2009.
- Canadian Nuclear Safety Commission (CNSC). 2016. Regulatory Oversight Report for Uranium Mines, Mills Historic and Decommissioned Sites in Canada 2015.
- Canadian Nuclear Safety Commission (CNSC). 2018a. Regulatory Oversight Report for Uranium Mines, Mills Historic and Decommissioned Sites in Canada 2017.
- Canadian Nuclear Safety Commission (CNSC), 2018b. Issuance of Licence Amendment UMDL-MINEMILL-CLUFF.01/2019.
- Canadian Standards Association (CSA). 2012. Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills. N288.6
- COGEMA Resources Inc. (COGEMA) 2000. Cluff Lake Project Comprehensive Study for Decommissioning, Comprehensive Study Report. Version 1, Main Report, Supporting Document, and Appendices. December 2000.
- COGEMA Resources Inc. (COGEMA) 2003. Cluff Lake Project - Detailed Decommissioning Plan, Version 1 Revision 0. October 2003.
- COGEMA Resources Inc. (COGEMA) 2004. Cluff Lake Project – Detailed Decommissioning Plan, Version 1 Revision 1. May 2004.
- Environmental Assessment and Review Process Guidelines Order. (EARPGO). 1984.
- Environmental Assessment Policy (EAP). 1978. Government of Saskatchewan.
- Flett, Edward., 2006. Submission to the CNSC from Edward Flett in the Matter of Regulatory Oversight Report for Uranium Mines, Mills, Historic and Decommissioned Sites in Canada; 2015. CMD 16-M49.6
- Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (Joint Panel). 1993. Dominique-Janine Extension, McClean Lake Project, and Midwest Joint Venture. Report of the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan. October, 1993.
- Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (Joint Panel). 1997. Report of the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (Cumulative Observations). November, 1997.
- Ministry of the Environment (MOE), 2015, Letter of Acceptance - Cluff Lake Project – Detailed Decommissioning and Reclamation Plan & Financial Assurance. July 6, Merkowsky to Huffman

Ministry of the Environment (MOE), 2019, Letter of Acceptance - Cluff Lake Project – Detailed Post-Decommissioning Plan (ver. 4, rev. 0) February 14, Moulding to Huffman

Orano Canada Inc. (Orano) 2019. Cluff Lake Project, Detailed Post-Decommissioning Plan: Post-Closure Monitoring and Maintenance (DPDP) Version 04, March 2019

Saskatchewan Ministry of Energy and Resources (SMER). 2009. Institutional Control Program. Post Closure Management of Decommissioned Mine/Mill Properties Located on Crown Land in Saskatchewan. December. Regina, SK.

SRC Publication (SRC) 1982. Cluff Mining: Cluff Lake Development Phase II Environmental Impact Assessment., November, 1982.

Appendix A TMA Cover Evaluation Report (SNC Lavalin)



SNC • LAVALIN

Environment & Geoscience

216 - 1st Avenue South
Saskatoon, Saskatchewan, Canada S7K 1K3
☎ 306.668.6800

March 14, 2019

Project: 663252

Orano Canada Inc.
817 45th Street West
Saskatoon, SK S7N 5X2

ATTENTION: Diane Martens, HSE Project Manager

REFERENCE: **Cluff Lake Project – Review of the Design Process and Performance of the Decommissioned Tailings Management Area**

1 Introduction

Orano Canada Inc. (Orano) is the owner and operator of the Cluff Lake Project (“the Site”), a former uranium mine and mill complex located in the Athabasca Basin of northern Saskatchewan, approximately 75 km south of Lake Athabasca and 15 km east of the provincial border with Alberta. Milling operations occurred between 1980 and 2002 while the majority of physical decommissioning work occurred between 2004 and 2006. A permanent presence on-Site was discontinued in 2013 after the majority of repair and maintenance activities at the Site were completed. The physical decommissioning of remaining surface infrastructure and minor earthworks was carried out in 2017-2018. Quarterly campaign monitoring events occurred at the Site until December 2017 after which annual monitoring took place. Orano is planning to apply for transferral of the Site into the provincial Institutional Control Program (ICP) as early as 2020.

One of the major decommissioned facilities at the Site is the Tailings Management Area (TMA), which is an above-ground tailings disposal facility containing uranium mill tailings. The tailings were decommissioned in-place by constructing an engineered landform incorporating a ‘dry’ or soil cover system over the entire tailings footprint. Some stakeholders are concerned about the decommissioning design selected for the TMA and in particular, the ability of the chosen cover system design to adequately protect the health of human and ecological receptors over the long term.

Orano requested that Mr. Brian Ayres, M.Sc., P.Eng. of SNC-Lavalin Inc. complete a review of the steps taken by Orano, formerly COGEMA Resources Inc. (COGEMA) and AREVA Resources Canada Inc. (AREVA), to select the final TMA decommissioning design, as well as a review of the current and anticipated long-term performance of the facility. This letter represents Mr. Ayres’ professional opinions on these matters. The qualifications of the author include a Master of Science degree in Geotechnical Engineering from the University of Saskatchewan, with a thesis focused on the Cluff Lake TMA and surrounding natural terrain (Ayres, 1998), as well as his 22+ years of experience and numerous publications in the mine waste reclamation field (CV contained in [Appendix I](#)).





2 Pertinent Background Information

Background information pertinent to the scope of the author's review includes:

- › Key elements of the TMA;
- › Decommissioning objectives for the Site;
- › Design functions and performance standards for the TMA cover system;
- › Site climatic conditions; and
- › Hydrogeologic setting of the TMA.

Key Elements of the TMA:

Initial construction of the Cluff Lake TMA occurred in 1979 with several modifications to the facility occurring throughout its life. [Figure 1](#) shows key features of the TMA as it existed near the end of operations. An earthen dam referred to as the Main Dam, comprising a gravelly-sand till shell and a compacted till-bentonite core extending into bedrock, was lengthened and raised in 1993, resulting in an approximate 1.24 km long and 7 m high (maximum) structure (COGEMA, 2000b). The downstream slopes of the Main Dam were flattened to 4H:1V using glacial till in 2006, to increase the long-term geotechnical and erosional stability of the structure (AREVA, 2006). Geotechnical stability analyses of the buttressed Main Dam indicate factors of safety ranging between 2.2 and 2.6 for local and overall stability (COGEMA, 2000b).

Sub-aerial deposition of slurry tailings from spigots located along the eastern perimeter of the TMA was the technique used to place the majority of tailings in the TMA (COGEMA, 2000b). Several internal dykes were constructed to create various cells for optimizing storage of tailings solids within the TMA (COGEMA, 1998). Approximately 3.28 million dry tonnes (~2.56 million m³) of tailings were discharged into the Upper Solids, Lower Solids, and Lower Solids Decant areas (footprint of ~57 ha) during operations (COGEMA, 2004). Liquids management (from the TMA, mines, and mill) consisted of chemical addition in the Primary Treatment System (PTS) plant, settlement in the Liquids Pond, final treatment in the Secondary Treatment System (STS) plant, and final settlement in the STS ponds prior to discharge to the receiving environment according to licensed treated effluent discharge quality limits.

The South Diversion Ditch (SDD) and North Diversion Ditch (NDD) were constructed in 1999 and 2000, respectively, to divert uncontaminated water (from the drainage basin surrounding the TMA) to Snake Lake (AREVA, 2014b). These ditches minimize run-on of clean water into the TMA and ensure that area runoff from a major precipitation event, including the Probable Maximum Flood (PMF), can be safely diverted around the TMA. The PMF was generated from the 24-hour point probable maximum precipitation (PMP) event for the Site, prescribed by Hopkinson (1994) as 497 mm acting on an aerial catchment of 1 km² or less. SRK (2018b) assessed performance of the SDD and NDD under vegetation conditions as well as breach of an upgradient beaver dam for the NDD. SRK (2018b) concluded surface water management for the TMA, under normal circumstances, is expected to function as intended based on the original design intent, without the need for further remedial works.





Figure 1 Features of the TMA as of 2000 (COGEMA, 2000a)





A minimum 1 m thick gravelly-sand till cover was placed over the tailings between 2001 and 2006 with a vegetated surface sloping 1.5% to 2.0% from the southeast to the northwest (AREVA, 2006). This is referred to as a 'moisture store-and-release' cover system with 'water-shedding' capabilities in the mine waste reclamation industry (International Network for Acid Prevention (INAP), 2017). The TMA cover system was constructed in three phases; namely, the Upper Solids levelling course (Q4 of 2001), the Lower Solids levelling course (Q1 and Q4 of 2013), and the TMA grading course (various times between 2004 Q4 and 2006 Q1). Construction of some portions of the cover was completed during winter months to take advantage of frozen conditions, which is common practice when working with softer materials in a cold region (Mine Environment Neutral Drainage (MEND), 2012). Approximately 751,000 m³ of local till material, with a grain size ranging from 0-8% boulders / cobbles, 12-30% gravel, 58-64% sand, and <16% silt and clay, was used to construct the cover system over the tailings footprint (AREVA, 2006). The mean till cover thickness over the tailings footprint is ~1.4 m (Figure 2).

The Liquids Pond was backfilled to an elevation above the anticipated post-closure phreatic surface and graded to minimize ponding water on the surface. The backfill was placed in maximum 2 m lifts, with the final surface graded smoothly and into adjacent topography such that local and upgradient runoff would flow onto and over the former Liquids Pond (COGEMA, 2004). Small areas of both the Lower Solids Decant Area and Liquids Pond were too soft to support final grading equipment during initial decommissioning; hence, final grading of these areas was deferred until the material had adequately dewatered to support grading equipment (Denison Environmental Services (DES), 2013). Settling resulted in low lying areas with temporary ponded water; larger areas with ponded water were backfilled in 2013 (DES, 2013). The mean till cover thickness in the former Liquids Pond is ~3.1 m (Figure 2).

Surface runoff waters incident to the TMA are routed via overland flow to a collector channel situated approximately 50 m upgradient of the Main Dam. This channel conveys runoff waters to the northeast corner of the former Liquids Pond, where an outlet channel provides a single point of discharge from the TMA. The discharge structure from the TMA is a 30 m wide armoured channel extending to the shoreline of Snake Lake. The surface water drainage channels are designed to pass the full volume of the PMF. A cobble dam was constructed within the channel alignment to reduce total suspended solids (TSS) from migrating off the TMA into Snake Lake, with the intent of it being removed after vegetation on the cover system had adequately established. The temporary cobble dam was removed in 2017 (AREVA, 2018).

The TMA cover system, Main Dam buttress, and perimeter grading area (total footprint of ~95 ha) were seeded in August 2005 with shallow-rooting grasses and forbs as detailed in AREVA (2006). This vegetative cover was intended to slow the rate of natural invasion onto the TMA cover system while at the same time, increasing the erosional stability of the cover system surface. As native vegetation progressively invades, the soil binding capabilities of the grass/forb understory will persist and be supplemented by the rooting systems of native species (AREVA, 2014b). The predominant native vegetation at the Site in upland, sandy soil areas is jackpine with moss, lichen and blueberry as a predominant understory (COGEMA, 2000a). Vegetation surveys have been completed on a regular basis since 2008, with the results of the 2014 survey detailed in HAB-TECH Environmental Ltd. (HTEL, 2015).



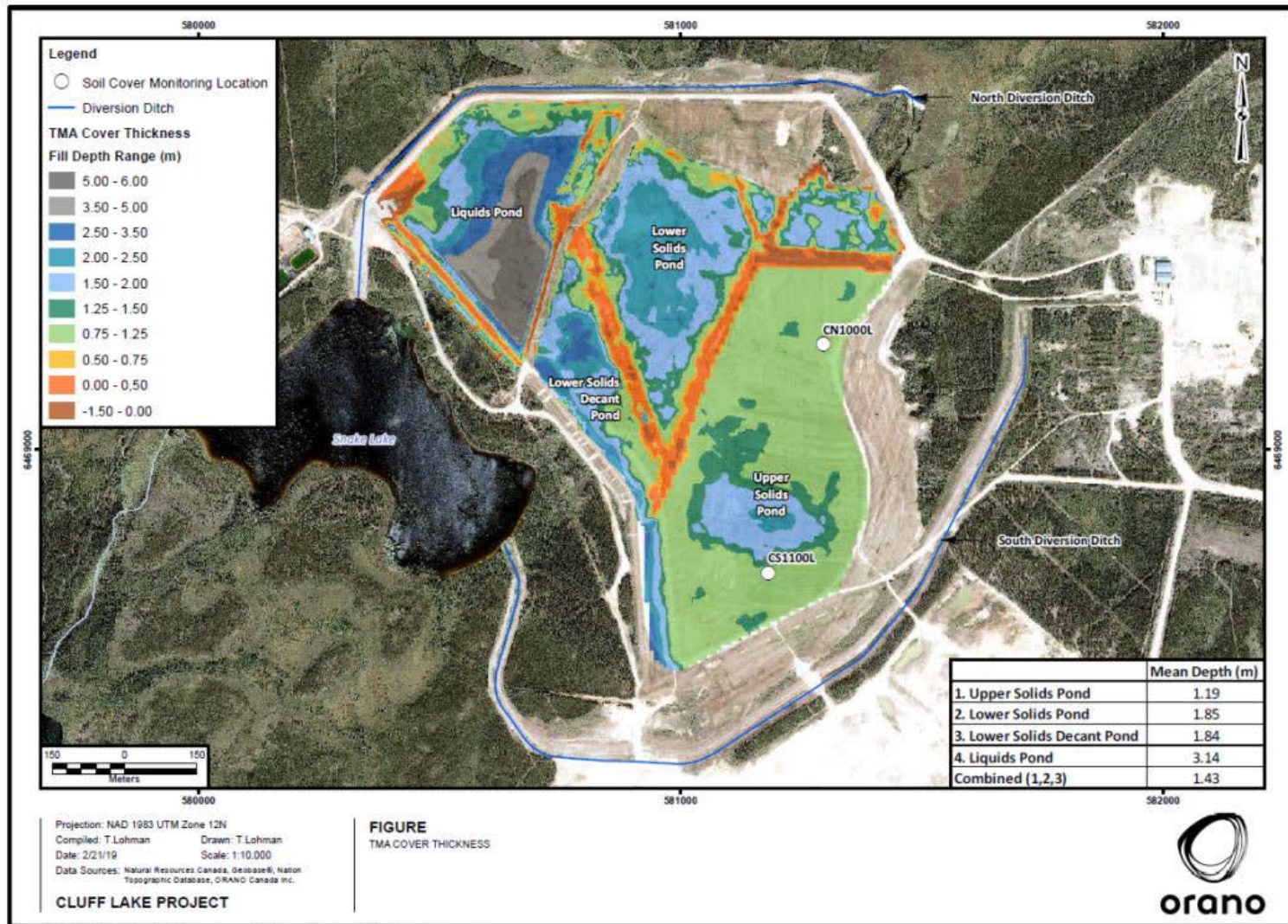


Figure 2 As-Built Thickness of the TMA Cover System (drawing courtesy of Orano)





Finally, various instruments were installed upgradient, within, and downgradient of the TMA, during and after the operations phases, to monitor the physical and chemical performance of the TMA pre- and post-decommissioning. This includes numerous groundwater monitoring wells (piezometers) for groundwater flow direction and quality monitoring (Orano, 2018), as well as soil water content and suction sensors installed within and below the cover system for estimation of net percolation (NP) rates through the cover system (O’Kane Consultants Inc. (OKC), 2006).

Decommissioning Objectives for the Site:

A Detailed Decommissioning Plan (DPP) was developed for the Site to achieve an end-state where the:

- › environment is safe for use by human and non-human biota;
- › reclaimed landscape is chemically and physically stable;
- › self-sustaining landscape allows utilization for traditional purposes; and
- › potential constraints on future land use are minimized (AREVA, 2014b).

Site-specific objectives were established to evaluate the success of the Site decommissioning program, which, when achieved, indicate the Site has been successfully decommissioned and meet the overall conditions described above. AREVA (2014b) states the following criteria are indicators of decommissioning success:

- › Achieving Decommissioning Surface Water Quality Objectives (DSWQO) and other accepted decommissioning objectives at surface water and flooded pit locations;
- › Levels of surface gamma radiation (SGR), radon progeny (RnP), and long-lived radioactive dust (LLRD) which pose no unacceptable risk to traditional land use, and which are consistent with application of the ‘as low as reasonably achievable’ (ALARA) principle;
- › A stable, self-sustaining landscape;
- › Reduction of NP rates through the TMA and Claude Waste Rock Pile (CWRP) to levels that adequately restrict contaminant movement to groundwater and are suitably protective of downstream surface water receptors; and
- › Return of the Site to an aesthetically acceptable state, similar in appearance and land capability prior to the start of mining, and that poses no unreasonable risk to humans or the environment.

Design Functions and Performance Standards for the TMA Cover System:

Design functions required for the TMA cover system to support Site decommissioning objectives include:

- › Stable from a geotechnical and soil erosion perspective;
- › Providing a medium for sustainable growth of vegetation to promote transpiration and wildlife habitat;
- › Attenuating radiological exposure to human and terrestrial receptors to acceptable levels; and
- › Reducing NP rates into the tailings mass to acceptable levels by promoting runoff and evapotranspiration of incident meteoric waters.

No specific performance standards exist for the TMA cover system in regards to physical stability (e.g. acceptable rate of soil erosion), other than the requirement for it to be ‘stable and self-sustaining’. It is noted, however, that performance standards exist for geotechnical stability of the Main Dam as per guidelines in CDA (2013) and CDA (2014).





No specific performance standards exist for the TMA cover system with regards to revegetation development (e.g. percent coverage for a given species), other than establishing a vegetative ground cover that is self-sustaining and effective in controlling erosion (COGEMA, 2000a).

Post-decommissioning LLRD and RnP levels are near background and did not require specific decommissioning objectives (AREVA, 2014a; 2014b). The potential exposure to SGR is assumed to be the primary exposure pathway for human and terrestrial receptors. The following performance standards for radiological exposure apply to the post-decommissioned Site (CNSC, 2003):

- › The annual effective dose to the most exposed person using the Site after the completion of all decommissioning activities will be less than 1 mSv; and
- › Wherever possible, SGR levels measured one metre above the surface of the ground are not to exceed a maximum spot dose of 2.5 μ Sv/h above background or 1 μ Sv/h above background averaged over a 100 m x 100 m surface.

Soil-plant-atmosphere (S-P-A; often referred to as ‘infiltration’) modelling completed for the Comprehensive Study for Decommissioning (CSD; Appendix C in Supporting Document 1 of COGEMA, 2000b) predicted mean annual NP rates ranging between 39 mm/yr (for a water table depth 1 m below the tailings surface) and 43 mm/yr (for a water table depth 1 m below the tailings surface); these NP rates equate to about 12% of the simulated “thawed season” precipitation (366 mm). It is important to note that NP rates for the TMA cover system will vary from year to year depending on antecedent moisture conditions as well as the timing and form of precipitation (MEND, 2007); the 12% NP of annual precipitation is a mean value over the life of the decommissioned facility. The overarching performance standard for NP is that it be controlled adequately to attenuate peak concentrations for contaminants of concern (COCs) in natural watercourses, to levels that can be assimilated without unacceptable adverse effects on the aquatic ecosystem.

Site Climatic Conditions:

The Site is located in the Northern Climatic Region (sub-arctic) of Saskatchewan. The following values are based on Environment Canada 1981 to 2010 climate normals for the Site (EC, 2019):

- › Mean temperatures of -0.7 °C annually and mean daily maximum of 22.7 °C for July and mean daily minimum of -25.5 °C for January;
- › Mean annual precipitation of 451 mm with approximately 70% occurring from April to October; and
- › Mean annual lake evaporation of 521 mm.

The Koppen-Geiger climate classification system allows seasonality to be considered across all climate regimes (Peel *et al.*, 2007). The classification for the Site is ‘Dfc’ (cold, no dry season, cold summer).

Hydrogeologic Setting of the TMA:

The hydrogeologic setting for the TMA is summarized herein based on information contained in COGEMA (2000a, 2000b) and AREVA (2015a). The TMA is located over a sandstone bedrock body that is bounded to the northeast by lower hydraulic conductivity Archean basement rock, to the southwest by lower conductivity Douglas Formation dolomite and siltstone, and the northwest and southeast by regional fault structures. The primary materials in the vicinity of the TMA consist of overburden over sandstone. The overburden consists of a glaciofluvial sand over a sand matrix till.





The local groundwater flow system in the vicinity of the TMA is a simple gravitational flow system. Groundwater recharge infiltrates to the zone of saturation in the upland areas adjacent to the TMA and moves downward and laterally, discharging into the TMA and Snake Lake. The pelitic sandstone unit, which underlies two-thirds of the TMA, acts as a low permeability barrier to groundwater flow; its estimated mean saturated hydraulic conductivity ranges between 3.5×10^{-8} to 1.0×10^{-9} m/s. Water levels that are close to ground level or higher have been observed in some monitoring wells in the former Liquids Pond, Lower Solids Decant area, and Lower Solids Pond both upgradient and downgradient of the Main Dam. This supports the fact that groundwater flow across the pelitic sandstone is under sub-artesian or artesian pressures.

3 The Process Leading to the Chosen TMA Decommissioning Design

Three primary alternatives were considered for decommissioning the TMA during the CSD (COGEMA, 2000a; 2000b):

- a) Decommissioning the tailings in-place with an engineered wet (water) or dry (soil) cover system;
- b) Reprocessing the tailings to reduce COC concentrations; and
- c) Relocating the tailings to a new above-ground storage facility, a specially constructed pit, or existing underground workings.

Orano and its CSD technical consultants determined that Options (b) and (c) were not technically or economically feasible based on the best available information at the time of executing the CSD. The following alternatives were considered in the CSD for decommissioning the tailings in-place:

- › A water cover system;
- › A barrier-type cover system, referred to as a 'zoned' cover system in COGEMA (2000a; 2000b); and
- › A moisture store-and-release cover system, referred to as a 'simple till' cover system in COGEMA (2000a; 2000b).

Although a water cover system has been effectively utilized at other sites (e.g. uranium tailings impoundments in the Elliot Lake, ON area), there were two principal reasons why it was not selected for decommissioning the Cluff Lake TMA as reported in COGEMA (2000a). Firstly, the TMA is located in the upper portion of a relatively small watershed and consistent supply of an adequate water cover could not be assured during dry periods. Secondly, the increased water head over the tailings surface would significantly increase NP rates through the tailings mass, leading to detrimental effects on the quality of water in Snake Lake.

The zoned cover system alternative considered in the CSD incorporated a low permeability layer of compacted till-bentonite and an overlying layer of till to protect the low permeability layer from desiccation and frost action and support plant growth. Compacted till-bentonite was the preferred material for creating a low permeability layer in the TMA cover system due to the following reasons:

- › Successful use of the material in creating a low permeability core for the Main Dam;
- › Lack of a sufficient volume of natural silty-clay or clayey soils within the region; and





- › Longevity concerns for geosynthetic products such as a high-density or linear low-density polyethylene (HDPE or LLDPE) geomembrane or a geosynthetic clay liner (GCL).

S-P-A modelling showed the zoned cover system alternative would adequately reduce NP rates and provide acceptable water quality results in Snake Lake. However, according to COGEMA (2000b), technical and logistical concerns existed for this alternative including structural integrity in areas where tailings were not fully consolidated, potential delays in construction, and considerable cost for purchasing and transporting the bentonite to Site (viable sources of sodium bentonite are located in Wyoming).

The 1 m thick till cover system was modelled in the CSD to determine its effectiveness in reducing NP rates and corresponding contaminant flux to Snake Lake. Modelling results showed that with a reasonable estimate for attenuation of COCs along the flowpath between the TMA and Snake Lake, COC concentrations predicted for the Snake Lake water column over a 10,000 year assessment period were within DSWQO values. As a result, there was no need for Orano to proceed with a more complex cover system design, one that would not only incur additional costs but also uncertainties associated with the longevity of a low permeability layer. Given the climatic setting of the Site and relatively high cation concentrations in the local till material (Table 2.8-2 in COGEMA, 2000a), frost action on and cation exchange within the compacted till-bentonite layer are two failure modes that would have a high likelihood of negatively affecting the integrity / performance of the zoned cover system (MEND, 2012).

Table A highlights the investigations and analyses that Orano completed to demonstrate that the chosen decommissioning design for the TMA would result in an absence of unreasonable risk to human and ecological receptors over the short, medium, and long terms. Based on the author's experience, the number and range of investigations / analyses completed by Orano and its technical consultants suggest that selection of the chosen decommissioning plans for the Cluff Lake TMA was based on a fairly thorough exercise. COGEMA (2004) completed additional analyses including hydrologic assessments for the PMF to support detailed design of the TMA final landform.

The preferred decommissioning design for the TMA was reviewed by pertinent provincial and federal regulatory agencies; comments and questions posed by regulators following their review of the 2000 CSD report as well as Orano's responses are detailed in COGEMA (2001). Orano also carried out public consultation meetings throughout the entire CSD process (Appendix F of COGEMA, 2000a). CNSC (2003) noted that some uncertainties exist in the predicted performance of the TMA final landform and cover system, and that an Environmental Monitoring Program (EMP) and Environmental Assessment Follow-up Program (FUP) would need to be carried out by Orano to address the uncertainties and confirm the success of the chosen decommissioning plans.





Table A Key Investigations and Analyses Completed to Support Chosen TMA Decommissioning Design

Timeframe	Description of Investigation or Analysis	Key Outcomes from Investigation or Analysis	Reference
1995 to 1998	Field monitoring of S-P-A fluxes through a bare tailings surface and natural soils at Site (U of S research program)	› Site-specific climatic and soil response database to support calibration of CSD S-P-A numerical models	Ayres (1998)
1995 to 1997	In-depth geochemical analyses of tailings (U of S research program)	› Supporting data for COC tailings source terms required for CSD 3-D GW flow and CT modelling	Goulden (1997)
~1980 to 2000	Surface water and GW levels and chemistry analytical data for various locations upgradient, within, and downgradient of the TMA (collected during OEMP or ad-hoc investigations)	› Supporting data for robust calibration of the CSD 3-D GW flow and CT modelling program	COGEMA (2000a; 2000b)
~1980 to 2000	Drilling and logging numerous boreholes at various locations upgradient, within, and downgradient of the TMA	› Robust 3-D model of the TMA and surrounding terrain geology for CSD 3-D GW flow and CT modelling	COGEMA (2000b)
1999 to 2002	Construction, instrumentation, and performance monitoring of a test soil cover over thawed coarse tailings	› Database of climatic and soil responses to support calibration of CSD S-P-A numerical models	CAL (2001; 2002a; 2002b)
2000	Geochemical modelling of tailings solids and pore-waters as part of the CSD	› Robust COC tailings source terms for input to CSD 3-D GW flow and CT modelling	COGEMA (2000b; 2001)
2000	S-P-A modelling of various till cover thicknesses and water table elevations using site-specific S-P-A data	› Initial understanding of expected performance of preferred cover system and mean annual NP rate for input to 3-D GW flow and CT modelling	COGEMA (2000b; 2001)
2000	3-D GW flow and CT modelling of pre-closure conditions and various decommissioning alternatives	› Predicted COC concentrations in downgradient surface water and GW receptors for input to pathways analysis	COGEMA (2000b; 2001)
2000	Pathways analysis including air quality and water / sediment quality modelling for preferred decommissioning plans for the entire Site	› Predicted COC concentrations in air, water, and sediment over a 10,000 year assessment period	COGEMA (2000a; 2001)
2000	Human health and ecological risk assessment for preferred decommissioning plans for entire Site	› Predicted risks to human and ecological receptors for the preferred TMA decommissioning design over a 10,000 year assessment period	COGEMA (2000a; 2001)

Legend: COC = contaminants of concern; CSD = Comprehensive Study of Decommissioning; CT = contaminant transport; GW = groundwater; NP = net percolation; OEMP = operations environmental monitoring program; S-P-A = soil-plant-atmosphere; U of S = University of Saskatchewan.



4 Review of Current Performance of Decommissioned TMA

Construction of the TMA final landform and cover system was completed in the fall of 2006 as detailed in AREVA (2006). A relatively large EMP has occurred at the Site since 2006 including follow-up investigations and analyses to better understand the current and anticipated long-term performance of the decommissioned TMA; key EMPs and investigations undertaken for the TMA since 2006 includes:

- › Air, surface water, and groundwater monitoring at regular intervals at various locations upgradient and downgradient of the TMA with recent trends summarized in Orano (2018);
- › *In situ* monitoring of soil and water conditions within and below the TMA cover system to support estimates of annual NP rates;
- › Gamma radiation surveys of the decommissioned TMA and background areas (AREVA, 2007);
- › Biennial geotechnical inspections of the entire decommissioned TMA with the 2018 inspection findings documented in SRK (2018a);
- › Detailed assessments of vegetation growth on the TMA cover system in 2008, 2009, 2010, and 2014 (HTEL, 2015); and
- › Review and assessment of the performance of the SDD and NDD under vegetation conditions as well as breach of an upgradient beaver dam for the NDD (SRK, 2018b).

The author completed a desktop assessment of the overall performance of the TMA cover system since its final construction in 2006. It is focused on performance of the TMA cover system as it relates to the design functions required to achieve the overall Site decommissioning objectives. The assessment is based on the results of the EMP as well as findings of other studies completed by technical consultants between 2006 and 2018.

Stable Landform:

Physical stability of the decommissioned TMA landform was examined based on a review of SRK's 2018 geotechnical inspection findings (SRK, 2018a) and their assessment of current conditions of the SDD and NDD (SRK, 2018b). Key findings of the 2018 geotechnical inspection of the decommissioned TMA include (SRK, 2018a):

- › No signs of geotechnical instability of significance for the Main Dam;
- › No signs of ponded water of significance on the TMA cover system (see [Figure 3](#));
- › No signs of active erosion damage of significance on the Main Dam, cover system, and surface water drainage courses;
- › Natural revegetation of the SDD and NDD is occurring; and
- › A large beaver dam exists at the start of the NDD, causing the water level to be ~1.5 m above the invert of the channel.

Orano retained SRK in 2018 to assess the potential effects of vegetation developments in the SDD and NDD on their design discharge capacity and a potential breach of the beaver dam upstream of the NDD. SRK (2018b) concluded the following based on their assessment:





Figure 3 Photo of the decommissioned TMA (looking east) as of September 2018 with Snake Lake on the right-side of the image (photo courtesy of Orano)

- › The increase in vegetation produces a minor reduction in capacity but does not cause the diversion ditches to overtop into the TMA in the event of a PMF, and therefore are considered cable of meeting design flow criteria;
- › The scenario of a PMF event coupled with the presence of a beaver dam greater than 2.0 m in height could overtop the banks of the NDD; however, this scenario may be appropriately considered in risk assessment accidents and malfunctions, long-term monitoring, or institutional control funds; and
- › Surface water management for the TMA is expected to function as intended under normal circumstances based on the original design intent.

Based on a review of SRK recent reports (2018a and 2018b), no evidence was presented to suggest the decommissioned TMA is physically unstable.

Medium for Sustainable Growth of Vegetation:

Establishing and sustaining a healthy community of various plant species on the TMA cover system is important for a number of reasons, including:

- › Stabilizing the surface to limit excessive soil erosion;
- › Promoting transpiration (and to a lesser extent interception) of incident meteoric waters to reduce NP through the tailings mass; and
- › Creating wildlife habitat.

Detailed assessments of vegetation growth on the TMA cover system were carried out in 2008, 2009, 2010, and most recently in 2014 (HTEL, 2015). Key findings and conclusions from the 2014 survey of vegetation growth on the TMA cover system include (HTEL, 2015):

- › Graminoid, forb, and bryophyte coverage has remained relatively stable since 2011; however, the number of saplings has increased significantly;





- › Vegetation samples from the reclaimed areas contained higher or similar concentrations of nutrients as the reference sites; hence, it is reasonable to suggest nutrient levels are sufficient for growth and hardiness of plants on reclaimed sites;
- › The seeded area of the TMA appears to be doing quite well and appears to be on a trajectory towards natural revegetation; and
- › More moose pellet groups or droppings was observed in 2014 compared to 2011 suggesting that ungulate use of the reclaimed area is increasing towards that of undisturbed areas.

More recently, Orano (2018) states “vegetation continues to establish on the cover and Main Dam, and new vegetation continues to be observed to be growing in areas where earthworks occurred in 2013” based on inspections completed during the 2017 quarterly campaign monitoring events. SRK (2018a) states the “cover is covered with grasses and bushes that appear to be growing healthy” based on observations made during the 2018 geotechnical site inspection.

Furthermore, representative samples of vegetation growing on the TMA cover system were collected and submitted for chemistry analyses between 2010 and 2014. According to Canada North Environmental Services (CNES, 2018), COC concentrations in TMA cover vegetation are not posing an unreasonable risk to ecological receptors.

The author is of the opinion that the TMA cover system appears to be functioning as designed as far as it pertains to providing a medium for sustainable growth of vegetation. This opinion is based on assessments and observations completed by others and in particular, the findings of the 2014 vegetation survey by a qualified vegetation and wildlife consulting firm.

Attenuating Radiological Exposure to Human and Terrestrial Receptors:

The two radiological exposure pathways of concern for human and terrestrial receptors post-decommissioning at the TMA include RnP and SGR. Radon monitoring uses track-etch cups, which have a radiosensitive element that records alpha particle emissions from the decay of radon and its progeny (Orano, 2018). Radon concentrations measured at the monitoring location nearest the TMA (TRK0011E) between 2006 and 2017 are well within the bottom half of the mean regional background levels measured at Wollaston Lake (15 to 90 Bq/m³) (Orano, 2018). An earthen cover reduces radon fluxes by about a factor of two for every 0.5 m of thickness and a high water content in the tailings / cover profile substantially reduces radon fluxes compared to drier conditions (Rogers *et al.*, 1980). Given the mean till cover thickness of approximately 1.4 m (Figure 2) and relatively shallow depth to the water table (AREVA, 2015a; OKC, 2019), it is not surprising that RnP levels in the vicinity of the TMA are comparable to regional background levels.

A SGR survey was completed over all disturbed and reclaimed areas including the TMA cover system as detailed in AREVA (2007). It was concluded that the TMA met the agreed-upon performance standards for SGR clearance. The CNSC contracted SENES Consultants Ltd. (SENES) in January 2008 to conduct an independent review that included demonstrating: i) that the criterion of 1.0 µSv/hr averaged over 10,000 m² areas was dose-based using site-specific considerations; ii) that AREVA used the approved procedures in CL-RP-62 Rev 0; and iii) that the results in the AREVA report met the criteria and guidelines for clearance. The scope of SENES' contract included an on-Site verification survey of SGR dose rates from areas of particular concern to the CNSC including the TMA. SENES (2009) concluded





from results of the verification survey that AREVA followed the approved procedure for conducting the SGR survey and interpreting the results.

The author is of the opinion that the TMA cover system appears to be functioning as designed as far as it pertains to attenuating radiological exposure to human and terrestrial receptors to acceptable levels. This opinion is based on measurements and assessments completed by others and in particular, the findings of the 2008 verification survey completed by a qualified radiological consulting firm.

Reducing NP Rates to Acceptable Levels:

The author used two approaches to examine performance of the TMA cover system as it relates to reducing NP rates to acceptable levels:

- a) Review of NP rates estimated at two soil cover monitoring stations; and
- b) Review of surface water quality for key COC concentrations measured upstream and downstream of the TMA.

Two automated stations (CN1000L and CS1100L) were established in the former Upper Solids Pond area in August 2006 (OKC, 2006). These stations continuously monitor changes in moisture and temperature conditions in the cover and upper tailings profile. An automated weather station was also installed near station CS1100L to monitor air temperature, relative humidity, wind speed and direction, net solar radiation, and rainfall. Two wells, CS1100G and CN1000G, are located adjacent to the automated stations and continuously monitor hydraulic head (i.e. water table elevation). The water balance method, which is described in MEND (2012) and INAP (2017), is used to estimate annual NP values at each location; the most recent water balance flux estimates including NP can be found in OKC (2019).

Table B summarizes the NP values estimated at each monitoring station since the onset of monitoring. Annual NP estimated as a percentage of incident precipitation ranged from 1% to 19% at station CN1000L and 6% to 22% at station CS1100L with a mean value of 12% for both locations. The variability in NP values is attributed to antecedent moisture conditions, the timing and form of precipitation, and the relative position of the water table (i.e. depth to the water table from surface). The mean annual NP values estimated for the TMA cover system during the first 11 years post-construction are within the long-term range used for predictions of contaminant transport in the CSD (COGEMA, 2000b).

Some questions have been raised regarding the importance or significance of vegetation and associated actual evapotranspiration (AET) in reducing NP rates through the TMA cover system. As part of the 1995-1998 U of S tailings research project, Ayres (1998) estimated 49 mm/yr of NP in 1996, or 9% of incident precipitation (572 mm), based on soil-atmosphere fluxes measured at a monitoring site established in the Upper Solids Pond area of the TMA. Furthermore, a mean NP value of 21 mm/yr was predicted for the TMA pre-decommissioning based on S-P-A modelling completed for the CSD (COGEMA, 2000b). This suggests vegetation and associated transpiration during the growing season is not essential to achieving lower NP rates through the tailings mass; the fact that the TMA is in a groundwater discharge area, coupled with the relatively low permeability of the consolidated tailings mass (1.3×10^{-8} to 4.0×10^{-9} m/s; AREVA, 2015a), results in a site with relatively low infiltration capacity.





Table B Annual NP Values Estimated for the TMA Cover Monitoring Stations (OKC, 2019)

Year	CN1000L NP as a Percentage of Precipitation	CS1100L NP as a Percentage of Precipitation
2007	9%	13%
2008	15%	6%
2009	14%	11%
2010	11%	9%
2011	1%	6%
2012	19%	22%
2013	n/a	10%
2014	10%	n/a
2015	14%	n/a
2016	n/a	15%
2017	12%	14%

Note: n/a = Insufficient data collected to enable a reliable estimate of NP to be developed.

Figures 4 and 5 respectively show uranium and radium-226 concentrations measured upstream and downstream of the TMA from 1998 to 2017. Tailings were discharged into the TMA until the end of 2002 while final construction of the cover system occurred in 2006. Uranium concentrations at the Snake Lake outlet (ISL2000S) remain well below the Saskatchewan Surface Water Quality Objectives (SSWQO) value, while uranium concentrations at the Island Lake outlet are gradually decreasing over time and are below the DSWQO criterion of 0.342-0.622 mg/L (0.002*Hardness). Radium-226 concentrations at the Snake Lake outlet are gradually decreasing over time and are well below the SSWQO/DSWQO value of 0.11 Bq/L. In short, the surface water quality measured downstream of the TMA since 1998 demonstrates that the decommissioned TMA is adequately reducing NP to limit COC movement in groundwater to downstream aquatic receptors.

The author is of the opinion that the TMA cover system appears to be functioning as designed as far as it pertains to reducing NP rates to acceptable levels. This opinion is based on measurements and assessments completed by others as well as the author’s expertise in the mine waste cover system field.

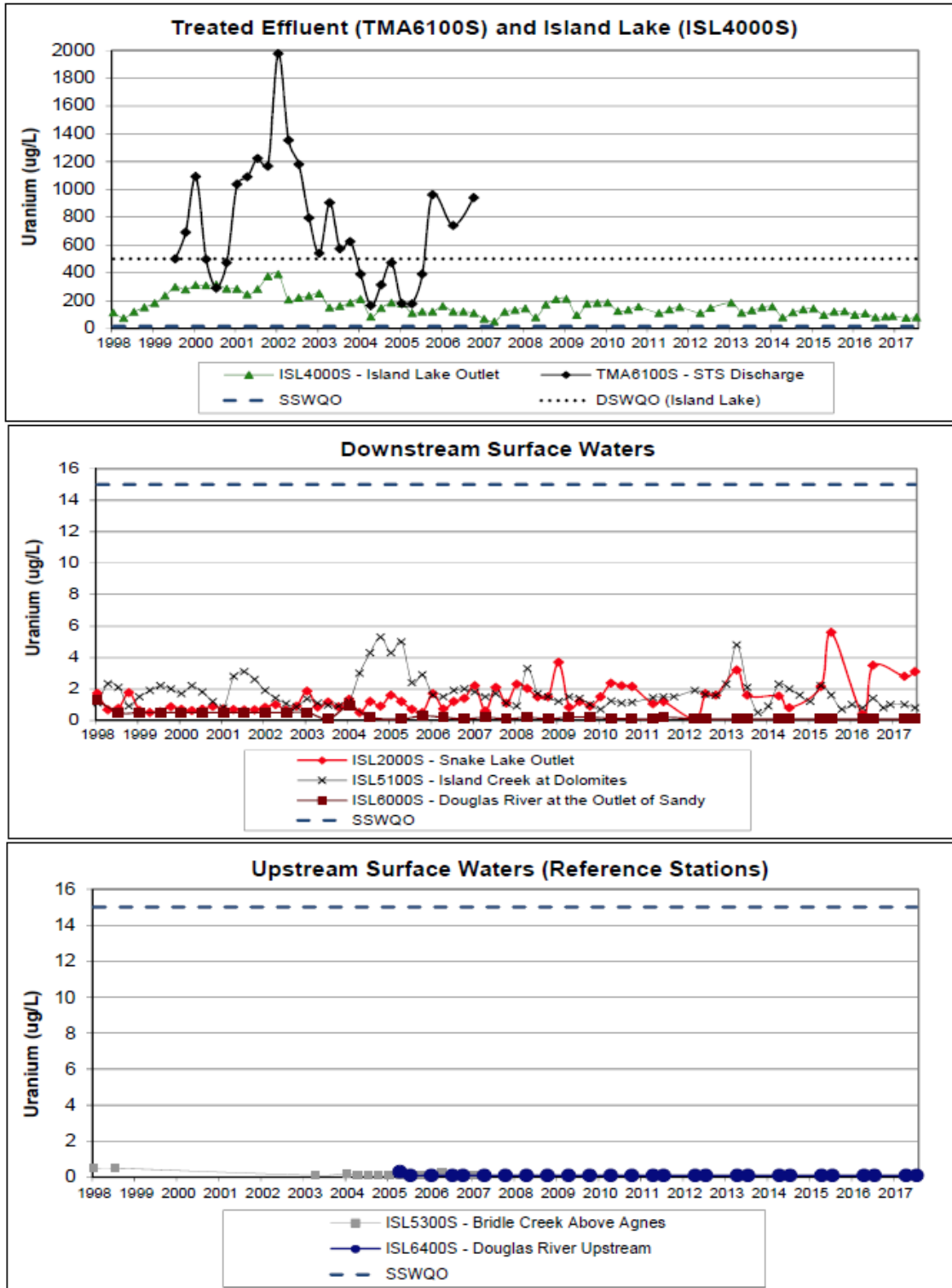


Figure 4 Uranium Concentrations Measured Upstream and Downstream of TMA (Orano, 2018)



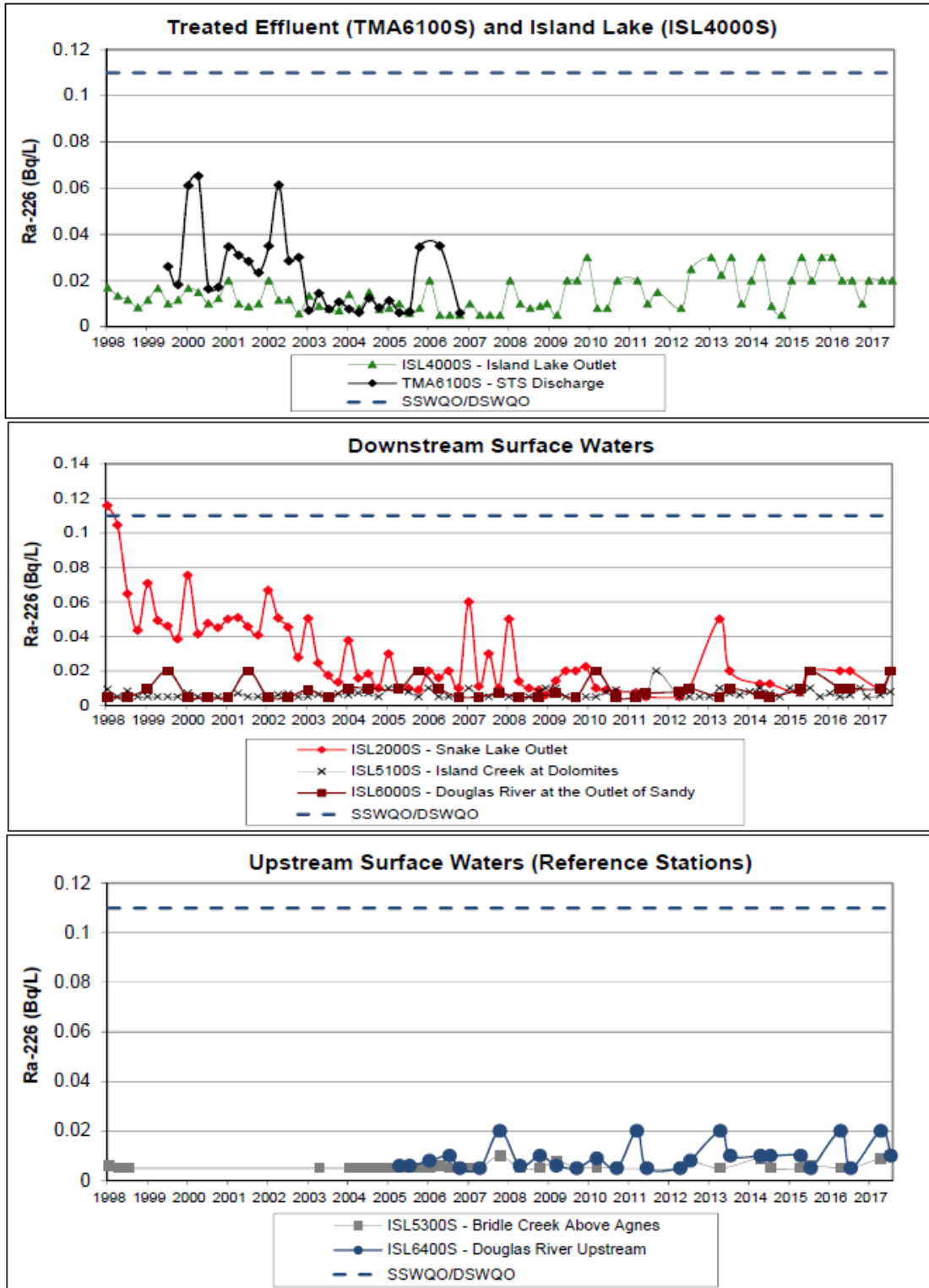


Figure 5 Radium-226 Concentrations Measured Upstream and Downstream of TMA (Orano, 2018)





5 Anticipated Long-term Performance of Decommissioned TMA

This section includes opinions of the author on the anticipated long-term performance of the decommissioned TMA with a focus on the cover system. The author's opinions are based on considerations of the following:

- a) Findings of the 2015 Environmental Assessment FUP (AREVA, 2015a; 2015b); and
- b) Potential effects of various physical, chemical, and biological processes on the long-term integrity / performance of the TMA cover system.

Findings of the 2015 Environmental Assessment FUP:

The primary purpose of the 2015 Environmental Assessment FUP was to verify the accuracy of predictions included in the Cluff Lake CSD (COGEMA, 2000a; 2000b) associated with environmental effects post-decommissioning. This involved re-calibration of CSD models using data collected during the post-decommissioning EMP as well as special studies, and subsequent predictive modelling to verify / refine predictions of environmental effects on human and ecological receptors over the long term. Three-dimensional groundwater flow and contaminant transport modelling was completed for the TMA (AREVA, 2015a), to simulate hydraulic head and estimate COC concentrations in the downgradient receiving environment over an assessment period ranging from 10,000 to 40,000 years. An expanded list of COCs was considered in the 2015 FUP, which was carried forward to an updated pathways analysis and subsequent human health and ecological risk assessment (AREVA, 2015b).

Key findings from the 2015 FUP groundwater flow and contaminant transport modelling include (AREVA, 2015b):

- › A mean annual recharge (NP) value of 65 mm/yr for the decommissioned TMA provided the best model calibration results (~59% higher than the CSD predicted mean value of 41 mm/yr);
- › Larger source terms compared to those estimated for the CSD, especially for arsenic and uranium; and
- › COC peak concentrations are expected to meet DSWQO values in Snake Lake for all parameters despite the larger source terms and higher mean annual NP value.

The updated human health and ecological risk assessment completed for the 2015 FUP indicates there should be no unacceptable adverse effects to human and ecological receptors post-decommissioning (AREVA, 2015b).

Various regulatory agencies including the CNSC reviewed the approach, methodology, results, and conclusions presented in the 2015 FUP report and supporting Technical Information Documents (TIDs). AREVA (2017) includes responses to the numerous comments and questions posed by the CNSC following their review of the 2015 FUP report and TIDs. Based on the results of the 2015 FUP and in particular, the updated contaminant transport modelling and pathways analysis, there is no evidence to suggest that the chosen decommissioning design for the TMA will fail to protect human and ecological receptors over the long term.





Key Processes Potentially Influencing the Long-term Integrity / Performance of the TMA Cover System:

The longevity of a mine waste storage facility final landform (including the cover system) should be evaluated in relation to site-specific physical, biological, and chemical processes that will alter as-built performance and determine long-term performance (INAP, 2003). It is noted, however, that in many cases the effect of biological and chemical processes specific to a site on long-term cover system performance can only be evaluated from a qualitative perspective (MEND, 2007). In contrast, many of the physical processes affecting long-term performance are quantifiable provided that the appropriate materials testing and numerical analyses are completed. In general, the simpler the decommissioning design, the less one has to be concerned about the potential effect of physical, chemical, and biological processes on long-term performance (Ayres and O’Kane, 2013).

Figure 6 shows a fairly thorough list of processes that may or may not be applicable for a given site in terms of influencing the integrity / performance of a mine waste cover system, to the point where the cover system fails to function as designed. Given the design of the TMA cover system and its current state 11 years post-construction, key processes considered relevant for the site include:

- › Soil erosion;
- › Frost action;
- › Consolidation / settlement;
- › Extreme climate events;
- › Forest fires;
- › Root penetration; and
- › Burrowing animals.

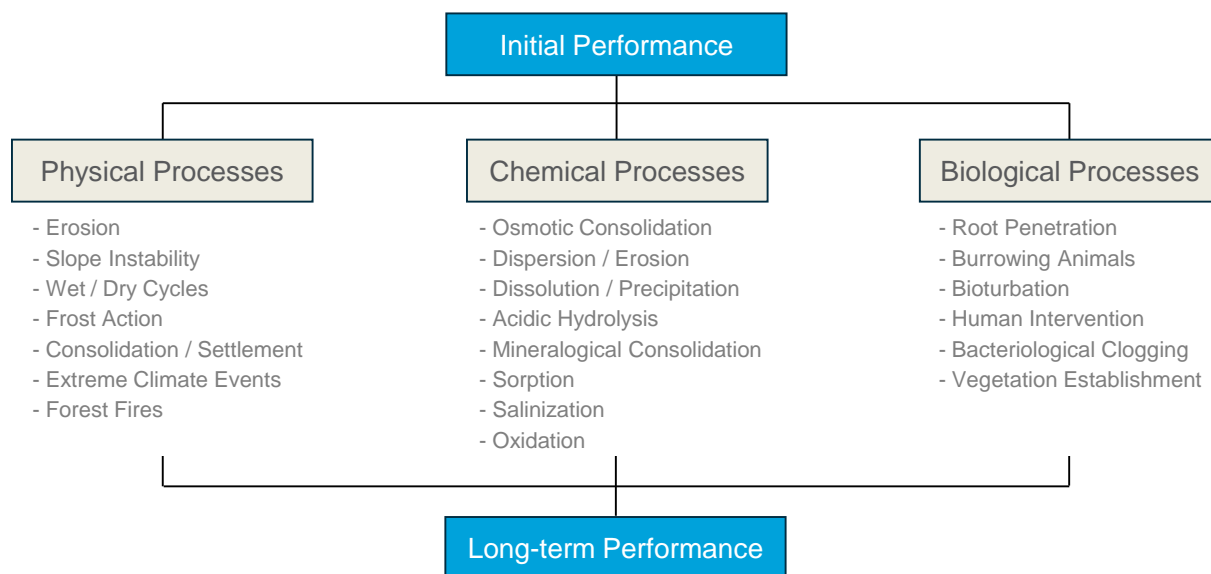


Figure 6 Processes that could Influence the Long-term Integrity / Performance of Mine Waste Cover Systems (adapted by INAP, 2003 from Haug, 1990)





The process of soil erosion has not been a significant issue for the TMA cover system since its final construction in 2006. This is attributed to the relatively shallow surface gradients as well as the robust surface drainage system implemented on the cover system. As the grass-forb vegetation cover has matured, supplemented by native species, the resistance of the cover system to erosive forces has increased. Also, given the well-graded nature of the till cover material, particularly the relatively high boulder, cobble and gravel content, the cover system has an ability to self-armour in areas where gullies have formed. In short, it is highly unlikely that soil erosion will have a significant effect on the long-term integrity or performance of the TMA cover system.

Frost action as it pertains to the subsurface is the result of freezing and thawing of water within the soil matrix. A common behaviour associated with frost action is frost heave, where water accumulates at the freezing front leading to the creation of ice lenses that cause an annual cycle of heave and settlement. The following conditions need to be present for frost heave to occur (Bell, 1998):

- a) A source of water within the subsurface;
- b) Capillary saturation throughout the freezing process; and
- c) A soil with high capillarity and moderate permeability (i.e. frost susceptible material).

No evidence has been found or reported to-date to suggest that the integrity of the TMA cover system is being compromised by frost action.

Several reports have stated the TMA cover system has experienced some differential settlement, mostly in the Lower Solids Pond and Lower Solids Decant areas, due to consolidation of the tailings mass following dissipation of excess pore-water pressures. Recent information provided in SRK (2018a; 2018b) suggests the tailings mass is approaching a near equilibrium state in terms of its long-term void ratio for the inherent hydrostatic pressures. Even if this is not the case, and further tailings consolidation occurs resulting in differential settlement of the cover system, a relatively small depression may form leading to localized surface water ponding. Orano has previously addressed differential settlement in the cover system by infilling relatively major depressions with local till material. According to CNES (2018), ponded water on the TMA cover system does not pose unreasonable risks to ecological receptors.

The potential effects of a major precipitation event, extended drought event, and global warming (i.e. climate change) on performance of the TMA cover system were considered during the CSD (COGEMA, 2000a). In short, given the design simplicity of the cover system, the fact the incident and upgradient diversion ditches are designed to pass the PMF, and the 2015 FUP contaminant transport modelling results, the likelihood of an extreme climate event or a reasonable climate change scenario significantly influencing the long-term performance of the TMA cover system is extremely low.

The potential effects of a forest fire on performance of the TMA cover system were considered during the CSD (COGEMA, 2000a). Forest fires are a natural occurrence and more than likely, vegetation on the TMA cover system will succumb to fire approximately every 40 years (Larsen, 1997). The loss of vegetation due to a forest fire would result in reduced canopy interception and transpiration and thus potentially higher NP rates until re-growth establishes in the burn area. However, observations from burn areas at the Site indicate that re-growth of native plants occurs within one to two years of a fire. In addition, burn matter from a forest fire increases the carbon and organic content on the ground surface, which adds nutrients for new plants and additional water holding capacity at the surface. In short, the loss





of vegetation on the TMA cover system due to a forest fire will have an insignificant effect on the long-term integrity and performance of the cover system.

The coniferous and deciduous woody species native to the Site are prone to lateral and shallow root development. Strong and La Roi (1983) examined the root system morphology of common boreal forest trees in Alberta; they found the following for jack pine trees ranging in age from 3 to 83 years:

- › Lateral roots comprised 60 to 95% of all roots (located mostly in the upper 12 cm of mineral soil);
- › Vertical roots comprised <3% of the total tree biomass of older pines; and
- › Large taproots were the principal vertical roots, extending to a maximum depth of 2 m although 1.3 m was a more common maximum depth.

The depth of taproots is largely a function of the soil moisture regime; longer taproots generally exist in drier soil conditions. Given the climatic setting of the Site, coupled with the relatively low permeability of the underlying tailings material (1.3×10^{-8} to 4.0×10^{-9} m/s; AREVA, 2015a), relatively high amounts of soil water will be available to plant rooting systems in the till cover profile throughout most growing seasons. All factors considered, it is anticipated that very few roots of native woody species growing on the TMA cover system will extend beyond the base of the cover system, especially when you consider the mean till cover thickness is approximately 1.4 m.

The potential for borrowing species native to the Site to develop dens in the TMA cover system was considered during the design phase (COGEMA, 2001) and was addressed further in Orano (2019). The author is not qualified to comment on the likelihood of borrowing animals developing dens in the cover system and more importantly, the typical depth of dens; however, the author has reviewed the information provided in Orano (2019) and supports the conclusion that animal borrows established on the TMA cover system do not pose an unreasonable risk to human and ecological receptors.

6 Summary and Conclusions

The author has completed a review of the process followed by Orano to support the chosen decommissioning design for the Cluff Lake TMA as well as performance of the cover system since its final construction in 2006. In addition, opinions have been provided on the anticipated long-term performance of the TMA cover system.

Based on the author's experience, the number and range of investigations / analyses completed by Orano and its technical consultants suggest that selection of the chosen decommissioning plans for the Cluff Lake TMA was based on a fairly thorough exercise. In addition, the approach, methodology, and findings of all investigations and analyses pertaining to the TMA decommissioning project were reviewed and ultimately approved by relevant provincial and federal regulatory authorities.

The author completed a desktop assessment of the overall performance of the TMA cover system to-date based on the results of the EMP as well as findings of other studies completed by technical consultants between 2006 and 2018. The assessment was focused on performance of the TMA cover system as it relates to the design functions required to achieve the overall Site decommissioning objectives. The author is of the opinion that the TMA cover system appears to be a stable, self-sustaining landform,





one that is adequately providing a medium for growth of various plant species while attenuating radiological exposure to human and terrestrial receptors and reducing NP rates to acceptable levels.

The anticipated long-term performance of the TMA cover system was assessed by considering pertinent findings of the 2015 Environmental Assessment FUP and potential effects of various physical, chemical, and biological processes acting on the cover system over time. No evidence was found to suggest that the chosen decommissioning design for the TMA will fail to function as-designed, to adequately protect human and ecological receptors over the long term.

Finally, the Site will be monitored and maintained for hundreds of years once it has been transferred into the provincial ICP. A monitoring and maintenance program will be designed to understand and manage risk and therefore maintain protection of human and ecological receptors over the long term. In addition, Orano will be required to contribute to an unforeseen events fund and provide additional financial assurance that will be available to the province. Comprehensive policy planning behind the ICP provides the people of Saskatchewan with assurance that the Site will continue to be monitored and the environment and public will be protected over the long term.

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8 List of References

- AREVA (AREVA Resources Canada Inc.). 2006. As Built Tailings Management Area Decommissioning, Cluff Lake Project. Prepared for CNSC and Saskatchewan Environment, October.
- AREVA. 2007. Submission for Gamma Radiation Clearance, Cluff Lake Project. Prepared for CNSC, Saskatchewan Environment, and Saskatchewan Labour, November.
- AREVA. 2014a. Cluff Lake Project – 2014 Gamma Radiation Clearance Submission. Prepared for CNSC and Saskatchewan Ministry of Environment, October 14.
- AREVA. 2014b. Cluff Lake Project – Detailed Decommissioning Plan, Version 3. Prepared for CNSC and Saskatchewan Ministry of Environment, December 23.
- AREVA. 2015a. Cluff Lake Project Technical Information Document – Hydrogeology and Groundwater Modelling Volume 01, June. Prepared for CNSC and Saskatchewan Ministry of Environment, June.
- AREVA. 2015b. Cluff Lake Project – Follow-Up Program Report. Prepared for CNSC and Saskatchewan Ministry of Environment, August.
- AREVA. 2017. Cluff Lake Project – Response to CNSC Comments Dated March 1, 2016. Letter report submitted to CNSC, October 20.
- AREVA. 2018. Cluff Lake Project – 2017 Minor Earthworks and Activity Report. Prepared for CNSC and Saskatchewan Ministry of Environment, January 22.
- Ayres, B.K. 1998. Field monitoring of soil-atmosphere fluxes through uranium mill tailings and natural surface soils at Cluff Lake, Saskatchewan. M.Sc. Thesis, Dept. of Civil Engineering, University of Saskatchewan, Saskatoon.
- Ayres, B. and O'Kane, M. 2013. Design, construction, and performance of closure cover systems for spent heap leach piles – a state-of-the-art review. *In* Proc. of 2013 Heap Leach Conference, Vancouver, BC, Sept. 22-25.
- Bell, F.G. 1998. Environmental Geology: Principles and Practice. Blackwell Publishing (229 pp.).
- CAL (Clifton Associates Ltd.). 2001. Final Construction Report Coarse Summer TMA Test Cover As-Constructed Report, Cluff Lake, Saskatchewan. Prepared for COGEMA, February 23.
- CAL. 2002a. Data Review Report Coarse Summer TMA Test Cover, Cluff Lake, Saskatchewan. Prepared for COGEMA, February 7.
- CAL. 2002b. Numerical Analysis Report Coarse Summer TMA Test Cover, Cluff Lake, Saskatchewan. Prepared for COGEMA, February 15.
- CDA (Canadian Dam Association). 2013. Dam Safety Guidelines 2007 (Revised 2013).
- CDA. 2014. Application of the Dam Safety Guidelines to Mining Dams. Technical Bulletin.
- CNES (Canada Northern Environmental Services). 2018. Cluff Lake Project Risk Assessment of the Presence of Pondered Water on the Decommissioned Tailings Management Area (TMA). Report prepared for Orano, August.
- COGEMA (COGEMA Resources Inc.). 1998. Cluff Lake Project: TMA Interim Construction Activities – 1998. Report prepared for AECB and SERM, February 27.
- COGEMA. 2000a. Cluff Lake Project Comprehensive Study for Decommissioning, Comprehensive Study Report. Main Document and Appendices A, B, C, D, E, F. Prepared for CNSC, December – Version 1.
- COGEMA. 2000b. Cluff Lake Project Comprehensive Study for Decommissioning, Supporting Document #1 – Tailings Management Area. Prepared for CNSC, December – Version 1.





- COGEMA. 2001. Cluff Lake Project Comprehensive Study for Decommissioning, Responses to Regulatory Comments. Prepared for CNSC, November.
- COGEMA. 2004. Decommissioning Design Tailings Management Area – Cluff Lake Project. Prepared for CNSC and Saskatchewan Environment, November.
- CNSC (Canadian Nuclear Safety Commission). 2003. Comprehensive Study Report, Cluff Lake Decommissioning Project, December.
- DES (Denison Environmental Services). 2013. Construction Completion Report 2013 Miscellaneous Earthworks and Site Cleanup, Cluff Lake Mine Site, SK. Prepared for AREVA, November 26.
- EC (Environment Canada). 2019. http://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?stnID=3360.
- Goulden, W.D. 1997. The geochemical distribution of Radium-226 in Cluff Lake uranium mill tailings. M.Sc. Thesis, Dept. of Civil Engineering, University of Saskatchewan, Saskatoon.
- Haug, M.D. 1990. New Developments in Geoenvironmental Engineering. CE 851 graduate course lecture notes, Department of Civil Engineering, University of Saskatchewan.
- Hopkinson, R.F. 1994. Point Probable Maximum Precipitation in Northern Saskatchewan. Environment Canada, Atmospheric Environment Service.
- HTEL (HAB-TECH Environmental Ltd.). 2015. Status of Vegetation Recovery in the Cluff Lake Project Reclaimed Areas 2008 – 2014. Report prepared for AREVA, March.
- INAP (International Network for Acid Prevention). 2003. Evaluation of the Long-term Performance of Dry Cover Systems, Final Report. March.
- INAP. 2017. Global Cover System Design Technical Guidance Document. November.
- Larsen, C.P.S. 1997. Spatial and temporal variations in boreal forest fire frequency in northern Alberta. *Journal of Biogeography*. 24: 663-673.
- MEND (Mine Environment Neutral Drainage). 2007. Macro-scale Cover Design and Performance Monitoring Reference Manual. Report no. 2.21.5, July.
- MEND. 2012. Cold Regions Cover System Design Technical Guidance Document. Report no. 1.61.5c, July.
- OKC (O’Kane Consultants Inc.). 2006. Cluff Lake Project – As-Built Report for the Tailings Management Area Cover Performance Monitoring System for the Upper Solids Area. Prepared for AREVA, November 28.
- OKC. 2019. Cluff Lake Project – Tailings Management Area 2017 Water Balance Numerical Modelling Program. Report prepared for Orano.
- Orano (Orano Canada Inc.). 2018. Cluff Lake Project 2017 Annual Report. Prepared for CNSC and Saskatchewan Ministry of Environment, March.
- Orano. 2019. Response to Concerns about Burrowing Animals at the Cluff Lake Tailings Management Area. Letter to Mr. Rodney Gardiner, February 15.
- Peel, M.C., Finlayson, B.L. and McMahon, T.A. 2007. Updated world map of the Köppen- Geiger climate classification. *Hydrology and Earth System Sciences Discussions*, 4(2), pp.439-473.
- Rogers, V.C., Overmyer, R.F., Putzig, K.M., Jensen, C.M., Nielson, K.K., and Sermon, B.W. 1980. Characterization of uranium tailings cover materials for radon flux reduction. Report prepared for Division of Safeguards, Fuel Cycle and Environmental Research, Office of Nuclear Regulatory Research, March.
- SENES (SENES Consultants Ltd.). 2009. Review of AREVA Surface Gamma Radiation Survey of Disturbed Areas at Cluff Lake Site. Report prepared for CNSC, February.
- SRK (SRK Consulting (Canada) Inc.). 2018a. 2018 Biennial Geotechnical Inspection, Final Report, Cluff Lake, Saskatchewan. Prepared for Orano, December.





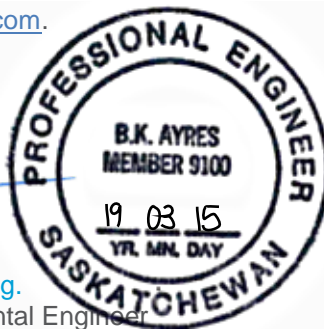
SRK. 2018b. TMA Water Management and 2013 Remedial Works Closure Report – Final Report, Cluff Lake, Saskatchewan. Prepared for Orano, August.

Strong, W.L. and La Roi, G.H. 1983. Root-system morphology of common boreal forest trees in Alberta, Canada. Canadian Journal of Forest Research. 13(6): 1164-1173.

9 Closure

Should you have any questions or require additional information regarding the subject of this report, please do not hesitate to contact Brian Ayres, P.Eng. at 306-668-6800 ext. 54141 or brian.ayres@snclavalin.com.

Prepared by:



Brian Ayres, M.Sc., P.Eng.
Principal Geoenvironmental Engineer

Reviewed by:

Moir D. Haug, Ph.D., P.Eng.
Senior Advisor
Environment & Geoscience
Infrastructure

**Association of Professional Engineers and Geoscientists
of Saskatchewan**

CERTIFICATE OF AUTHORIZATION

**SNC-Lavalin Inc., Environment Division
Number C1365**

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Geotechnical	9100	



Appendix I

Curriculum Vitae of Brian Ayres, M.Sc., P.Eng.



BRIAN AYRES, M.Sc., P.Eng.

Mr. Brian Ayres, M.Sc., P.Eng. is a Principal Geoenvironmental Engineer responsible for leading and overseeing the design, construction, and monitoring of varying types of geoenvironmental projects. Over a 23-year career, Mr. Ayres has gained considerable experience in waste storage facility design and closure, waste management, cover system design/construction / performance monitoring, liner system design, landform design, surface water management system design, and vadose zone hydrological assessments. Mr. Ayres also provides third-party technical advisement to clients including private and public companies and regulatory agencies. Prior to joining SNC-Lavalin, Mr. Ayres was a Senior Geoenvironmental Engineer with O'Kane Consultants (OKC) based in Saskatoon, Saskatchewan. Over a 15-year period, he helped OKC grow from two staff in 2000 to approximately 60 staff in 2015, with offices across Canada and in the US, Australia, and New Zealand. Mr. Ayres' current focus at SNC-Lavalin is business development and project execution in the areas of closure and reclamation for mine waste and municipal solid waste storage facilities in Saskatchewan and abroad.

SECTORS OF EXPERTISE

- Mining & Metallurgy** › Mine rehabilitation; Mine waste cover system design
- Materials & Geotechnical** › Soil and rocks investigations; Materials engineering and expertise; Geoenvironment; Landform engineering
- Environment** › Landfills; Mine waste management; Closure planning
- Additional Expertise** › Project Coordination; Project Management

EDUCATION

- 1998 | M.Sc., Geotechnical Engineering, University of Saskatchewan, Saskatoon, SK, Canada
- 1994 | B.E., Civil Engineering, University of Saskatchewan, Saskatoon, SK, Canada

EXPERIENCE

- SINCE 2015 | **SNC-LAVALIN INC., SASKATOON, SASKATCHEWAN, CANADA**
Environment & Geoscience
Principal Geoenvironmental Engineer
 - › Ochapowace First Nation (SK) – Project Mgr. and Senior Engineer for solid waste feasibility study and preliminary design of a transfer station facility.
 - › WRLI Regional Landfill (Kindersley, SK) – Project Mgr. and Senior Engineer for detailed design and construction mgmt. for a new regional landfill facility
 - › Touchwood Hills Regional Landfill Inc. (Raymore, SK) – Project Mgr. and Senior Engineer to develop engineered solutions for several regulatory compliance issues
 - › Village of Spy Hill, RM of Norton, and Town of Zealandia (SK) – Project Mgr. and Senior Engineer for Phase II ESA to support final closure plans for MSW landfills
 - › Project CLEANS (Saskatchewan Research Council) – Project Mgr. and Senior Engineer for remediation planning for mine-openings at legacy uranium sites
 - › Loraas Disposal Northern Landfill Leachate Collection Pond (SK) – Senior Technical Advisor for detailed design and preparation of Technical Specifications
 - › Town of Zealandia Sewage Lagoon Upgrades – Project Mgr. and Senior Engineer
 - › City of Moose Jaw Landfill Development Plan – Project Mgr. and Senior Engineer for options assessment for future waste mgmt., including life cycle cost analysis

Years of Experience

- › 23 years

Years with SNC-Lavalin

- › 3 years

Key Positions

- › Advisor - Technical
- › Engineer - Environment
- › Engineering Specialist - Geotechnical

Languages

- › English

2000 - 2015

O'KANE CONSULTANTS INC., SASKATOON, SASKATCHEWAN, CANADA
Senior Geoenvironmental Engineer / COO

Gained considerable experience in the mining industry through involvement in a wide range of mine closure planning studies. Work focused on application of unsaturated zone hydrology to closure of mine waste storage facilities, specializing in design, implementation, and performance monitoring of cover systems for all types of mine waste. Experience in design of erosion control measures and other hydraulic structures for surface water management systems, and development of detailed cost estimates for construction of mine waste cover systems. Conducted fieldwork at several mine sites located in Canada, Australia, and USA. Roles included being a senior technical advisor, project coordinator, project manager, field engineer, construction supervisor, office manager, and Chief Operating Officer.

Escarpment Mine Project – Engineered Landform Design for Acid-Generating Overburden, Buller Coal / Bathurst Resources, New Zealand

Senior engineer for review and preliminary design of a low permeability cover system for closure of engineered landforms (ELFs) containing PAF overburden waste materials; tasks included oversight of a geotechnical laboratory testing program, review of various low permeability layer options, and development of mitigation measures to address potential failure modes for the preferred option.

Key Lake Mine – Closure of Deilmann North Waste Rock Pile, Cameco Corporation, SK, Canada

Senior engineer for design of a cover system and final landform for closure of the Deilmann North Waste Rock Pile; tasks included oversight of several numerical modelling programs, detailed design of a surface water management system, and development of technical specifications, construction drawings, and a construction QA/QC program.

Keno Hill Silver District – Closure Planning for WRSAs, Alexco Environmental Group, YT, Canada

Senior engineer and project manager for developing conceptual-level or indicative cover system design alternatives for closure cover systems for waste rock storage areas, including preliminary estimates of hydrological performance and construction costs for three different cover system types.

Myra Falls Operations – Detailed Closure Design for Tailings Disposal Facility, NVI Mining Ltd., BC, Canada

Senior engineer and project manager for design of a cover system and final landform for closure of an above-ground tailings storage facility; tasks included design of a final landform and surface water management system to handle peak flows from the design storm event, as well as development of technical specifications, construction drawings, and a construction QA/QC program.

Whistle Mine – Detailed Design of Backfilled Pit Cover System, Vale, ON, Canada

Project manager for the final design and construction of a 10 ha engineered cover system for an open pit backfilled with acid-generating waste rock; tasks included

Site Experience

- › Australia
- › Canada
- › New Zealand
- › United States

Computer Applications

- › MS Office Suite
- › Win TR-55 Model

developing detailed cost estimates for construction of various cover system alternatives, technical advisor for soil-plant-atmosphere (VADOSE/W) and erosion / landform evolution (WEPP / SIBERIA) modelling programs, and technical advisor for QA/QC field program during construction.

Spruce Pine Operations – Technical Guidance for Dry Stack Tailings Operation & Closure, The Quartz Corporation, North Carolina, USA

Project manager and senior engineer for the development of guidelines for improved design, operation, and closure of dry-stacked tailings management areas; tasks included a material characterization program and technical advisor for several numerical modelling programs.

Kemess Mine – Closure Planning for Leach Cap WRD, Northgate Minerals Corp., BC, Canada

Project manager for evaluation of several cover system alternatives for a waste rock dump containing elevated concentrations of Selenium; tasks included developing construction cost estimates for various cover alternatives, overseeing a soil-plant-atmosphere numerical modelling program and designing a cover system field trial program.

Gunnar Mine – Tailings Areas Remediation Detailed Design, Saskatchewan Research Council (SRC), SK, Canada

Senior technical advisor for detailed design of cover systems and final landforms for closure of various tailings deposits at a legacy uranium mine.

Meadowbank Mine – Design of Closure Cover System for TMF, Agnico Eagle Mines, NU, Canada

Senior technical advisor for detailed design of a permafrost-aggradation cover system and landform for closure of an acid-generating tailings deposit; tasks included oversight of thermal analyses with considerations for climate change and design of drainage channels and spillways for the proposed closure landform.

Cantung Mine – Sr. Technical Advisor for Revised Tailings Management (Dry Stack), North American Tungsten Corporation Ltd., NT, Canada

Senior technical advisor on seepage rates and closure plans to support an application to the Mackenzie Valley Land and Water Board to move from slurry tailings to dry-stack tailings deposition; tasks included oversight of an analytical drain-down assessment of the proposed dry-stack tailings landform and technical presentations at a Public Hearing for amendment to the site's operations license.

Rabbit Lake Mine – Detailed Closure Design for B-Zone WRP, Cameco Corporation, SK, Canada

Project manager and senior engineer for developing a detailed design for reclamation of the B-zone waste rock pile; tasks included developing methods and technical specifications for implementation of each reclamation activity, proposing safety, health and environmental protection measures to be implemented during the reclamation work, and developing a schedule for reclamation activities.

Bingham Canyon Mine (KUCC) – Infiltration Assessment on Reactive WRDs, Rio Tinto Technical Services, Utah, USA

Project engineer for a Phase 1 evaluation of the surface infiltration characteristics of three large waste rock dumps at the KUCC site; tasks included field sampling / in situ testing of various waste rock materials and technical advisor for a soil-plant-atmosphere (VADOSE/W) modelling program.

Red Dog Operations - Closure Planning for Main Waste Rock Dump, Teck Cominco, Alaska, USA

Project manager for evaluation of several cover system alternatives for acid-generating waste rock piles; tasks included technical advisor for a soil-plant-atmosphere (VADOSE/W) modelling program and development of detailed cost estimates for construction and instrumentation of several cover system field trials for the Main waste stockpile.

Mt. Morgan Mine – Design, Construction, and Instrumentation of Waste Rock Closure Cover Trials, Queensland Dept. of Natural Resources & Mines, Queensland, Australia

Supervised the installation of field performance monitoring equipment during construction of two large-scale cover trials (30 m by 150 m) on an acid-generating waste rock pile; field instrumentation installed included two large-scale lysimeters, two interflow and four surface runoff collection and monitoring systems, and ~140 soil moisture sensors (matric suction and volumetric water content).

Key Lake Mine – Closure Planning for Above-Ground TMF, Cameco Corporation, SK, Canada

Project manager for evaluation of several cover system alternatives for closure of the above-ground uranium tailings management facility; tasks included developing cost estimates for construction of each cover alternative and technical advisor for soil-plant-atmosphere and seepage modelling programs.

1997 - 2000

AREVA RESOURCES CANADA (FORMERLY COGEMA), SASKATOON, SASKATCHEWAN, CANADA
Geoenvironmental Engineer – Corporate Office

Responsible for managing several projects undertaken by the Environment, Health & Safety department, including overseeing the preparation of detailed decommissioning plans for waste rock piles and several other facilities at Cluff Lake Mine. Developed conceptual plans and associated costs to decommission and reclaim two mine sites in northern Saskatchewan. Responsible for overseeing the implementation of an environmental information management system (Envista) at two mine sites and the corporate office.

1996 - 1997

AREVA RESOURCES CANADA (FORMERLY COGEMA), SASKATCHEWAN, CANADA
Environment Technician – McClean Lake Operation

Responsible for conducting environmental monitoring at the mine site as per facility operating licenses. Ensured that employees and contractors adhered to provincial/federal regulatory requirements and the corporate environmental policy during construction and operation of various site facilities. Collected surface water, groundwater, & air quality samples for laboratory analysis.

PROFESSIONAL ASSOCIATIONS

SINCE 1997

Association of Professional Engineers of Saskatchewan, Membership no. 09100

PROFESSIONAL DEVELOPMENT

2014

Project Management Foundation Principles and Techniques (EXP022), EXP Consulting Ltd., Canada

1999

Contaminant Transport graduate-level course (By Dr. L. Barbour), University of Saskatchewan, Canada

1998

Applications of Geochemistry in Geo-Env. Eng. Practice, Canadian Geotechnical Society, Edmonton, Alberta, Canada

1997

Design and Construction of Reservoir, Lagoon, and Landfill Liners, MD Haug & Associates Ltd., Saskatoon, Saskatchewan, Canada

PUBLICATIONS AND PRESENTATIONS

Ayres, B. Cover systems and landforms for closure of mine waste storage facilities – practical insights with a focus on Saskatchewan. Presentation at SMA Environmental Forum, Saskatoon, SK, Canada, 2018

Ayres, B. and Dickson, D. Landfill final cover system design – not as simple as one may think. Presentation at SustainTech 2018 Conference, Saskatoon, SK, Canada, 2018

Ayres, B.K. Overview of the Mine Overlay Site Testing (MOST) Project – A Collaborative Initiative, Canada, 2015

Ayres, B. and O’Kane, M. Design, construction, and performance of closure cover systems for spent heap leach piles – a state-of-the-art review., Vancouver, British Columbia, Canada, 2013

Ayres, B., O’Kane, M., Barber, L., Hiller, D., and Helps, D. Performance of an engineered cover system for a uranium mine waste rock pile in northern Saskatchewan after six years., Whitehorse, Yukon, Canada, 2013

Ayres, B. and O’Kane, M. Mine waste cover systems: An international perspective and applications for mine closure in New Zealand. Paper presented at the 2013 AusIMM New Zealand Branch Annual Conference., Nelson , New Zealand, 2013

Ayres, B., Lanteigne, L., O’Kane, M., and Meiers, G. Whistle Mine backfilled pit dry cover case study – Performance based on six years of field monitoring. Paper presented at 9th International Conference on Acid Rock Drainage., Ottawa, Ontario, Canada, 2012

Ayres, B., Dobchuk, B., Christensen, D., O’Kane, M. and Fawcett, M. Incorporation of natural slope features into the design of final landforms for waste rock stockpiles. Paper presented at the 7th International Conference on Acid Rock Drainage., St. Louis, Missouri, United States, 2006

Ayres, B., Landine, P., Adrian, L., Christensen, D., and O’Kane, M. Cover and final landform design for the B-zone waste rock pile at Rabbit Lake Mine. Paper presented at the 4th International Conference on Uranium Mining & Hydrogeology., Freiberg, Germany, 2005

Ayres, B., Lanteigne, L., and O’Kane, M. Design and construction of the backfilled pit cover system at Whistle Mine, Canada: a case study. Paper presented at Securing the Future 2005, International Conference on Mining and the Environment., Skelleftea, Sweden, 2005

Ayres, B.K., O’Kane M., and Barbour, S.L. Issues for consideration when designing a growth medium layer for a reactive mine waste cover system. Paper presented at the 11th International Conference on Tailings and Mine Waste, Vail, Colorado, United States, 2004

Ayres, B., Silveira, C., Ellice, C., Christensen, D., and O’Kane, M. Development of a cover system design for potentially acid-forming tailings at Peak Gold Mines, NSW, Australia. Poster paper presented at the 6th International Conference on Acid Rock Drainage., Cairns, Queensland, Australia, 2003

Ayres, B., Dirom, G., Christensen, D., Januszewski, S., and O’Kane, M. Performance of cover system field trials for waste rock at Myra Falls Operations. Paper presented at 6th International Conference on Acid Rock Drainage., Cairns, Queensland, Australia, 2003

Ayres, B.K., O’Kane M., Lanteigne, L., and Christensen, D. Construction and instrumentation of waste rock test covers at Whistle Mine, Ontario, Canada. Paper presented at the 9th International Conference on Tailings and Mine Waste., Fort Collins, Colorado, United States, 2002

Ayres, B.K., Barbour, S.L., and O’Kane, M. Field monitoring of soil-plant-atmosphere fluxes through uranium tailings and natural surface soils at Cluff Lake, Saskatchewan. Paper presented at the 52nd Canadian Geotechnical Conference., Regina, Saskatchewan, Canada, 1999

Ayres, B., Barbour, S.L., Bews, B., O’Kane, M., Andrews, C., and Barsi, R. Development of environmental technology in support of the decommissioning of uranium tailings at Cluff Lake Mine. Paper presented at the 1995 Saskatchewan Conference on Environmental Management for Mining., Saskatoon, Saskatchewan, Canada, 1995

PUBLIC HEARINGS

2014 | Cantung Mine Water Licence Amendment - Proposed Dry Stack Tailings Facilities, Mackenzie Valley Land and Water Board, Yellowknife, Northwest Territories, Canada

Appendix B Follow-up Program Summary

Uncertainties Resolved – Follow-up Program

Decommissioning risk assessments require understanding of how contamination from a source (e.g. mine and mill waste) will move downgradient in groundwater and downstream in surface water, and how contaminants interact in the environment. To reduce uncertainties in Cluff Lake groundwater contaminant transport modelling, there were six FUP items for the mining area and two FUP items for the TMA. To gain a better understanding of ecological risk uncertainties, there were four FUP items. The closure of each of these FUP items is summarized below.

Groundwater Contaminant Transport Modelling - Mining Area

Source Term: To verify the potential loading of soluble COPCs for transport through groundwater, the Claude waste rock pile, Claude pit, and former DJN waste rock pile source terms were studied. Three approaches were used to estimate source terms for the areas: leach tests, calculation from mass released to the groundwater system, and monitoring well breakthrough curves. The three approaches provided results in the same range and supportive of previous modelling.

CWRP Cover Infiltration: By limiting the amount of precipitation infiltrating the pile, weathering of rocks and minerals can be significantly reduced, thus limiting the mobilization of COPCs to groundwater and surface water. Orano decommissioned the CWRP by shaping and compacting the waste rock, covering the pile with 1 meter glacial till, and seeding grasses and legumes. Orano developed and installed an extensive CWRP cover monitoring system and, using over a decade of monitoring results, produced water balances to evaluate cover performance and trends. Following the cessation of fertilization in 2009, the vegetation cover achieved equilibrium in about 2011. Vegetation surveys were conducted in 2008, 2009, 2010, 2011, and 2014. Similarly, the net infiltration rates on the CRWP have been stable from 2011 to 2018. Net infiltration rates monitored and modelled, considering post-fertilized equilibrium vegetation, confidently protect downstream surface water quality. Orano modelled a scenario with no established vegetation (i.e. bare cover) and found that the protection of surface water quality is achieved regardless of the presence/absence of the net infiltration attributed to the vegetation cover. The cover is stable and resistant to erosion.

Claude Pit Pore Water: The Claude pit was backfilled in 2006, mainly with DJN waste rock and a combination of other site clean-up and demolition waste. The concentration of COPCs within the pore water is an important input to the contaminant transport model. To quantify the source term of the pit water, a monitoring well was installed in 2007 followed by installation of piezometers in 2010 and 2012. The 2010 and 2012 installations provided spatially variable monitoring data throughout the pit. The 2010 and 2012 sampling campaigns verified, and allowed refinements to, the values collected from the 2007 installed well.

Claude Lake Sediment Attenuation: Claude Lake contains a significant layer of organic sediment with potential to intercept and remove contaminants preventing their further transport downstream. The FUP studies quantifying the ability of Claude Lake sediments to attenuate contaminants were completed in two

phases: the first phase was initiated in 2001 with 17 months of testing, and the second phase was initiated in 2004 with five additional months of testing. These tests, the second of which built and improved on the conditions of the first, advanced the understanding of the mechanisms for intercepting various COPCs and the efficiency for attenuation specific by COPC.

Peat Trench: A pair of Permeable Reactive Barriers, referred to in the FUP as peat trenches, were installed and studied as a method to passively remove uranium and nickel from further downstream groundwater transport. Installing a peat trench was considered a supplementary removal mechanism, i.e. unnecessary for decommissioning but potentially reducing peak contaminant loads. A licensing agreement was signed by COGEMA and the University of Waterloo, who held the patent on Permeable Reactive Barrier technology, and the first peat trench was installed in 2006. Beyond what was considered in the FUP, monitoring results from the first trench prompted the improved design and installation of a second peat trench, about 10 m up gradient of the first peat trench, in the spring of 2007. Monitoring data suggests that approximately 50% of the total nickel and nearly 100% of the uranium that reached the peat trench from the Claude waste rock pile was retained with effectiveness expected to decline overtime leading to the eventual release of some or all COPCs initially retained. Less than 5% of the contaminant transport from the CWRP is expected to be intercepted by the peat trenches. Long term modelling shows that meeting surface water quality objectives has not been, and will not be, dependent on the function of the peat barriers.

Water Quality in Flooded DJX Pit: Water quality studies of flooded open pits in western Canada, including the D-Pit at Cluff Lake, show that a stable chemocline forms in flooded pits, permanently sequestering COPCs within the bottom reaches of the pit. The physical characteristics of the pits (i.e. deep but with a small surface area) prevents total mixing of the pit volume. The FUP included monitoring to confirm that a stable chemocline would establish in the flooded DJX pit. Pumping from Cluff Lake to expedite the flooding of the DJX pit was completed in January 2006 and water levels were allowed to equilibrate naturally slowing rising from 2006 to 2014 and then stabilizing, as predicted, at about 320 mASL. Since 2006, water has been sampled at the surface of the water column, at 1/6, 1/3, 1/2, 2/3 and 5/6 of its total depth, and at the bottom (~80 m) for temperature, dissolved oxygen, pH, and specific conductivity profiles. A double chemocline, one at a depth of about 50m and a second at a depth of about 12 m, established in 2006 and have remained stable since.

Groundwater Contaminant Transport Modelling - Tailings Management Area

TMA Cover Infiltration: By limiting the amount of precipitation infiltrating and flowing through the tailings, potential contaminant transport from the TMA to Snake Lake can be reduced. Between 2001 and 2007 a 1 m thick till cover was placed on top of the tailings and in 2007 and 2008 the cover was seeded with grasses and legumes. Monitoring instrumentation was installed during the summer of 2006 including automated stations for continuous monitoring including water content, suction, and groundwater levels. Using over a decade of monitoring results, water balances were produced to evaluate cover performance and trends. The percentage of precipitation that infiltrates the TMA is variable within the range of about 2-20% with an average of 12%. Performance of the TMA cover confidently protects downstream surface water quality. The cover is stable and resistant to erosion.

TMA Pore Water: As an important contaminant transport model input, four monitoring wells were installed in the TMA in 2006, seven wells were installed in 2010, and six wells were installed in 2012 to monitor hydraulic head and pore water chemistry. This extensive monitoring data allowed the TMA to be spatially divided into three zones with zone-specific pore water quality for refined numerical modelling.

Ecological Risk

Uranium Surface Water Quality Objective/Risk: At the time of the Cluff Lake Project CSD, there was no Saskatchewan or Canadian surface water quality objectives or guidelines for uranium. In the absence of a guideline, a uranium decommissioning surface water quality objective was developed based on an assessment of the available scientific literature. The uranium decommissioning objective was set as $0.002 \times$ water hardness (mg/L). To confirm that the proposed uranium objective posed no unreasonable risk to the environment, toxicity tests were designed using representative species present in Cluff Lake and using Cluff Lake waters. Since the CSD, substantial site-specific, regional and national uranium toxicity testing has been undertaken leading to the establishment of a Saskatchewan Surface Water Quality Objective (SSWQO) and Canadian Council of Ministers of the Environment (CCME) uranium water quality guideline of 15 ug/L. Although the CSD uranium value remains the decommissioning objective, the uranium water quality guideline of 15 ug/L is used as a conservative screening tool in the Cluff Lake risk assessment. Potential exceedances of the SSWQO and CCME uranium guideline were identified locally in Island Lake, D pit, and DJX pit and site-specific risk assessments were completed concluding that uranium exposure will not result in unacceptable risk to individuals or populations.

Implications of Selenium to Fish Reproduction: Elevated selenium levels were identified in fish associated with Island Lake which is a concern for fish reproduction. Monitoring and studies were completed in 2002, 2009, and 2015 to better understand the potential effect on reproduction. The studies indicate that I) at the cessation of operations, the level of selenium in Island Lake was having a negligible to slight potential effect on white suckers, II) the concentration of selenium in fish tissue is declining, i.e. the lake is demonstrating recovery from treated effluent release, and III) fish reproduction is not impaired.

Wildlife Risk in Island Lake Drainage: The ecological risk assessment completed as part of the CSR identified non-significant impacts to wildlife in the Island Lake Drainage. The FUP included a study of key dietary pathways (e.g. occupancy time on site, dietary composition) to better quantify the predicted risk. Field measurements were collected for sediment, water, benthic invertebrates, aquatic and terrestrial vegetation, fish and a small mammal survey was completed. These site-specific studies were used to refine risk assessment assumptions. The conclusion remains the same – non-significant risk to wildlife in the Island Creek Watershed. There is some potential risk to mink, muskrat, otter, yellowlegs, and the nighthawk with potential risks limited to Island Lake and the Island Lake fen. The aquatic system is recovering and will continue to improve in the future. There was an additional study to confirm that forage associated with Island Lake does not pose a molybdenosis risk for ungulates. There is an absence of molybdenosis risk and additionally, the risk assessment did not identify any potential for adverse effects in moose.

Island Lake Fen: Island Lake was the primary receiving water body of treated effluent from the now decommissioned Cluff Lake mill site and the Island lake fen is located downstream of Island Lake. The Island lake fen has accumulated a contaminant load over the operational period and the FUP included studies to confirm the stability of contaminants in the fen after the cessation of water treatment (i.e. a change in the water regime) or due to other disturbances (e.g. fire, climate change). Numerous studies were completed to address these uncertainties including: sediment and vegetation characterization; mass balance of COPC inventories; sediment and pore water sampling; assessments of COPC retention characteristics; studies of COPC mobilization during intense fire events; geophysical surveys; piezometer installations; and geochemical and contaminant transport modelling. Studies concluded that I) water levels have stabilized since cessation of operations; II) the fen continued to limit to transport of COPCs

downstream; III) the geochemical processes that concentrated uranium and other trace COPC in the fen are the same processes that limit their mobility; IV) COPC are expected to be retained within the Island Lake fen for the long term.

Information gained through the completion of these FUP studies was integrated into the risk assessment. These works complement, refine, and validate monitoring and modelling efforts and build a comprehensive understanding of the decommissioned site. The FUP addressed uncertainties identified in the CSD; confidence in long-term predictions is improved.

Other Studies

In addition to verifying accuracy of predictions and the effectiveness of mitigation, the Cluff Lake FUP also included components to address public concerns and confirm lower risk knowledge gaps. The following additional studies were included under the FUP.

Landfill Monitoring: Waste management on site was addressed with landfilling using the trench method, consecutive excavation and deposition with excess soil from new trench used to cover previous trench. Monitoring of main landfill sites was deemed sufficient during the CSR but reviewers requested greater certainty on the performance of small landfill sites. Landfill monitoring under the FUP validated that landfills were not a significant source of contaminants. Results from the landfill piezometers demonstrate good water quality with generally low concentrations of metals, major ions, and radionuclides. Hydrocarbon concentrations have generally been below detection for most of the wells. When detected, concentrations of hydrocarbons have been low and recent samples indicate that concentrations are decreasing towards the detection limit. Monitoring of the landfills was removed from the monitoring program with regulatory approval in 2017.

Leach Vault Temporary Storage: Between 1980 and 1983 concrete vaults were used to store tailings that were to be reprocessed for gold recovery. During the tailings storage period some contamination of the soil in the vicinity occurred and clean-up took place in 1989. A member of the public raised concern on the adequacy of the clean-up, thus, a program of verification monitoring was included in the FUP. In 2005, soil and vegetation monitoring as well as a gamma radiation survey were conducted and confirmed that the area poses no risk and clean-up objectives had been met.

Wildlife Investigation Studies: The key element identified at the CSR was to determine the presence/absence of moose and muskrat. An intensive terrestrial wildlife survey was conducted in 2005/2006. The survey included habitat classification and mapping; habitat classification accuracy assessment; small mammal survey; assessment of small mammal reproduction and material ingestion; winter track survey; ungulate pellet group/browse survey; moose observation survey; muskrat shoreline survey; muskrat push-up survey; amphibian call survey; breeding songbird call survey; and waterbird and raptor aerial survey. These studies confidently identified the presence of moose and muskrat for the purposes of the risk assessment. The site is safe and stable for wildlife use should wildlife choose to use the site; there is no decommissioning objective for a certain frequency or density of use.

Aquatic Monitoring of Island Lake and Cluff Lake Drainages: Consistent with the terrestrial survey, an aquatic survey was conducted following the end of operations in 2005/2006. The mandate of this program was to assess the effects of treated effluent discharge on the benthic invertebrate communities and fish populations in the receiving aquatic environment of the Cluff Lake site. Studies included I) fish community assessment of Snake Lake; II) fish habitat assessment of Snake Lake; III) analyses of contaminant

concentrations in fish flesh and bone of white sucker and northern pike from Snake Lake; and IV) analyses of contaminant concentrations in whole body white sucker from Island Lake and whole body northern pike and white sucker from Snake Lake. Most importantly, these studies demonstrate that, as predicted, the Island Lake watershed continues to recover from operations.

The intent of the FUP monitoring and studies were to document efforts to reduce identified uncertainties, discuss the confidence gained, and resulting refinements to long-term effects predictions. The completion of the FUP was a milestone towards demonstrating achievement of the decommissioning objectives. Uncertainties are resolved sufficiently to predict future site performance with confidence.

Appendix C Results of the 2018 Open House Tour

Orano hosted open houses in November 2018 in the communities of Clearwater, Beauval, Buffalo Narrows, Ile a la Crosse, and La Loche¹. The main topics of interest were: safety of traditional foods harvested from the Cluff Lake site; circumstances of previous employment or lack of employment; general description of how the mining and decommissioning activities were undertaken at Cluff Lake; long term protection of water. During the open houses many community members also shared their personal stories about working at Cluff Lake.

Attendance at the open houses was recorded as 182. During the open house, surveys were distributed to community members with a potential door prize winning as incentive for completing the survey. A total of 88 surveys were returned with results presented in Figures C.1 to C.11 below.

¹ There were also meetings with leadership in La Loche, Dillon, Turnor Lake, Ile a la Crosse, and Beauval

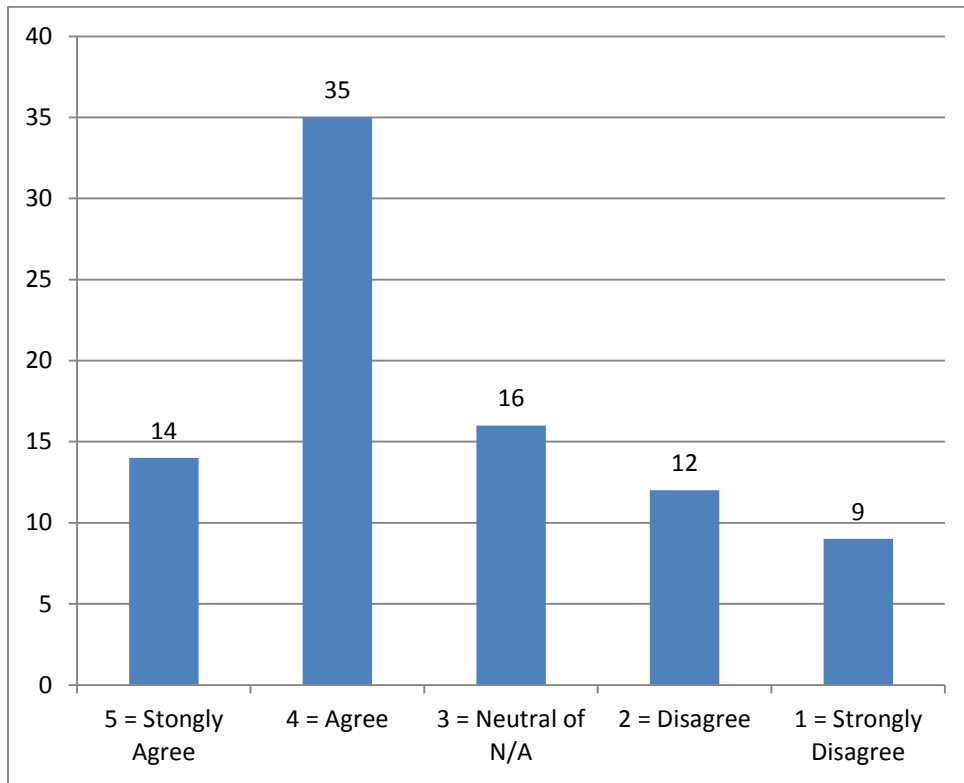


Figure C.1: I have a good understanding of risks associated with the decommissioned Cluff Lake Site

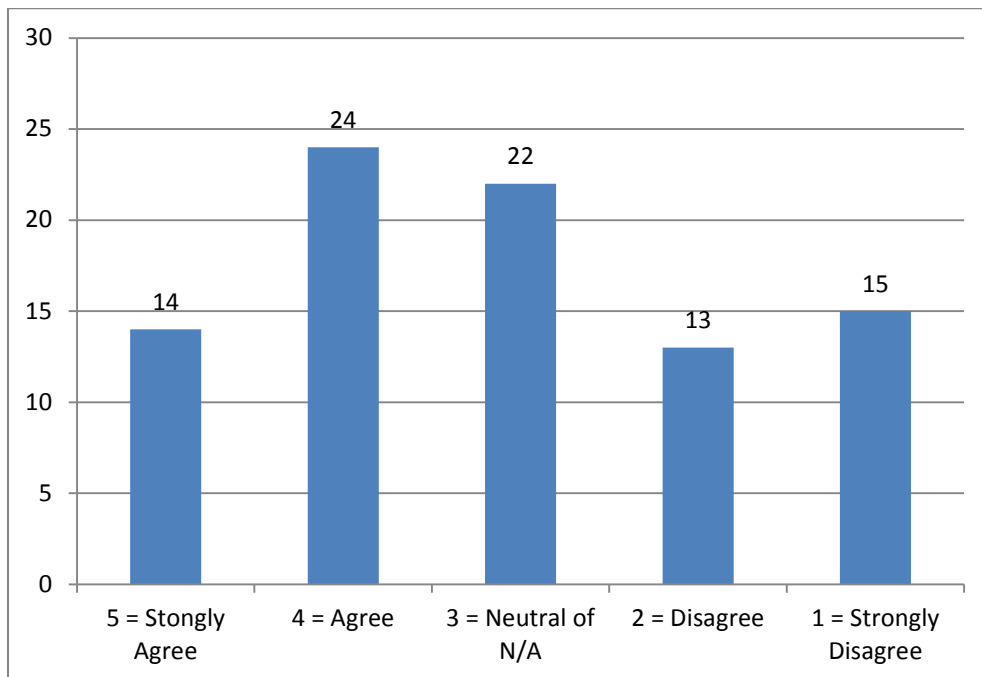


Figure C.2: I am confident that the decommissioned Cluff Lake Project will not harm the land, wildlife, fish (ecosystem integrity)

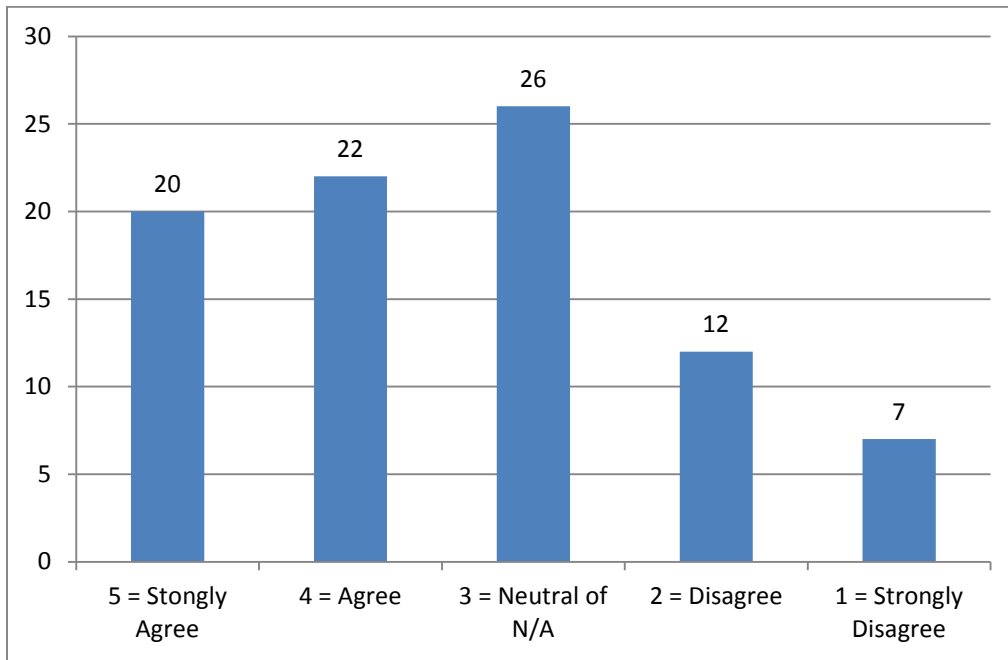


Figure C.3: I am confident about what land use activities/traditional activities are safe to do at Cluff Lake

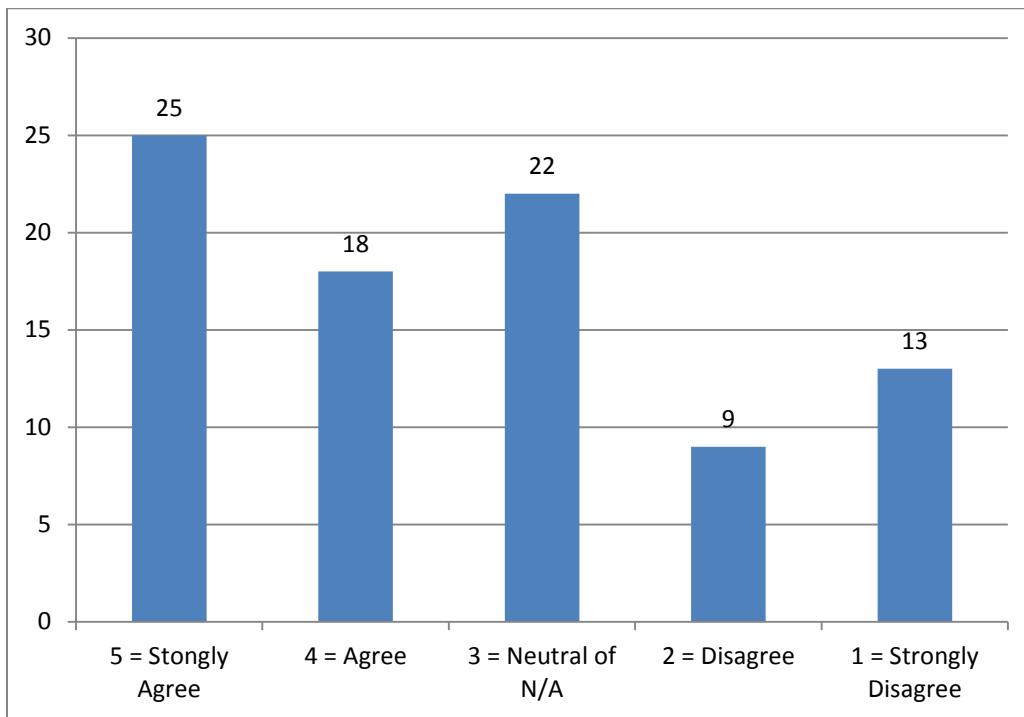


Figure C.4: I am confident using the land at or near Cluff Lake for traditional activities including hunting, berry picking, fishing, occasional camping, etc.

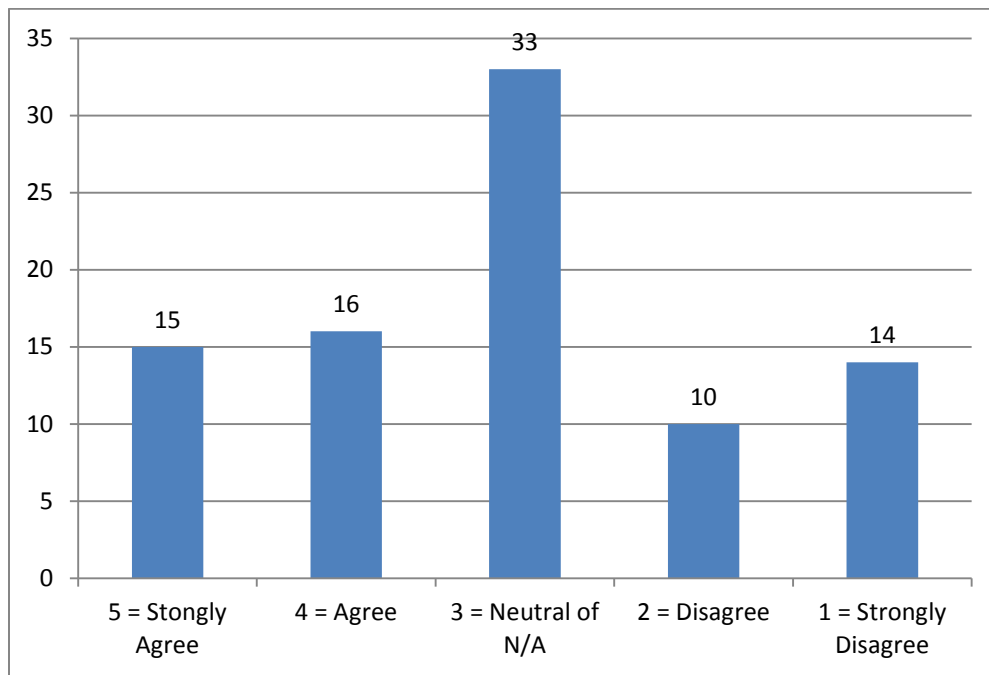


Figure C.5: I am confident that the Cluff Lake site does not pose radiological risk to members of the public

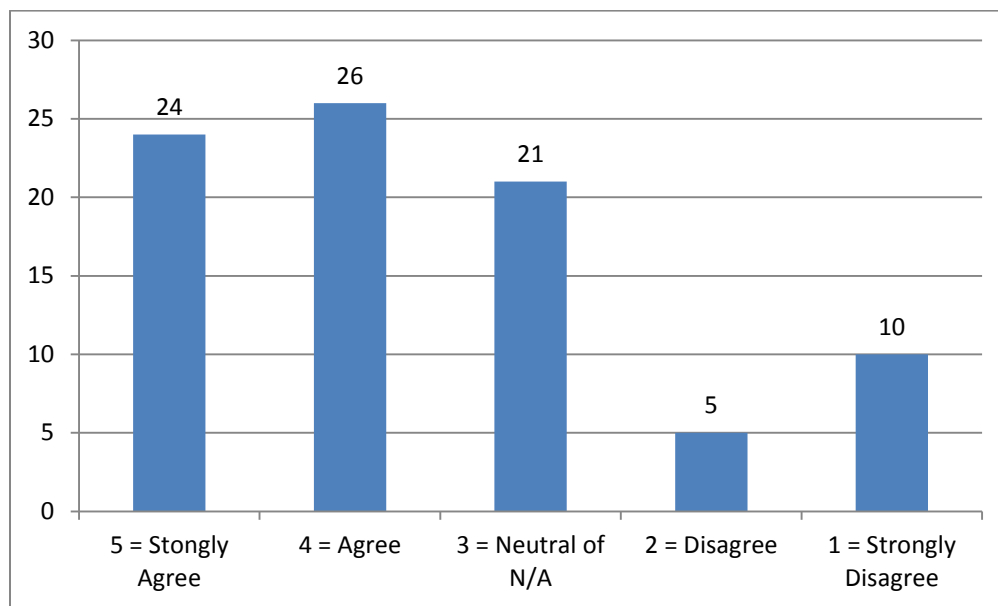


Figure C.6: The footprint of the Cluff Lake site is small compared to areas used for traditional purposes

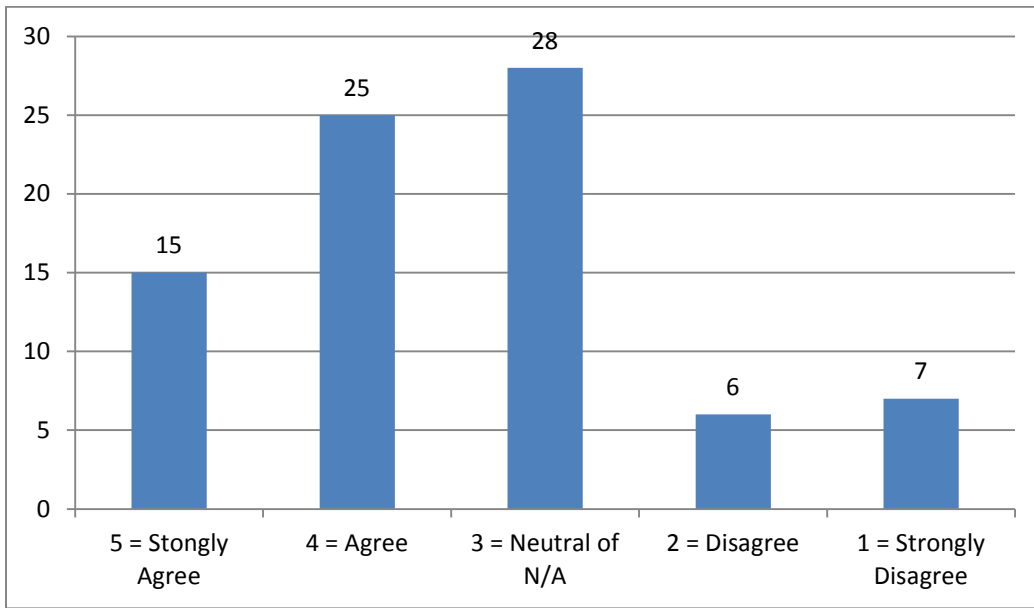


Figure C.7: There is an abundance of preferred fishing locations in the north; if I stayed at Cluff Lake is would be mostly as a base

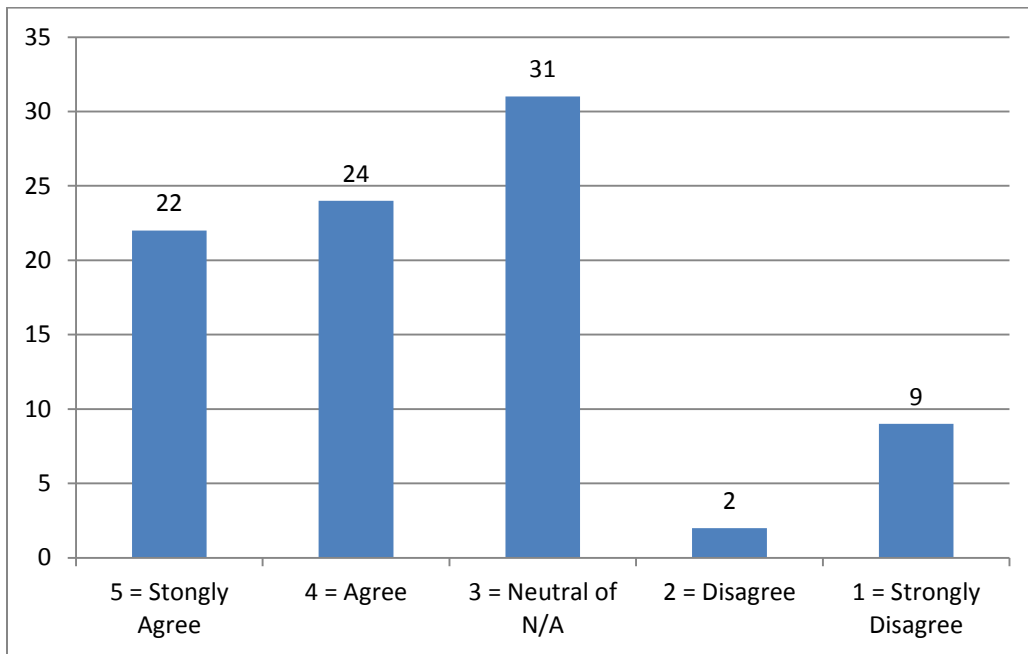


Figure C.8: I am confident that Orano has successfully decommissioned Cluff Lake Site

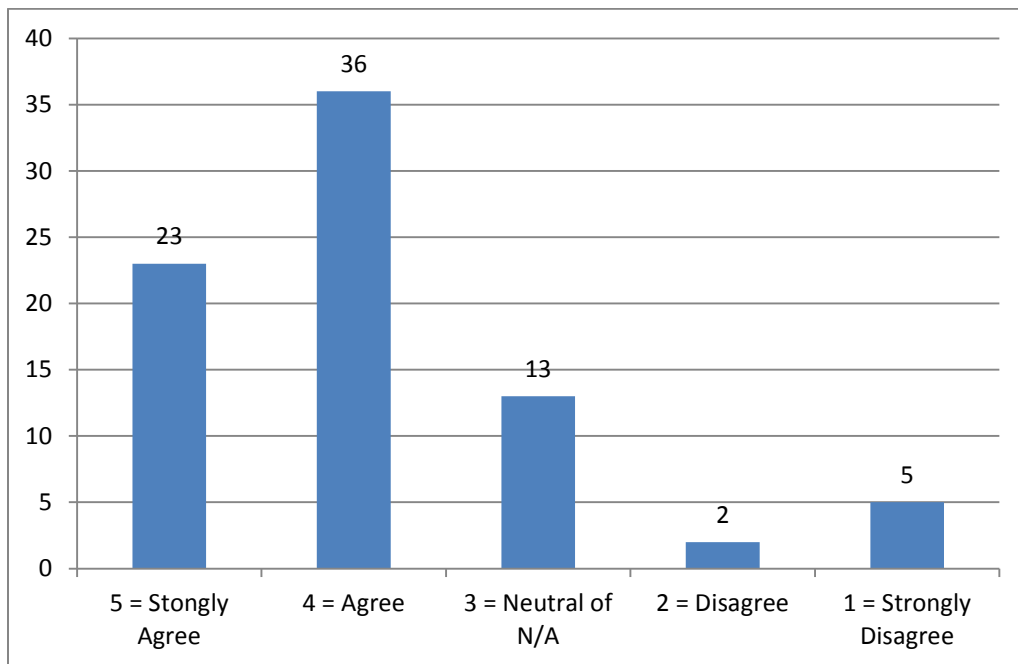


Figure C.9: Orano staff have adequately answered my questions

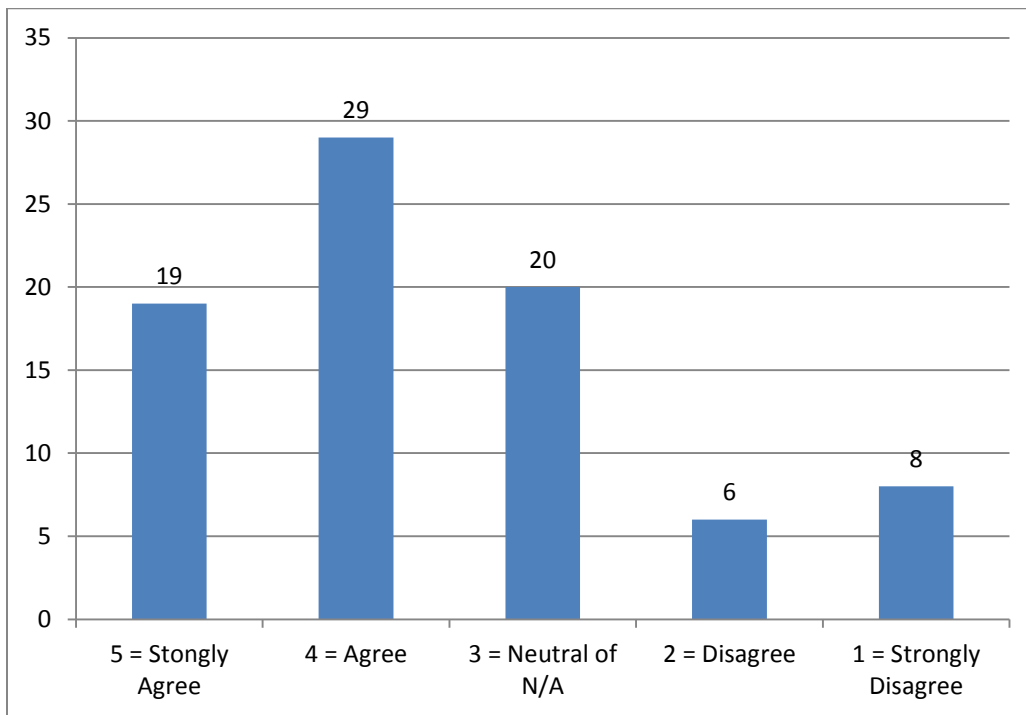


Figure C.10: I have all the information I wanted or needed about the decommissioned Cluff Lake site

From those who completed the surveys, the following is observed:

- there are varying perspectives on the site's residual risks and safe land uses;
- there is a rough split between those who agree that Cluff Lake poses no radiological risk and those that believe it does, with most responses neutral on the issue. This is likely due to the complexity of understanding radiological risks;
- people agree that Cluff Lake is small relative to the large regions in which people generally undertake traditional activities;
- there is some confidence in the decommissioning activities that Orano has undertaken at Cluff Lake; and
- Orano staff adequately responded to peoples' questions during the open house and there is a base of knowledge and understanding.

Figure C.11 presents an aggregation of all responses by community. Overall, more than 50% of responses were agree (4) or strongly agree (5) and more than 80% of responses were neutral (3) to strongly agree (5).

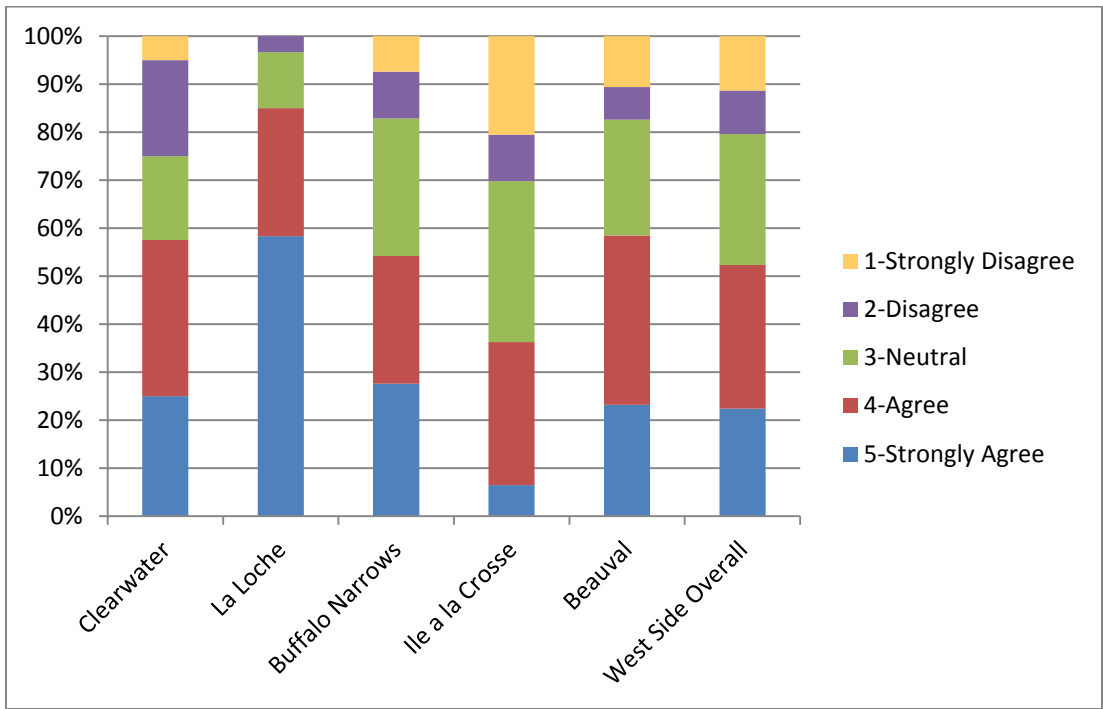


Figure C.11: Survey Results across Communities