

CLUFF LAKE PROJECT

**Detailed Decommissioning Plan
Version 2**

February 2009

**AREVA Resources Canada Inc. - Cluff Lake Project
Detailed Decommissioning Plan
February 2009 –Version 2**

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February 2009 – Version 2

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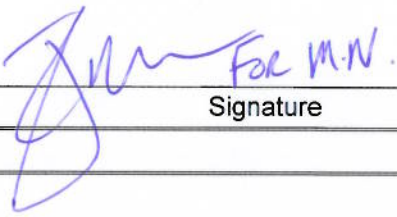
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Revision	Date	Details of Revision
0	October 2003	First release; submitted to CNSC, SE and Sask Labour on Oct 31, 2003.

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1	May 2004	<p>Second release; incorporates comments received from CNSC and revisions required because information had become non current. Major changes are noted below:</p> <p>Section 1.3.1 revised according to CNSC comment 2 (G-219)</p> <p>Section 1.5 added according to CNSC comment 4 (History)</p> <p>Section 1.6 revised to reflect actual dates.</p> <p>Table 2.2-1 revised to reflect current organization</p> <p>Section 3 revised according to CNSC comment 7 (Traditional use)</p> <p>Section 4.1 revised to correspond to the planning envelopes as described in April 28/04 correspondence S. Grinius to C. Natomagan</p> <p>Sections 4.3.1, 4.3.1.1, & 4.3.1.2 revised to reflect activities at Claude Pit and current plans.</p> <p>Section 4.6 revised according to CNSC comment 15 (to correct reference)</p> <p>Sections 4.6.3 and 4.6.3.2 revised to reflect the current schedule</p> <p>Section 4.7 revised to reflect bypassing PTS Plant</p> <p>Table 5.1.1 removed and section 5.1 revised as per CNSC comment 19 (sources)</p> <p>Section 6.9.3 revised according to CNSC comment 21</p> <p>Section 7.1 revised according to CNSC comment 22 (G-219)</p> <p>Section 7.6 revised according to CNSC comment 23 (Training)</p> <p>Sections 8.3.2.1 added and 4.3.2 and 4.4.1 revised according to CNSC comment 24 (Source Term Verification)</p> <p>Section 8.5, Table 8.5-1 revised according to CNSC comment 25.</p> <p>Section 5.4.1 and Table 5.4-1 added according to CNSC comment 80.</p> <p>Section 12 revised to include a reference to the Corporate IQMS Manual and to include specific corporate and site IQMS documents as amended.</p>
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2	September 2008 (DRAFT)	<p>Revised to reflect the physical decommissioning work substantially completed and current status of the Cluff Lake Project</p> <p>Section 1.3.2 - updated to reflect change to Provincial Surface Lease</p> <p>Section 1.4 - updated to History of Operations to include summary of decommissioning activities</p> <p>Section 2.1 – updated list of Board of Directors and Organizational Structure</p> <p>Section 3.2 – revision to discussion surrounding Water Quality Decommissioning Objectives</p> <p>Section 4 – updated figures; updated status of each planning envelope</p> <p>Removal of section describing mill operation (4.6.1)</p> <p>Section 6 – Potential Environmental Effects - updated status of individual elements; including planned path moving forward</p> <p>Removal of section 7.8 Supporting Activities – Engineering Program and Construction Program</p> <p>Updated summary of FuP to reflect changes made to FuP (modified timelines associated with individual elements)</p> <p>Increased detail and aspects of the Long Term Monitoring Plan (section 9), to adopt elements of the FuP</p> <p>Modified approach to schedule (section 11) and financial guarantee (section 12)</p> <p>Inserted a figure indicating document structure (section 1.2)</p>
2	February 2009	Updated to incorporate CNSC UMMD comments received February 4, 2009

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List of Acronyms

Acronym	Meaning
ALARA	As Low As Reasonably Achievable
CCD	Counter-Current Decantation
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
CEO	Chief Executive Officer
CMD	Commission Member Document
CNSC	Canadian Nuclear Safety Commission
COGEMA	COGEMA Resources Inc.
COP	Code of Practice
CSQG	Canadian Sediment Quality Guidelines
CSR	Comprehensive Study Report
CWRP	Claude Waste Rock Pile
DFO	Department of Fisheries and Oceans
DJ (X) (W)	Dominique Janine (Extension) (West)
DP	Dominique Peter
DWQO	Drinking Water Quality Objective
EH&S	Environment, Health, Safety and Radiation Protection
EMS	Environmental Management System
EPPM	Environmental Protection Procedures Manual
EQC	Environmental Quality Committee
ETP	Environmental Transfer Pathway
IQMS	Integrated Quality Management System
LOEC	Lowest Observable Effect Concentration
MFLM	Mining Facility Licensing Manual
MMER	Metal Mining Effluent Regulations
MWHP	Mine Water Holding Pond
OH&S	Occupational Health and Safety
PAD	Personal Alpha Dosimeter
PEL	Probable Effects Level
PMP	Probable Maximal Precipitation
PTS	Primary Treatment System
RSIC	Radiation Safety Institute of Canada
RW&SQWG	Regional Water and Sediment Quality Objectives Working Group
SMOE	Saskatchewan Ministry of Environment
SEL	Severe Effects Limit
SSWQO	Saskatchewan Surface Water Quality Objectives
STS	Secondary Treatment System
TDG	Transportation of Dangerous Goods
TDS	Total Dissolved Solids
TMA	Tailings Management Area
VP	Vice President

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WHMIS

Workplace Hazardous Materials Information System
--

1 INTRODUCTION

1.1 Project Overview

The Cluff Lake Project, owned by AREVA Resources Canada Inc. (AREVA), is 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 (Figure 1.1).

The facilities at the Cluff Lake Project previously 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. Figure 1.2 shows the former location of these facilities at the Cluff Lake Project.

AREVA announced in August 1998 that it would indefinitely suspend operations at the Cluff Lake Project as of December 31, 2000, due to depletion of economically viable ore reserves and the volume of tailings approaching the authorized capacity of the existing TMA. Additional ore reserves in one of the underground mines, with a higher grade than the historical average, made it economically feasible to extend the operation into 2002. The higher grade also reduced the rate at which tailings were generated; thereby extending the period until the TMA reached its authorized capacity. Mining operations extended through May of 2002, while milling, to process all of the remaining ore, was completed in December of 2002.

The Comprehensive Study Report for the decommissioning of Cluff Lake was completed and accepted in 2004, resulting in the issuance of required authorizations to proceed with decommissioning activities. Active decommissioning of the mill, TMA and mining areas was completed from 2004 through to 2006. The current facilities at the Cluff Lake Project include a small residential camp which includes potable and sewage treatment plants, 2 steel Quonsets which serve as storage and mechanical shop area, along with a small power generation system. Also remaining, standby, in the TMA area is the STS water treatment plant which is designed as a contingency radium treatment system. Ancillary facilities which include roads, power lines, and the airstrip also remain.

Figure 1.3 shows the current facilities of the Cluff lake project.

This Detailed Decommissioning Plan (DDP) replaces the Mining Facility Licensing Manual (MFLM) as the key reference in the license issued by the Canadian Nuclear Safety Commission (CNSC) for decommissioning the Cluff Lake Project. Refer to Figure 1.4 Document Structure.

The preparation, review, revision and distribution of this document will be done in accordance with the Cluff Lake - Integrated Quality Management System (IQMS) Manual.

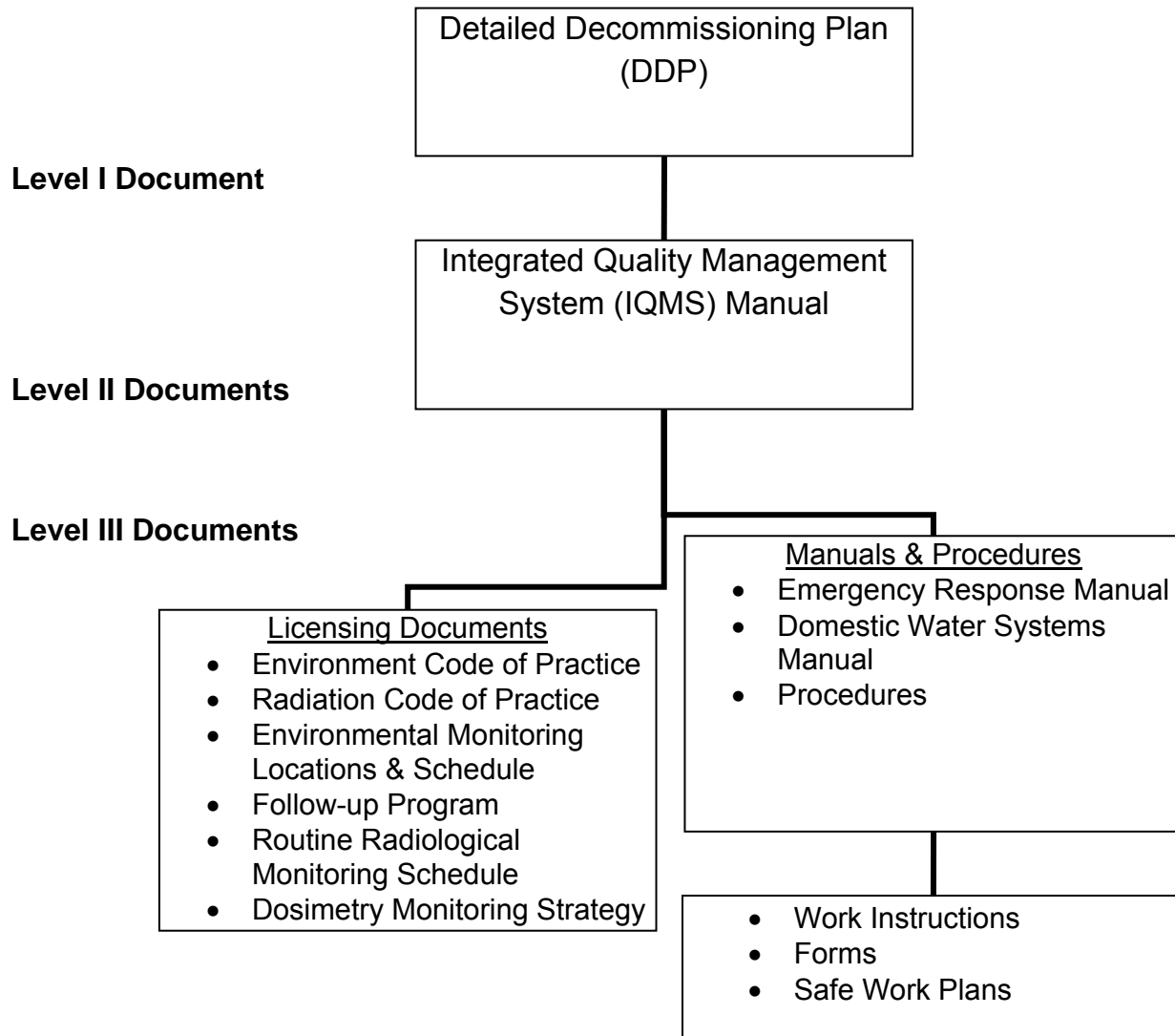


Figure 1.4 Document Structure

1.2 Licensee

AREVA Resources Canada Inc., with headquarters in Saskatoon, is one of the world's largest producers of uranium. The owner of AREVA Resources Canada Inc. is AREVA NC which is based in France, and is part of the AREVA Group of companies, a world leader in nuclear energy, and in electricity transmission and distribution. The Areva Group is involved in all aspects of the nuclear fuel cycle, including uranium mining, conversion, enrichment, fuel fabrication, reactors and services, reprocessing and recycling, and all related engineering services.

In addition to the Cluff Lake Project, AREVA Resources Canada Inc. is operator and majority owner of the McClean Lake and Midwest uranium projects. The company is also a minority owner of the Key Lake, McArthur River and Cigar Lake uranium projects. All of these projects are located in the Athabasca Basin of Northern Saskatchewan.

The business address is:

AREVA Resources Canada Inc.
P.O. Box 9204
817 - 45th Street West
Saskatoon, Saskatchewan
S7K 3X5

1.3 Federal and Provincial Regulatory Requirements

The decommissioning of the Cluff Lake Project is governed by a number of federal and provincial acts, regulations and policies. The primary regulatory agencies are the Canadian Nuclear Safety Commission (CNSC) and Saskatchewan Ministry of Environment (SMOE). The regulatory requirements for the Cluff Lake decommissioning project are outlined in the following sections.

1.3.1 Federal

The federal government, under the Nuclear Safety and Control Act, has responsibility for the regulation of matters relating to atomic energy, including uranium mines. Under this Act and its regulations, the CNSC has responsibility for the licensing of various stages of a uranium mining and milling facility, which may include site preparation, construction, operation, decommissioning and abandonment (i.e. cessation of CNSC licensing). The main regulations under this Act applicable to a uranium mine site are as follows:

- *Uranium Mines and Mills Regulations*
- *General Nuclear Safety and Control Regulations*
- *Nuclear Substances and Device Regulations*
- *Radiation Protection Regulations*

- *Packaging and Transport of Nuclear Substances Regulations*

In addition, various guidelines and consultative documents applicable to the decommissioning of the Cluff Lake Project have been used in preparing this document and the supporting documents, including:

- *Policy on the Decommissioning of Nuclear Facilities, Regulatory Document R-90*
- *Decommissioning Planning Guide for Licensed Activities, G-219*
- *Financial Guarantees Guide for the Decommissioning of Licensed Activities, Consultative Document G-206*

Other federal Acts such as the Canadian Environmental Protection Act, specifically the Federal Halocarbon Regulations, and the Fisheries Act also apply to this site

During operations, the site was subject to the Metal Mine Effluent Regulations (MMER) which came fully into force on December 6, 2002. The Cluff Lake Project attained Recognized Closed Mine Status as of January 16, 2006 and no longer falls under MMER.

Further requirements with regards to environmental assessments are detailed in Section 1.6.

1.3.2 Provincial

While the CNSC is the lead regulatory agency for uranium mines and mills, the Cluff Lake site is subject to a number of key provincial acts and regulations, under the direction of Saskatchewan Ministry of Environment (SMOE), as follows:

Environmental Management and Protection Act (2002)

- *Mineral Industry Environmental Protection Regulations*
- *Hazardous Substances and Waste Dangerous Goods Regulations*
- *Water Regulations*
- *Environmental Spill Control Regulations*

Provincial Lands Act

- *Crown Resource Lands Regulations*

Clean Air Act and Regulations

SMOE issues permits for the operation of potable water systems and approvals for the operation of pollutant control facilities.

Saskatchewan First Nation and Métis Relations, Northern Affairs Branch, formerly Saskatchewan Northern Affairs has responsibility for the land access rights at the Cluff Lake

site. In July 2004 AREVA re-negotiated the April 2000 Cluff Lake surface lease agreement with the Province of Saskatchewan for lands located at approximate UTM Grid Zone 12/6469000mN/582000mE, identified by property number 200085. The negotiation resulted in a partial surrender of the surface lease reducing the total lease area from 4131 hectares (ha) to 1631 ha. Of this total, 634.78 ha are developed and 995.88 ha are undeveloped. The areas generating the current surface lease is shown on the attached Figure 1.3. The current surface defined in this figure by the areas that are colored. Items encompassed by the surface lease include the following:

- Bush roads (with no buffer)
- Main roads 30 meters wide (road, ditch and buffer) raise and access road
- Developed areas with 20 meters buffer into undeveloped land
- Small amounts of undeveloped area
- Lakes including Cluff Lake, Island Lake and Snake Lake

The lease agreement identifies specific requirements in the areas of occupational health and safety of workers, environmental protection, direct employment and economic benefits for residents of Saskatchewan's North.

1.4 History of Operations

1.4.1 Site Development and Operational Chronology

Construction of the Cluff Lake Project began in 1979 and the final barrel of yellow cake was produced in December 2002. During the 22 years of production and milling at the site, six (6) different ore bodies were approved for extraction and milling using a combination of open pit, underground and surface-to-underground extraction methods. At the conclusion of the project, five (5) ore bodies were extracted using either underground or open pit techniques. Mining of the N ore body was deferred in favour of the Dominique-Janine (DJ) ore body. The delineation of extent of the DJ ore body was completed in 1989. The surface-to-underground extraction method approved for the DJ ore pods proved to be uneconomical and did not proceed beyond the test phase. An outline of the mining and milling chronology is presented in Table 1.4-1

Table 1.4-1 Chronology of Mining and Milling

Stage	Ore Body - Method	Duration
Phase I	D - Open Pit	1979-1981
Phase II	Claude - Open Pit	1982-1989
	N - Open Pit*	
	OP - Underground	1983-1999
	DP - Underground	1983-1999
	N - Underground*	
DJ Ore Body	DJ North – Open Pit	1989-1991

	DJ Extension – Open Pit	1994-1997
	DJ - Underground	1994-2002
	DJ Ore Pods - Test	1995-1996

Ore from the D Pit was milled under two phases. Phase I included the milling of the D Pit ore using conventional methods. Phase I Extension provided approval for the re-milling of uranium-bearing gravimetric tails that were generated from Phase I milling.

The approval process for the various project developments changed significantly from during the 22 year production life of the facility. All developments within the site required primary approvals from both federal (AECB and later CNSC) and provincial environment department regulators.

Portions of the Cluff Lake operation were the subject of a provincial public inquiry and a joint federal-provincial panel review that was struck to review several proposed uranium developments in northern Saskatchewan. Further details on the historical role of environmental assessment as it relates to the Cluff Lake project can be found in Section 1.6 of the DDP.

The Dominique-Janine Extension project was modified in response to recommendation from the joint federal provincial panel. At this time further assessment work on the contaminant transport model for the Tailings Management Area (TMA) was conducted by AMOK (now AREVA Resources Canada). In addition tailings research was conducted by the Civil Engineering Department of the University of Saskatchewan.

Milling of all remaining ore stockpiles was completed in 2002 with the final barrel of yellowcake being produced in December of 2002. The mill was subsequently mothballed in preparation for decommissioning.

The operation was in a state of care and maintenance from 2002 through July 2004 when decommissioning approval was received. From 1999 until the summer of 2004, a number of miscellaneous clean-up and reclamation activities were carried out to reduce risks to health, safety and the environment.

By November 2004, phase 1 of the mill demolition was completed. AREVA received CNSC and SMOE approval to initiate the TMA Grading Course.

In 2005, Phase 2 of the mill demolition was completed from August to December. Further work at the DJ yard included radiological cleanup, removal of the DJ fuel tank and backfill of the DJN sump. All waste was disposed of in the Claude Pit. Flooding of DJX Pit with water from Cluff Lake commenced in May 2005. Waste rock excavation from DJN Pit (initiated in 2004) was completed and all waste was disposed of in Claude pit.

TMA activities included continuation of the Grading Course, breach of the main dam, and initiation of the Liquids Pond backfilling. Claude mining area activities included completion of the Claude Pit dewatering, excavation and relocation of waste rock from the waste rock pile, regarding of the waste rock pile, compaction of the waste rock, initiation of the cover placement, removal of the Claude pit dykes, reclamation of the ore pad area, and backfilling of the Clay Pit. Where final grading was completed, tree seedlings were planted as part of the Revegetation Project.

In 2006, final landscaping of the DJ yard and pit areas was completed. Flooding of DJX Pit was completed in January. TMA activities included completion of the Grading Course, completion of the Liquids Pond backfilling, buttressing of the Main Dam, and construction of the stormwater/runoff management structures. Claude mining area activities included completion of the covers for Claude Pit and the waste rock pile and removal of the Claude Shop. The Claude Yard was covered with glacial till and graded to match the surrounding contours. To address a contaminated groundwater plume originating from the waste rock pile, a permeable reactive barrier (peat trench) was constructed southwest of the pile to intercept the plume. Details on the construction and intended function of the Peat Trench can be found within the document entitled, *As-Built Report Permeable Reactive Barrier (Peat Trench) Adjacent to Claude Creek* (April 2006a). Revegetation activities included planting tree seedlings where final grading was completed, as well as seeding the TMA and Claude Waste Rock Pile with a blend of grasses and legumes. Establishing a grass/legume cover for these areas is essential for minimizing erosion and percolation of moisture through the covers.

In 2007, reclamation work was essentially limited to continued revegetation of the major decommissioned areas and removal of power poles and power lines that were no longer needed. Some erosion gullies were observed along the TMA Main Dam and along the slopes of the Claude Waste Rock Pile. These gullies were repaired and revegetated. A second permeable reactive barrier was constructed next to the first barrier, details can be found within the document entitled, *As-Built Report Permeable Reactive Barrier (Peat Trench) Adjacent to Claude Creek* (June 2007).

In 2008, reclamation activities to date include fertilizing the TMA and Claude Waste Rock Pile grass/legume covers. Hydroseeding was completed on areas of the TMA and Claude pile that showed poor germination. Some minor erosion gullies were repaired at the TMA Main dam, while some restructuring and relining of the runoff channel are on-going at the Claude Waste Rock Pile.

1.5 Current Licences and Approvals

For the Cluff Lake Project, AREVA currently holds a CNSC decommissioning licence (UMDL-MINEMILL-CLUFF.01/2009), issued under section 24 of the Nuclear Safety and Control Act,

and a Saskatchewan Ministry of Environment (SMOE) Approval to Operate Pollutant Control Facilities (Approval No. IO-191); issued under various sections of *The Mineral Industry Environmental Protection Regulations*, *The Environmental Management and Protection Act*, *The Hazardous Substances and Waste Dangerous Regulations*, and the *Clean Air Act*. The CNSC licence is valid until July 31, 2009 and the SMOE approval is valid until August 31, 2009. The initial decommissioning CNSC license was amended in May 2006 to reflect the official company name change from COGEMA Resource Inc. to AREVA Resourced Canada Inc. Under the terms of the CNSC licence, AREVA is currently authorized to decommission a nuclear facility.

1.6 History of Environmental Assessments

In February 1977, the Province of Saskatchewan appointed three commissioners to conduct a public inquiry into the probable environmental, health, safety, social and economic effects of the proposed mining facility at Cluff Lake, and the desirability of expanding the uranium mining industry in Saskatchewan. Following an extensive review by the Cluff Lake Board of Inquiry, their report, issued in June of 1978, recommended that the Cluff Lake Project be allowed to proceed subject to certain conditions.

In 1984, the Federal Government established the Environmental Assessment and Review Process (EARP) to guide future assessments of major projects.

In August 1991, the governments of Canada and Saskatchewan appointed the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan (also referred to as “the Panel”) to review several proposed uranium mining developments in northern Saskatchewan. At the same time, AMOK Ltd., (now AREVA Resources Canada Inc.), submitted an Environmental Impact Statement for the expansion of the Cluff Lake Project to the Panel.

In October 1993, the Panel issued its report and recommendations on three proposed developments including the DJ Extension of the Cluff Lake Project. In December 1993, the respective governments responded to the Panel report and approved expansion of the Cluff Lake Project to proceed to the detailed licensing stage with federal and provincial regulatory bodies; primarily, the CNSC and SE.

In 1995, the Federal Government replaced EARP with the *Canadian Environmental Assessment Act* (CEAA). This Act and regulations made pursuant to the Act, formalized the previous process and allows for various levels of environmental assessments to be conducted including;

- Screening Report
- Comprehensive Study with option for:
 - a) Panel Review, and/or
 - b) Mediation.

In April 1999, COGEMA (now AREVA Resources Canada Inc.) submitted a Project Description for the proposed Cluff Lake Decommissioning Project to the CNSC. In May 1999, CNSC advised COGEMA that they had determined a Comprehensive Study was required under CEAA, with the CNSC as the Responsible Authority. CNSC further established, in consultation with Saskatchewan Environment (now SMOE), that an environmental assessment of the decommissioning project was not required by the Saskatchewan Environmental Assessment Act. However, SE agreed to participate as technical reviewers in the assessment process, and were also required under the provincial process to approve the decommissioning plan prior to its implementation.

Guidelines for the scope of the project and the scope of the assessment were provided by CNSC to COGEMA in October 1999. Pursuant to Section 17 of CEAA, CNSC delegated to COGEMA responsibilities for public consultation and the preparation of technical Environmental Assessment studies and documentation.

The results of the studies were submitted to the CNSC in the form of a draft Comprehensive Study Report (CSR) in January 2001. The draft CSR detailed the environmental impacts and plans for decommissioning the Cluff Lake Project and was reviewed by CNSC, SE, and other regulatory agencies including Environment Canada, Health Canada, Natural Resources and Saskatchewan Labour. The government agencies responded with a list of issues and concerns requiring further information in September 2001. COGEMA submitted responses to the Regulators' concerns in December of 2001 in an Addendum to the draft CSR. A second round of comments was received from government agencies in May of 2002, which were responded to by the end of 2002. The CSR which is a comprehensive assessment of the project and residual impacts after mitigation was completed by the CNSC in October of 2003. Following a review by various Federal Authorities and translation into French, the CSR was submitted to the Canadian Environmental Assessment Agency (CEAA) in January of 2004 and received Ministerial approval in April of 2004.

1.7 History of Incidents and Accidents

Throughout the twenty two year operational life of the project, there have been a number of minor spills and incidents. These events have been described in detail in Section 2.4.3.2 of the COGEMA, 2000a. Accidents and or incidents are reported according to procedure

There was also one incidence of surface-expressed subsidence of an underground mine working which occurred on February 28, 1999. A complete account of this incident can be found in Section 5.5.6 of COGEMA, 2000a. Additionally, a geotechnical report on the subsidence and an assessment of the potential for further underground subsidence is contained within Appendix C of Appendices – Volume 2 of 2, COGEMA, 2000e, which is a supporting document for the CSR.

Incidents and accidents that occurred during active decommissioning were reported according to procedure. Summaries of these incidents and accidents can be found in the Cluff Lake annual reports and in the applicable as-built reports, AREVA 2007b through e.

2 ORGANIZATION AND RESPONSIBILITIES

2.1 Board of Directors

The following people comprise the Board of Directors of AREVA Resources Canada Inc.:

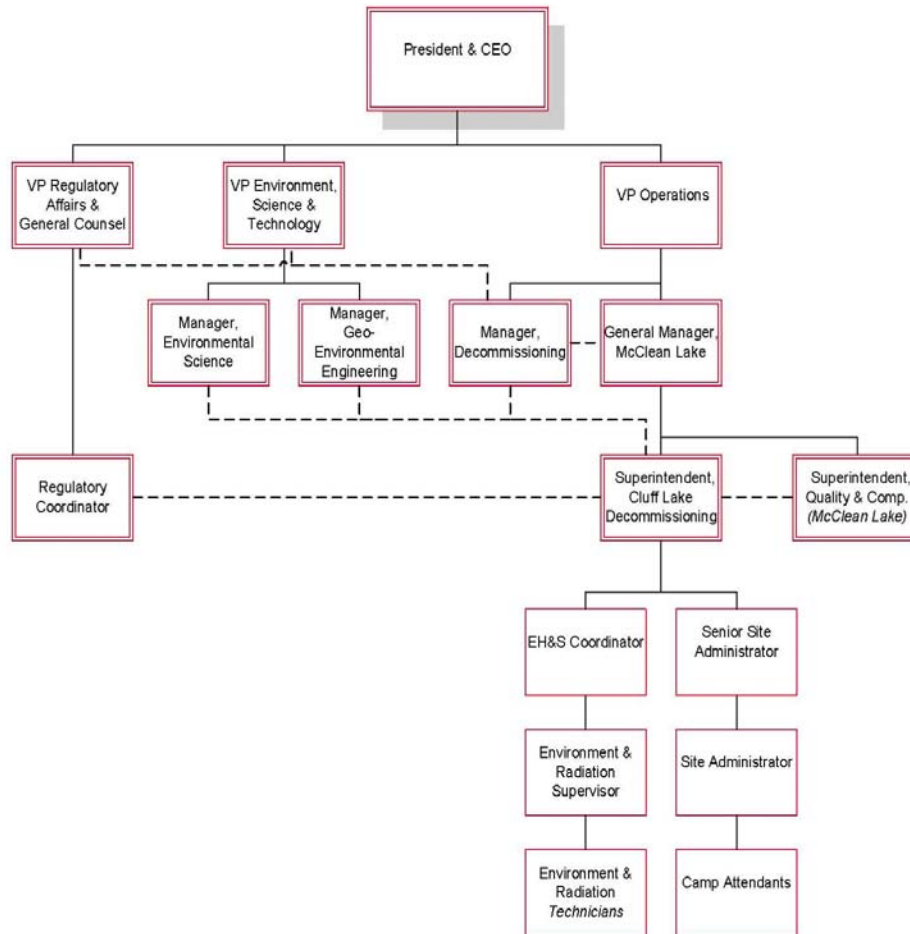
Mr. Sebastien de Montessus BU Mines Director Tour AREVA 1, place de la Coupole 92084 Parils La Defense CEDEX France	Mr Xavier Chabot Director of Operations Tour AREVA 1, place de la Coupole 92084 Parils La Defense CEDEX France	Mr. Armand Laferrere President, AREVA Canada Inc. 925 Brock Road Pickering ON L1W 2X9
Mr. Vincent Martin President & CEO AREVA Resources Canada Inc. 817 45th St. West Saskatoon SK S7K 3X5	Mr. Gerald Scherman Sr. VP & Chief Financial Officer AREVA Resources Canada Inc. 817 45th St. West Saskatoon SK S7K 3X5	Ms. Tammy Van Lambalgen VP Regulatory Affairs and General Council AREVA Resources Canada Inc. 817 45th St. West Saskatoon SK S7K 3X5
Mr. Jean-Pierre Nicoud VP Engineering and Projects AREVA Resources Canada Inc. 817 45th St. West Saskatoon SK S7K 3X5		

2.2 Company Management

The senior management positions most likely to interact with the Canadian Nuclear Safety Commission (CNSC) for the Cluff Lake Project are shown in Figure 2.1. Saskatoon positions are the primary contact with the CNSC for new projects or “generic” licensing topics. Cluff Lake positions are the working contact with the CNSC for the Cluff Lake Decommissioning License.

Responsibilities for the Saskatoon positions are outlined in the corporate *Integrated Quality Management System Manual (COGEMA 2004a)*. Responsibilities for the Cluff Lake and McClean Lake positions and the site departmental organizational structures are outlined in the Cluff Lake *Integrated Quality Management System Manual (AREVA 2006)* or the McClean Lake *Integrated Quality Management System Manual (AREVA 2008)*.

Figure 2.1 Cluff Lake Organizational Structure



3 DECOMMISSIONING OBJECTIVES

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 proponent's public consultation process.

The objectives of decommissioning activities are to remove, minimize, and control potential contaminant sources and thereby minimize the adverse environmental effects associated with the decommissioned property. The decommissioning project is designed to achieve an end-state property that will be safe for non-human biota and human use, stable, allow utilization for traditional purposes, and that minimizes potential constraints on future land use planning decisions. The decommissioning project is designed to minimize the need for care and maintenance activities, and long-term institutional control taking into consideration socio-economic factors.

Traditionally, the site was seasonally accessed by an aboriginal trapper who maintained a commercial trap line in the local study area. The trapper also hunted and fished for personal consumption. There is no evidence of any other site activities by aboriginal or non-aboriginal peoples prior to site development. Throughout the Cluff Lake Lake Project history, this same trapper has continued to trap within the Cluff Lake site. The trapper maintained cabins at both Cluff Lake and Sandy Lake. In addition, more recently, an outfitter also established a fishing/hunting lodge on the shore of Carswell Lake, approximately 20 km north of the site. While some fishing has occurred on Cluff Lake, most fishing is being concentrated on the nearby Sandy and Carswell Lakes. Gathering and consumption of locally available low bush cranberries, blueberries and mushrooms has also been conducted throughout the project history.

Specific decommissioning values were established using existing federal and provincial guidelines, and taking into consideration site specific conditions. In the absence of federal and provincial guidelines for identified contaminants of potential concern, information obtained from the scientific literature and site specific conditions were evaluated to derive benchmarks for inclusion as decommissioning objectives.

3.1 Locations for the Achievement of Decommissioning Objectives

Locations chosen to meet the water quality decommissioning objectives for key surface waterbodies were identified by the consideration of the locations, and the distances of potential contaminant sources in relation to potentially impacted natural surface waterbodies, and in consultation with federal and provincial authorities. The selected locations are listed in Table 3.1.

3.2 Water Quality Decommissioning Objectives

Water quality objectives generally represent contaminant concentrations below which significant adverse effects on aquatic organisms are unlikely. Therefore, water quality that meets or exceeds such objectives will ensure that waterbodies on the Cluff Lake site can support a healthy aquatic community.

The 1997 Saskatchewan Surface Water Quality Objectives (SSWQO) for “General” and “Protection of Aquatic Life and Wildlife” were adopted as Decommissioning Surface Water Quality Objectives (DSWQO), with the exception of iron because of its naturally high background level in the Cluff surroundings. At the time decommissioning objectives were being established, there were no Saskatchewan or national water quality guidelines for uranium, molybdenum or cobalt. Therefore, site-specific decommissioning water quality objectives were developed for iron, uranium, molybdenum and cobalt based on prevailing site conditions, the consideration of past, interim and current guidelines from other jurisdictions, and experimental toxicity data published in the literature.

In 2006 Saskatchewan Environment issued new SSWQO which, as a whole, recognize the water quality objectives of the Canadian Council of Ministers of the Environment (CCME) for the protection of aquatic life has being acceptable for Saskatchewan. Although the provincial water quality objectives have been updated from 1997 to 2006, the surface waters at Cluff Lake site continue to be measured against the DSWQO.

3.2.1 Water Quality Objectives for Flooded Pits

Because of their geometry and isolation from natural freshwater ecosystems, flooded mined out pits do not generally represent good aquatic habitat. Experience in northern Saskatchewan and elsewhere has shown that mined out flooded pits may become colonized with aquatic organisms and may be occasionally used by wildlife and waterfowl. For this reason, water quality decommissioning objectives have been set for flooded pits at the Cluff Lake site.

The decommissioning water quality objectives for flooded pits are set for the upper 50% of the water column, which represents approximately 80% of the pit volume. Wildlife and waterfowl use of flooded pits is expected to be infrequent and restricted to the upper water column, well above this depth objective. These depth objectives require achievement of better quality water in the upper portion of the water column. However, poorer water quality is expected at the bottom of the pits where the basement rock is the lowest permeability and biological activity is minimal. Groundwater transport from the bottom of the pit to downstream surface waters will be reduced in comparison to the larger flows of better quality water moving through overburden.

3.2.2 Site Specific Water Quality Objective for Iron

In the Athabasca Basin, many small lakes, wetlands and creeks exhibit naturally elevated concentrations of iron in their waters. Measured iron concentrations in surface waters within the local study area, which are unimpacted by mining and milling activity, are up to 13.0 mg/L. This is appreciably greater than the 2007 SSWQO for iron of 1 mg/L. Therefore, a site-specific decommissioning objective for iron was adopted based on the natural background variability observed in surface water iron concentrations. For a particular watershed, the site-specific values selected represent the 95th percentile of the observed iron concentrations recorded since 1992 at reference locations within that watershed. The decommissioning objective to be achieved in the upper water column of flooded pits represents the highest 95th percentile iron concentration measured in the watersheds.

3.2.3 Site Specific Water Quality Decommissioning Objective for Uranium

To develop a uranium surface water decommissioning objective, the scientific literature describing uranium toxicity to freshwater organisms was reviewed. The review suggested that, like several metals (e.g. cadmium, copper, nickel, zinc), uranium bioavailability is reduced with increasing water hardness.

To assess the relationship between uranium bioavailability and water hardness, the scientific literature describing uranium acute and chronic toxicity was compiled in conjunction with the water hardness under which each test was conducted. The data was classified into two toxicity test types: acute and chronic, and three classes of organisms: fish, invertebrates and algae. The majority of available data consists of two categories: fish acute toxicity tests (n=19) and invertebrate acute toxicity tests. For these two categories of data, linear regression was used to evaluate the relationship between uranium toxicity, as represented by toxicity test LC50 concentrations, and water hardness. Invertebrates were the more sensitive of the two groups. For invertebrates, the regression relationship was $LC50 [mg/L] = 0.20 \text{ times the water hardness } [mg/L]$. Since this relationship was derived from acute toxicity tests, a safety factor of 100 was applied to this relationship to derive a suitably protective benchmark. The hardness dependent site specific DSWQO for uranium (mg/L) was therefore adopted as 0.002 times the water hardness (mg/L).

A Regional Water and Sediment Quality Working Group (RW&SQWG), consisting of representatives of Government (provincial and federal), Academia (University of Saskatchewan) and the uranium mining industry, was formed to contribute to further research toward confirming or, for some parameters, developing appropriate regional objectives for northern Saskatchewan. In particular, this working group was the platform for the development a new uranium objective for northern Saskatchewan. An interim surface water quality objective for uranium of 15 µg/L was proposed by the RW&SQWG. The objective was considered to be interim as it was deemed to require further validation. As part of the Follow-up Program described in Section 8 of this document, AREVA's responsibility is to conduct uranium speciation modeling and a review

of toxicity tests conducted using native species and site water to assess whether site-specific decommissioning surface water quality objectives for uranium need to be revised.

3.2.4 Site Specific Water Quality Decommissioning Objective for Molybdenum

Two water quality objectives were selected for molybdenum. The more stringent objective of 0.073 mg/L was adopted for Snake Lake and the Cluff Lake watershed. This is the interim *Canadian Water Quality Objective* (CWQO) [adopted from the Ontario Ministry of Environment (MOE) guideline objective] for the protection of aquatic life and is based on chronic effects on eyed eggs of rainbow trout (0.73 mg/L) with a safety factor of 10 (standard for objectives based on chronic tests).

Island Lake molybdenum concentrations were substantially elevated as a result of past operations. The molybdenum decommissioning objective for Island Lake was set at 0.5 mg/L. This value was considered not likely to adversely affect aquatic life as it was below all of the chronic response levels used in the development of the interim CWQO and also corresponded to the value recommended for the protection of wildlife.

The molybdenum objective set for the flooded pits was also 0.5 mg/L. This value was considered acceptable as the pits will remain isolated from natural waterbodies. There will be no surface water interchange between the flooded pits and local lakes and streams. Protection based on wildlife use of water for drinking was therefore considered appropriate.

3.2.5 Site Specific Water Quality Objective for Cobalt

The literature was reviewed in the development of a suitable cobalt objective (COGEMA 2001, Response to Regulatory Comments). Based on the available information, a dissolved (filtration through a 0.45 micron filter) water quality decommissioning objective of 0.020 mg/L was adopted. This value was derived from the Lowest Observable Effect Concentration (LOEC) derived for a species present in the region. This value fell below all values for acute toxicity and most values for chronic toxicity in a data set collated by the Ontario MOE and, therefore, was deemed a suitably protective benchmark.

In summary, decommissioning objectives for water quality for key watercourses, following the completion of decommissioning, are identified in Table 3.1.

**Table 3.1
Summary of Decommissioning Surface Water Quality
(Total Concentrations Unless Otherwise Specified)**

		Snake Lake	Island Lake	Claude Lake	Claude Creek	Peter River	Earl Creek	Cluff Lake	Flooded Pits*
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##	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 ***	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 **	mg/L	**	**	**	**	**	**	**	**
Mo###	µg/L	73	500	73	73	73	73	73	500
Co#	µg/L	20	20	20	20	20	20	20	20

* Flooded Pits – Objectives apply to upper 50% of the water column only

** Uranium was calculated as 0.002 [Hardness in mg/L] at the site in question.

*** 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

Cobalt objective was set as site specific decommissioning objective as explained in the above section.

Fe and Mo are waterbody specific as explained in the above sections.

3.3 Decommissioning Sediment Quality Assessment Guidelines

The *Canadian Sediment Quality Guidelines* (CSeQG) were used to assess the suitability of predicted post-decommissioning sediment quality to support a healthy benthic invertebrate community. For Snake Lake, Island Lake, and Cluff Lake, the CSQG classifies sediment quality with respect to specific contaminants and their potential for effects on benthic organisms. These general guidelines provide a range from low to high contaminant concentrations (Table 3.2). Of the major constituents of concern at the Cluff site, no sediment quality guideline exists for nickel (under review), uranium or molybdenum. A review of the scientific literature was undertaken to derive decommissioning benchmarks. Recent studies show a large range of benchmark toxicity values for uranium, molybdenum, and nickel, indicating that factors affecting chronic toxicity levels are not well understood and additional study is necessary. These benchmarks are used in the ecological risk assessment to gauge potential adverse effects.

The assessment of both sediment quality guidelines and site data against benchmarks will be conducted under the Follow-up Program.

Table 3.2
Sediment Quality Benchmark Values

Analyte	Interim Sediment Quality Guideline ($\mu\text{g/g}$)	Lowest Effect Level ($\mu\text{g/g}$)	Severe Effect Level ($\mu\text{g/g}$)	Probable Effect Level ($\mu\text{g/g}$)
	CCME 2005	Thompson <i>et al.</i> 2005	Thompson <i>et al.</i> 2005	CCME 2005
Arsenic	5.9	9.8	346.4	17
Cadmium	0.6	-	-	3.5
Chromium	37.3	47.6	115.4	90
Copper	35.7	22.2	268.8	197
Molybdenum	-	13.8	1238.5	-
Nickel	-	23.4	484	-
Lead	35	36.7	412.4	91.3
Lead-210	-	0.9	20.8	-
Polonium-210	-	0.8	12.1	-
Radium-226	-	0.6	14.4	-
Selenium	-	1.9	16.1	-
Uranium	-	104.4	5874.1	-
Vanadium	-	35.2	160	-
Zinc	123	-	-	315

Notes: $\mu\text{g/g}$ = micrograms per gram

Source: CCME 2005, Thompson *et al.* 2005

3.4 Decommissioning Radiological Objectives

The decommissioning radiological objectives are based on a need to keep radiation doses to nuclear workers and the general public below the regulatory limits and compliant with the “as low as reasonably achievable” (ALARA) principles, through the final decommissioning and post-decommissioning phases.

3.4.1 Workers

The limits on effective dose to nuclear energy workers (NEW) under the *Radiation Protection Regulations* (RPR) are 50 mSv in any year and 100 mSv in any five-year period (an average of 20 mSv per year). The regulations specify that the limit includes committed doses from external sources, inhalation of radon progeny, and ingestion and inhalation of radioactivity according to the sum rule provided.

Given the minimal remaining radiological hazards and the radiation monitoring program already in place at the licensed facility, the regulatory limits will be readily met. The objective will therefore primarily focus on the application of the ALARA principle. The attainment of this objective will be assured by an evaluation of measured doses from personal monitoring for

gamma radiation, and the potential for LLRD and RnP exposures. If required, additional measures will be established to keep these exposures ALARA.

3.4.2 Members of the Public

The limit on annual effective dose to a member of the public under the CNSC's RPR is 1 mSv. The regulations specify that the proposed 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]. Pathways analyses will be used to verify that exposures to members of the public, under a variety of potential land use scenarios, will be well below this limit both during and after the completion of decommissioning activities.

The decommissioning radiological objectives were derived on the basis of achieving a safe, stable property that would allow utilization of the area for traditional purposes or occasional access. A workshop at the Cluff Lake site with representatives from northern communities was held in 2005 to gain a better understanding of what future traditions use of the land might include. This assumes casual access with no individuals spending greater than 1000 hrs/year in an impacted area for specific activities. This does not include time spent at a cabin or camp which would typically be set up at a more desirable location in the area.

Radon progeny (RnP) and Long Lived Radioactive Dust levels (LLRD) were reduced through removal of source material or by covering with clean soil material. Sufficient cover materials will be applied to eliminate LLRD, and to reduce radon progeny levels to near background conditions where source terms exist. Post-decommissioning LLRD and RnP levels are, therefore, expected to be near background and will not require specific decommissioning objectives. The potential exposure to gamma radiation is assumed to be the primary exposure pathway.

Details on Surface Gamma Clearance for all major decommissioning activities were submitted under a separate cover entitled *Submission for Gamma Radiation Clearance - Cluff Lake Project* (AREVA 2007a), submitted to the regulatory agencies in November 2007.

3.5 Care and Maintenance and Long-term Institutional Controls

In the post-decommissioning or abandonment phase, institutional controls will be necessary, but will be minimized as much as feasible, taking into account socio-economic factors. It is expected that some provincial land use restrictions, including restrictions on groundwater use, will be necessary; however, traditional land use should not be restricted. The need for long-term care and maintenance shall be minimized. Long-term monitoring requirements should be infrequent and limited as the site should be in a relatively stable, self-sustaining state.

3.6 Objectives for Soil Covers

The purpose of soil covers for the Claude Waste Rock Pile (CWRP) and the Tailings Management Area (TMA) are to promote surface runoff, minimize infiltration and thus the release of contaminants to groundwater. To ensure that these objectives are met, a soil cover monitoring program has been implemented. Following final grading of the TMA and CWRP, continuous monitoring stations were installed at select locations to monitor soil and weather conditions to gauge the success of the cover systems.

Of key importance to the success of the soil covers is the establishment of a comprehensive grass/legume cover crop to maximize evapotranspiration. To attain this objective, a mixture of native grass and legumes was seeded within the TMA and Claude Waste Rock Pile covers in 2006 and 2007, and some hydroseeding was done in 2008 to cover some of the bare patches. This vegetative cover is being monitored for biomass and N content. In the fall of 2008, the covers averaged 273 and 191 g dry weight m² on the Claude pile and TMA, respectively.

3.7 Objectives for Revegetation

The objective is to accelerate the natural development of a forested environment similar to that which existed prior to site operations.

The revegetation approaches for the Cluff Lake site involve two different strategies: one for areas of soil covers and a second for the remaining areas of the site.

The TMA and Claude waste rock pile will be overlain with a soil cover. A commercially available mixture of shallow rooting grasses and legumes was seeded on these areas. This type of vegetative cover establishes very quickly and offers a comprehensive ground cover with significant sod formation to limit erosion of the cover material and maximize transpiration. These types of vegetative covers tend to resist and slow the rate of natural invasion onto the site and ensure the integrity of the covers for an extended period of time. As the native vegetation progressively invade, the soil binding capabilities of the grass/legume understory persists and is supplemented by the rooting systems of the native varieties.

The remaining areas were regraded to allow the indigenous vegetation to establish naturally. The principles of natural evolution and ecological development dictate a certain methodology for sustainable revegetation within each ecosystem. Cluff Lake, located in the northern boreal ecosystem, commonly begins the revegetation process with early successional species including various types of forbs such as fireweed and a selection of native grasses, such as northern reedgrass. Deciduous shrubs and trees, such as alder, willow, balsam poplar, trembling aspen and birch tend to establish next as soil conditions improve. Climax species in the Cluff Lake area are generally conifers, such as black spruce and jackpine, which take

advantage of early life cover and enriched soil conditions largely attributable to the earlier deciduous successional stage.

To date, all of the decommissioned areas mentioned in Section 1.4.2, with the exception of the TMA and the CWRP grass/legume covers, have been planted with a mixture of six native woody species, including Green Alder, Balsam Poplar, White Birch, Trembling Aspen, Willow and Jack Pine. The woody species selected for planting were propagated from local seed and tree cuttings, grown in a greenhouse environment and planted as seedlings. For areas planted in 2006, densities ranged from 82.4% to 137.1%. Survival rates are based on the target planting density of 3400 trees/ha. Results in excess on 100% indicate a slight over planting in that area along with good survival of the seedlings and some natural invasion. In general, excellent survival and density of trees have been obtained throughout the Cluff Lake site.

4 DECOMMISSIONING APPROACH

4.1 General

The purpose of this section is to provide an overview of the decommissioning activities remaining on site. This section includes a description of each major work area and provides general details regarding the decommissioning work performed within each area.

Detailed descriptions of the decommissioning work completed can be found in the following reports.

- *As-Built Claude Mining Area Decommissioning*, (AREVA 2007b)
- *As-Built Dominique Janine Area Decommissioning*, (AREVA 2007c)
- *As-Built Mill Demolition*, (AREVA 2007d)
- *As-Built Tailings Management Area Decommissioning*, (AREVA 2007e)
- *As-Built Permeable Reactive Barrier (Peat Trench) Adjacent to Claude Creek*, (April 2006a)
- *As-Built Second Permeable Reactive Barrier (Peat Trench) Adjacent to Claude Creek*, (June 2007)

Aerial photos of the key areas where structures and facilities previously existed were taken in the summer of 2008 are shown in Figures 4.1 to 4.5.

A list of the planning envelopes includes:

- 4.2 **D Mining Area** including the D Pit and the D waste rock pile.
- 4.3 **Claude Mining Area** including the Claude Pit, Claude Waste Rock Pile (CWRP), buildings and Surface Infrastructure
- 4.4 **DJ Mining Area** including DJN/DJX Pit, DJN Waste Rock Pile, DJ Underground Mine, DJ Overburden Pile, Building and Surface Infrastructure.
- 4.5 **OP/DP Underground Mine** including OP/DP Underground Mine, Buildings and Infrastructure
- 4.6 **Mill Complex** including Phase I and Phase II Mill Demolition
- 4.7 **TMA** including Solids Area, Liquids Pond, Main Dam, Stormwater Management, Revegetation, Buildings and Infrastructure.
- 4.8 **Ancillary Buildings and Services** including the Germaine Camp, Cluff Centre, South Gate, Batch Plant, Cluff Lake Pumphouse, Airstrip, Site Roads, Fuel Storage Facilities, Power Generation/Transmission, Pipelines, Monitoring Wells, Potable Water Supply, Spills/Contaminated Areas, Borrow Areas, Landfills and Revegetation.

4.2 D Mining Area

4.2.1 D Pit

D Pit was the first orebody mined at the Cluff Lake Project. Mining began in 1979 and was completed in 1981. The D ore body contained the highest-grade uranium ore at Cluff Lake and significant gold reserves. The pit, with a maximum depth of 28 m, became flooded in 1983 when ice formation during the spring thaw caused Boulder Creek to overflow its banks. The pit has remained flooded since that time. There is no surficial outflow from the pit; water either discharges as groundwater or is lost to evaporation.

Routine monitoring on 5m intervals throughout the water column has been conducted since 1987. The water column is stable, has an established chemocline with very little seasonal depth fluctuation. All decommissioning surface water quality objectives for flooded pits (Table 3.1) are met in the upper 50% of the water column in D Pit. The shoreline has naturally revegetated with native emergent and submergent aquatic macrophytes.

No further decommissioning action is planned.

4.2.2 D-Waste Rock Pile

The D waste rock pile is small (2.3 ha) and contains less than 150,000 m³. The pile is entirely D Pit waste and is located immediately adjacent to the pit. The pile was resloped and revegetated shortly after pit flooding. A self-sustaining vegetative cover has been established, initially from seeding of agronomic species, and more recently by native colonization. Infiltration from the waste rock pile reports to the flooded D Pit.

Extensive cleanup, grading and revegetation has been undertaken at the D mine area. A final radiological survey was conducted on the D pile as part of the Gamma Radiation Clearance procedure. The survey identified some areas that required remediation. Remediation was carried out in strategic areas to reduce all individual readings to below 2.5 µSv/hr and to meet the ALARA objectives with the exception of the large area average. To meet this objective a substantial amount of vegetation in advanced stage of growth that has occurred over the past 25 years would need to be destroyed. The D-Pit area represents a small area in relation to the entire Cluff Lake site and the increased readings are not considered significant for potential to increase the annual dose.

No further decommissioning activities are planned for this area.

4.3 Claude Mining Area

Decommissioning the Claude mining area involved:

- the completion of Claude Pit backfilling and grading of the surrounding area;
- resloping of the CWRP and construction of an engineered cover; and
- decommissioning of remaining Claude area buildings and surface infrastructure.

The following sections will provide a brief summary of the decommissioning activities completed at the Claude mining area. More detailed information on decommissioning activities and area history can be found within AREVA (2007b).

4.3.1 Claude Pit

Claude open pit is the largest pit at Cluff Lake and was mined from 1982 through to 1989. The pit has been used as a repository for waste rock, scrap steel, contaminated materials and demolition wastes generated at Cluff Lake.

To facilitate the backfilling of Claude Pit, dewatering of the Claude Pit started in 2003 and was completed by September 2005. Backfilling involved the placement of waste rock from DJX Pit and the DJN Waste Rock Pile into Claude Pit, disposal of demolition waste from the Mill complex and other site buildings and the application of a final cover. After final capping and grading, the remaining till cover was revegetated with tree seedlings, as per Section 3.7 of this report.

Ongoing maintenance of the Claude Pit will be limited to minor surface grading and erosion control as required.

4.3.2 Claude Waste Rock Pile

The CWRP was constructed between 1982 and 1989 and contains all waste rock from Claude pit. The pile contains roughly 5.2 million cubic meters of waste, is approximately 30 m high and covers an area of approximately 29.5 hectares to the south of Claude pit. The pile was developed by end dumping and contains well-developed traffic surfaces between the lifts of dumped material. The pile was recontoured in 1993 to reduce side slopes to 2H:1V or less. In 2001 and 2002, resloping and compaction tests were conducted on the CWRP to evaluate constructability and performance issues in support of the final cover design.

Decommissioning of the CWRP included:

- Recontouring the pile to a maximum slope of 4H:1V,
- Compaction of the regraded waste rock surface,
- Installation of a 1 m glacial till cover and
- Construction of stormwater management structures.

Subsequently, revegetation was completed as described in Section 3.6 of this report.

Ongoing maintenance of the CWRP will mostly consist of erosion gully repair as required.

Applications of fertilizer to enhance vegetation growth along with reseeding of select areas by means of hydroseeding or broadcast seeding may be utilized, depending on the nutrient analysis results as described in Section 8.

4.3.3 Buildings and Surface Infrastructure

Claude Shop, formerly used for heavy equipment storage and maintenance was removed in 2006. The surrounding area was covered with clean glacial till and graded for aesthetic reasons. Subsequently, the Claude Shop yard area was cleared for surface gamma radiation (AREVA 2007a) and revegetated with tree seedlings.

One small storage/electrical shed remains and will be decommissioned or relocated at such time it is deemed no longer necessary.

4.4 DJ Mining Area

Decommissioning the DJ mining area involved:

- entire DJN Waste Rock Pile and part of the DJX waste rock moved to Claude pit
- decommissioning of remaining DJ area buildings and surface infrastructure

The following sections provide a brief summary of the history and decommissioning work for the DJ mining area. More detailed information can be found within AREVA (2007c).

4.4.1 DJN/DJX Pit

The DJX and DJN open pits are located south of the Claude deposit and adjacent to the north end of Cluff Lake. The DJN pit came into production in 1989 and continued through to 1991. Mining of the DJX pit occurred from 1994 through to 1997.

The DJN pit was allowed to fill with water prior to mining of the DJX ore body. The DJN pit was drained and later filled with clean waste rock (< 0.03% uranium) from the DJX pit.

While mining DJ underground mine, the DJX pit was maintained in a dewatered state by seasonal pumping. The de-watering flow rate was approximately 70,000 m³/yr, which represented catchment area runoff, groundwater, and water seeping into DJX pit from the DJN pit. From November 2000 to May 2002, the pit was used as a temporary sump for minewater from the DJ underground mine.

Decommissioning the DJN/DJX Pit complex involved relocating a portion of the existing waste rock in DJN Pit, flooding of the pits, regrading the area, stormwater management and revegetation.

4.4.1.1 Pit Flooding

Following relocation of the waste rock, both pits were flooded to form a single water body at the natural groundwater elevation (anticipated to be marginally above the level of Cluff Lake, 317.4 masl). Water was pumped from Cluff Lake to expedite flooding to an elevation below 317.4m masl (~2.7 million cubic meters). Following this initial stage of flooding, the pit water. Following this initial stage of flooding, the water column pit water was allowed to reflood to its natural elevation. Water level in the pit continues to be monitored.

4.4.2 DJN Waste Rock Pile

The DJN waste rock pile was constructed between 1989 and 1991 during the development of the DJN open pit. The pile contained approximately 1.4 million cubic meters of waste rock, was up to 16 m high and covered an area of approximately 14 ha. The entire pile was relocated to Claude Pit in 2004 and 2005 and the area regraded and revegetated.

No further decommissioning work is anticipated in this area.

4.4.3 DJ Underground

The DJ underground (DJU) mine was developed in 1994 and operated until mine closure in 2002. The DJU mine was essentially dry with pumping required only for inflows from groundwater originating in overburden and weathered till near the surface and from water used during mining operations. The de-watering flow rate for this mine in 1998 was approximately 140 m³/d (52,000 m³/yr).

There has been one instance of surface subsidence related to mining activities at the DJU mine.. This is the only area of the DJU mine which sub-outcrops to surface and was therefore, vulnerable to crown pillar failure. It was stabilized at the time, and eliminated from further ground-fall considerations.

During site cleanup operations in 2002, all DJU raises and the DJU decline were backfilled with till material. All DJU raises were entirely backfilled from the bottom of the raise to the raise collar elevation. The DJU decline was backfilled from approximately 181m down the ramp to the portal opening. Reinforced concrete caps were placed above all backfilled raises and a concrete plug was poured at the DJU portal opening. The mine was partially flooded in 2002 using minewater from the adjacent DJX pit. The mine continues to flood under natural water flow conditions.

Similar to the OP/DP underground mine, waters in the DJU mine are projected to become anoxic over time thereby restricting long term loading to the environment.

No further work is required to decommission the DJU underground mine.

4.4.4 DJX Overburden Pile

The DJX Overburden Pile consists of till material removed from the DJX Pit prior to mining. This material was used as cover material in the cover construction of the CWRP. Once the till haulage was completed, the area was graded and revegetated with tree seedlings.

No further decommissioning activities are planned for this area.

4.4.5 Buildings and Surface Infrastructure

One small storage/electrical shed remains and will be decommissioned or relocated at such time it is deemed no longer necessary.

4.5 OP/DP Mining Area

Decommissioning the OP/DP mining area involved:

- Decommissioning of the OP/DP underground mine
- Decommissioning of DP area buildings and surface infrastructure

4.5.1 OP/DP Underground

Stripping and construction of ramps for the OP/DP mine began in 1983 and production commenced in 1985. Mining was discontinued in 1999, and the OP/DP mine was allowed to flood under natural conditions. Complete flooding of the workings was achieved in August 2002. The de-watering flow rate for the OP/DP underground mine was approximately 300 m³/d (110,000 m³/yr) during operation, however this flow was predominantly surface inflow and water pumped into the mine for drilling, shotcreting and dust suppression.

The OP/DP raises were partially backfilled in 2000 with final backfilling completed during site cleanup operations in 2002. The OP/DP decline was backfilled from approximately 176m down the ramp to the portal opening. Reinforced concrete caps were placed above all backfilled raises and a concrete plug was poured at the OP/DP portal opening.

Floodwaters deep within the mine and near surface are routinely monitored. Water in the mines will react with shotcrete (placed on the mine wall surfaces for stability and radiation protection) and concrete (used in backfill) and cause the mine water pH to increase. The mine water is projected to become anoxic over time as it reacts with sulphide and uranium minerals in the mine walls. Anoxic conditions will decrease or reverse the reactions that release constituents from sulphide and uranium minerals and should substantially restrict long term loadings from the mine. In addition the relatively dry conditions during operations suggest very limited groundwater movement out of the mine. However, the DP fresh air raise is equipped with water pumping capabilities. Final water elevations and water quality will be monitored to confirm that no additional mitigation measures are required.

No further decommissioning activities are planned for this area.

4.5.2 Buildings and Surface Infrastructure

All buildings and surface infrastructure in this area have been decommissioned, the area has been regraded and revegetated with seedlings.

4.6 Mill Complex and Supporting Facilities

The mill complex at the Cluff Lake Project consisted of facilities for primary and secondary crushing, grinding, acid leaching, counter-current decantation, solvent extraction, yellow cake precipitation and drying.

Historically, the mill went through three phases of operations. Phase 1 operations, commencing in early 1980 and completed in 1983, consisted of the mining and milling of ore from the 'D' ore body. During this time, the higher grade concentrate from a gravimetric process and the highest grade ore (average 29.3%) were processed through grinding and acid leaching (see Section 2.3 in COGEMA, 2000a for details regarding this process). In the next phase, Phase 1.5 (1983-1984), the gravimetric tails (1-3% U) generated during Phase 1 were reprocessed through upgraded mill processes, which were similar to those in place in the current mill. In Phase II, from 1984 until closure, the mill was modified to accommodate the lower grades of ore from the Claude, OP and DP orebodies. Phase 2 consisted of operations conducted from 1984 to the end of milling in December 2002. In 2003, COGEMA proceeded with mothballing of the mill. From 1983 to 2002, the mill processed approximately 3 million tonnes of ore at an average grade of 0.6% U generating nearly 2.4 million cubic meters of solid tailings. Over recent years roughly 1.2 million m³/yr of process water was used in the mill. Of this volume, at least 50% was water from the dewatering of mined out pits and used cooling water from the powerhouse.

Power supply for the operation was provided by diesel generators, with extra generators readily available on site to provide emergency back-up, if required.

4.6.1 Decommissioning

Decommissioning the mill area was completed in two phases. Phase 1 was carried out from August to November 2004. Phase 2 was carried out from August to December 2005. All demolition material was disposed of in the Claude Pit during backfilling. Following demolition, the former Mill area was covered with clean glacial till, graded, cleared for surface gamma radiation (AREVA 2007a), then revegetated with tree seedlings. Additional decommissioning details can be found within AREVA (2007d).

On-going maintenance in this area will be limited to surface grading and or minor erosion repair. No further decommissioning activities are planned for this area.

4.7 Tailings Management Area (TMA)

The TMA was the disposal location for all tailings produced during the operating life of the Cluff Lake site. The TMA is an aboveground facility located in a topographic low with tailings solids (and liquids previously) retained behind a clay-core dam. The TMA has also been used as a receptor for contaminated mine water and site runoff requiring treatment.

The South Diversion Ditch and North Diversion Ditch were constructed in 1999 and 2000, respectively, to divert uncontaminated water (from the drainage basin surrounding the TMA) to Snake Lake. These ditches minimize run-on of clean water into the TMA and ensure that area runoff from a major precipitation event, including a Probable Maximum Precipitation event, can be safely diverted around the TMA.

Decommissioning the TMA area involved the following primary work items:

- Covering all tailings materials with a minimum 1m glacial till cover
- Backfilling the Liquids Pond
- Buttressing the main dam
- Construction of stormwater management structures
- Removal of buildings and surface infrastructure, and
- Revegetation

A brief summary of the decommissioning work completed at the TMA is included in the following sections. More detailed decommissioning information can be found within AREVA (2007e)

4.7.1 TMA Cover and Main Dam

Ongoing maintenance planned at the TMA will focus on the TMA cover and the Main Dam. Minor erosion gullies and surface grading will be conducted as required. Ensuring sufficient vegetation cover will also ensure a stable soil cover on the TMA and Main Dam.

Applications of fertilizer to enhance vegetation growth along with reseeding of select areas by means of hydroseeding or broadcast seeding may be utilized.

4.7.2 Stormwater Management

The majority of upgradient flow reporting to the TMA area is currently diverted around the TMA in either the North or South Diversion ditches. Since construction, both ditches have been monitored for performance and stability. Both ditches have been performing as designed and no further work on either ditch is anticipated.

The final cover was designed and constructed to control and manage surface water runoff, minimize the potential for long-term erosion and prevent the exposure of underlying tailings.

The design discharge structure from the TMA is a 30m wide armored channel, which also accommodates flow from the North Fresh Water Diversion Ditch, extending to the shoreline of Snake Lake.

As a temporary measure discharge from the TMA is currently accomplished either over or through a temporary cobble dam located at the entrance to the TMA outlet channel. Downstream of the cobble dam, the TMA discharge flow is diverted from the outlet channel into a temporary diversion channel that routes the flow to a settling area near the toe of the main dam.

Following establishment of a healthy stand of vegetation on the TMA, the temporary cobble dam and temporary diversion channel will be removed, such that the TMA stormwater management structures are established to the as-designed system, which is intended to safely convey a Probable Maximum Flood (PMF), while remaining stable to erosional forces.

4.7.3 Buildings and Surface Infrastructure

The STS WTP along with settling ponds remains in the TMA area. The STS is a radium removal plant and is being retained as a contingency measure should the need arise to treat radium contaminated water. Power lines and power poles leading to the STS have been removed. However power can be supplied by a portable generator located at the site, if required.

4.8 Ancillary Buildings and Services

4.8.1 Germaine Camp Area

A permanent camp for the Cluff Lake operations is located adjacent to Germaine Lake near the southwest end of Cluff Lake. With reduced site personnel following decommissioning of the major mining areas, a portion of the camp was decommissioned in 2006. Germaine camp now comprises of 5 residence buildings, a kitchen/dining facility, a recreational hall, a sewage treatment building, and a stand-by generator. Employee offices are now located at the Germaine Camp. The remaining camp facilities support both the staff providing monitoring and minor maintenance for the Cluff Lake Project and exploration staff working at the Shea Creek site located to the south of the Cluff Lake site.

Remaining buildings will be decommissioned as they are no longer required and will be buried in place or at the current site landfill.

At the end of physical decommissioning, the sewage treatment plant and freshwater supply plant will no longer be necessary, and will be dismantled. Non-salvageable materials will be buried in place. The lagoon will be backfilled and the tile field will be left in place. The area will then be regraded and revegetated.

Although there is no suspected radiological contamination, areas will be gamma surveyed to ensure it meets the decommissioning objectives for surface gamma.

It is proposed to remove the camp area from the CNSC licence and remain with the Province of Saskatchewan's oversight.

4.8.2 Cluff Center

A portion of the Cluff Centre area is used for core storage. The fenced core storage area provides a specific storage area for mineralized core and other sections for non-mineralized core. The core storage area continues to be used by the AREVA Exploration Department.

The unfenced portions of area referred to as Cluff Centre have been regraded and revegetated as described in Section 3.7. The area was cleared for surface gamma radiation (AREVA 2007a)

No further decommissioning activities are planned for this area.

4.8.3 Southgate Entrance

The Southgate Entrance is a security building and gate located at the south end of the site property on the main access road. It is the primary location for controlling site access. In December 2002, a camera was installed at the Southgate location to allow for remote monitoring and recording of activities. Monitoring equipment at the Southgate house is connected to the Cluff Lake computer network, which allows for viewing on any network computer including the Saskatoon office.

A security gate will be maintained at the Southgate location or at another specified location until the site has been deemed safe for access by the general public

4.8.4 Batch Plant

This area (Figure 4.2) included the batch plant that provided concrete for mining operations, an A-frame, a pump house at Earl Creek, the cement and fly ash silos, and gravel quarries. The batch plant was sold and removed in 2003. Decommissioning activities were completed with final grading and revegetation.

No further decommissioning activities are planned for this area.

4.8.5 Cluff Lake Pumphouse

The Cluff Lake pumphouse, and associated pipeline to the mill, were demolished with the Mill complex. Demolition materials that were not salvageable were disposed of in the Claude Pit during backfilling and the area has been regraded and revegetated.

No further decommissioning activities are planned for this area.

4.8.6 Airstrip

The airstrip is shown in Figure 4.2. It consists of a runway, an above ground aviation fuel storage tank, and two small buildings.

Once decommissioning activities are complete, the final fate of the runway will be determined through discussions with federal and provincial agencies. Final decommissioning, if required, will consist of either salvage or disposal of the aboveground aviation fuel storage tank, dismantling and disposal of the two small buildings and scarifying and revegetation of the runway surface.

4.8.7 Site Roads

These include several on-site roads used during the mining and milling operations.

Upon completion of all decommissioning activities, all on-site roads and travelways will be deactivated. The processes utilized in achieving road deactivation are as follows:

- All culverts will be removed and replaced with drive - through cross ditches (in consultation with and approval of Fisheries and Oceans Canada);
- All road fill slopes that exceed 65% will be reduced to 27% or less and recontoured;
- All road berms that impede natural drainage flows will be removed;
- All ramps will be cross-ditched at no more that 30 m intervals; and,
- All travelways will be regraded and revegetated.

4.8.7.1 Highway 955

Highway 955 access to the Cluff Lake site will be required until the end of the decommissioning period. While requirements for food, fuel, parts and supplies have been reduced, road access must be retained during this period.

Once the need for continuing on-site personnel ceases, Highway Road 955 will no longer be required for the Cluff Lake facility. The Saskatchewan Ministry of Highways and Infrastructure (SMHI) may choose to maintain, abandon or decommission the highway. AREVA will proceed with scarifying and revegetating the portion of the highway within the surface lease agreement,

or transfer responsibility for ongoing maintenance and final decommissioning to SMHI, pending a final decision from SHT.

4.8.8 Fuel Storage Facilities

Facilities include gasoline and diesel fuel storage tanks and propane tanks. As part of site cleanup and reclamation, redundant tanks and fuel storage facilities have been decommissioned. All fuel storage decommissioning activities are carried out in accordance the Saskatchewan Hazardous Substances and Waste Dangerous Goods Regulations.

As fuel and propane tanks are no longer required, any remaining product will be transferred into tanks that are remaining in service. Tanks that are no longer required will be drained and prepared for sale or disposed of on-site if the tanks are considered unsalvageable. Contaminated soils and groundwater (if applicable) at fuel storage areas, maintenance shop areas, and other hazardous material storage facilities will be investigated and remediated on an as-required basis following provincial and federal guidelines.

4.8.9 Monitoring Wells

All active piezometers, access casings and boreholes, which are currently part of the environmental monitoring program, will be maintained in operational condition until it is determined that they are no longer required. After monitoring requirements at each of these locations has been fulfilled, the wells will be grouted off with cement or bentonite. Boreholes/piezometers/monitoring wells that penetrate bedrock will be grouted to at least 3m below the top surface of the bedrock.

4.8.10 Spills/Contaminated Areas

All reportable spills that have occurred on the Cluff Lake site are documented in the annual reports and are listed in the CSR. Spills have been of limited volume, concentration and impact. Spills were immediately remediated at the time of occurrence and the areas where radiological spills have arisen were scanned following clean up to verify the effectiveness of clean up.

The soils and groundwater (if applicable) at all fuel storage facilities, maintenance shop areas, and other hazardous material storage facilities will be investigated and remediated as each facility is removed, similar to what was undertaken during the operational phase.

4.8.11 Borrow Areas

There are several borrow areas on the Cluff Lake site. The most significant are the borrow areas located near the former concrete batch plant and the southwest of the TMA. Both of which have been reclaimed.

No further decommissioning activities are planned for these areas, unless the borrow areas need to be used for further site remediation, grading, or covering.

5 WASTE MANAGEMENT

The waste management activities for decommissioning are primarily an extension of the practices applied for managing wastes during the operational period. Now that the majority of decommissioning has been completed, waste volumes have reduced significantly and comprise mainly domestic waste, although a small volume of industrial waste is generated due to on-going site clean-up.

5.1 Decontamination and Salvage of Assets

Decontamination, re-use, recycling and disposal of equipment, materials and infrastructure have been routinely undertaken at Cluff Lake. Decontamination and salvage of assets was done in accordance with existing methods and procedures at Cluff Lake. These methods and procedures, including radiological clearance criteria, have evolved based on acquired experience and changes in requirements.

During decommissioning activities to date, AREVA took steps to recycle, reuse, salvage, or sell any materials that were deemed to be of good quality and could meet the appropriate radiation criteria for release from site. Contamination control was maintained as per the Suite 171 of the Cluff Lake Project radiation protection procedures and work instructions. Items that were deemed non-salvageable, or could not be properly decontaminated, were disposed of in the Claude pit prior to backfilling.

The Cluff Lake Project no longer has any nuclear substances or radiation devices that exceed the exemption quantities identified in Schedule 1 of the Nuclear Substances and Radiation Devices Regulations. Sources used to check instrument calibration at Cluff Lake are either made from natural uranium from the site or are below the exemption quantities.

5.2 Solid Waste

Each department is responsible for sorting of wastes into appropriate categories and containers.

5.2.1 Domestic Waste

Domestic wastes are general waste materials originating from the camp and administration offices. All domestic waste is incinerated on-site as per Section 3.6 of the *Approval to Operate Pollutant Control Facilities*. The incinerator is located at Germaine Camp adjacent to the kitchen. Ashes from incineration are collected in a dumpster and transported to the domestic landfill, as required.

5.2.2 Concrete Pads and Foundations

Many pads were removed or covered as part of on-going site clean-up and reclamation activities. For all remaining pads and foundations sufficient till will be placed over top so that any trees that establish themselves on the till cover and are blown down, will not expose concrete. Observations of Jackpine trees on the Cluff Lake site, demonstrate root penetration of less than 0.5 m, therefore a 0.75 m cover should provide adequate coverage for pads which will not be broken up prior to coverage.

5.3 Hazardous Substances and Waste Dangerous Goods

Hazardous substances and waste dangerous goods, not suitable for landfill disposal, are managed as per the current provincial *Hazardous Substances and Waste Dangerous Goods Regulations*. The following substances used on site are designated hazardous substances or waste dangerous goods:

- used oil;
- used oil filters;
- waste flammable liquids;
- waste antifreeze;
- waste batteries;

Waste oil, oil filters, vehicle batteries and waste anti-freeze are collected and stored in approved containers and containment facilities. They are routinely removed from site by a licensed carrier and delivered to a licensed facility for recycling or disposal.

5.4 Radioactive Material

Decommissioning and management of material falling in this category stored in waste rock piles or the tailings management area is discussed in Section 4 of this document.

5.5 Effluent Treatment

5.5.1 Secondary Treatment System (STS)

Final decommissioning of the STS facility will be completed once final water treatment and water discharge needs for the decommissioned site have been established and it has been demonstrated that the facility is no longer required. Table 5.4-1 provides the maximum allowable concentrations in treated effluent and action levels. These remain the same as previously authorized, in the event that the STS facility operation should need to be resumed.

Table 5.4-1
Maximum Allowable Concentrations
Treated Effluent
(Values in mg/L unless otherwise stated)

	SMOE		CNSC				COP
	Monthly Mean (1)	Single Grab	Monthly Mean	Single Composite	Single Grab	Composite Action Level	Action Level, 2 consecutive composites
N as NH ₃	(²)	(²)					0.5
Se	0.6	1.2					0.6
As	0.5	1	0.5	0.75	1		0.5
Cu	0.3	0.6	0.3	0.45	0.6		0.3
Ni	0.5	1	0.5	0.75	1		0.5
Pb	0.2	0.4	0.2	0.3	0.4		0.2
V	0.5	1					0.5
Zn	0.5	1					0.5
Turbidity(NTU)							
TSS	25	50	15	22.5	30		15
pH (units)	(³)	(³)	6	5.5	5	6.0<pH<9.5	6.5<pH<9.0
²²⁶ Ra (Bq/L)	0.37	1.11	0.37	0.74	1.11	0.3	0.37
²³⁰ Th (Bq/L)	1.85	3.7					1.85
²¹⁰ Pb (Bq/L)	0.92	1.84					0.92
U	2.5	5					2.5

Notes: the CNSC pH values are minimum acceptable values.

- (1) This represents a maximum arithmetic mean concentration for parameters sampled more frequently than monthly.
- (2) Un-ionized ammonia maximum limit is dependent on pH, temperature, and total ammonia in the receiving waters, and is arrived at through calculation.
- (3) The pH of water discharged to the environment shall be between 6.0 and 9.5 in 75% of the samples during any month, and the pH level of grab samples shall never be less than 5.0 or greater than 10.

“Composite” means:

- i) a quantity of undiluted effluent consisting of a maximum of three equivalent volumes of effluent, or three volumes proportional to flow, that have been collected at approximately equal time intervals over a sampling period of not less than 7 hours, and not more than 24 hours, or a quantity of undiluted effluent collected continually at an equal rate, or at a rate proportional to flow, over a sampling period of not less than 7 hours, and not more than 24 hours.

5.6 Sewage Management

The primary sewage treatment system at the Cluff Lake Project, located at Germaine camp, consists of a package treatment plant with an extended aeration basin, tile field and lagoon. Sewage flows by gravity from the sewer main that services the camp and into the aeration basin inside the plant. Effluent from the basin flows into the tile field. Some of the plant effluent that goes into the tile field exfiltrates naturally before it gets to the end of the tile field. Some tile field effluent collects in an irregular-shaped lagoon at the end of the tile field. The lagoon is discharged (via pumping) over a rise and into an old borrow pit where it exfiltrates naturally.

5.7 Treatment of Radiologically Contaminated Water

The STS will remain available for any potentially radium contaminated water; however this is not expected now that physical decommissioning of the TMA, mining areas and mill complex are complete.

In the event that water quality in DJX pit does not meet the decommissioning objectives or water removal is necessary to allow for the placement of material from the Claude waste rock, in-situ treatment will be first considered to favorably adjust the surface water quality in the pit.

6 POTENTIAL ENVIRONMENTAL EFFECTS

Decommissioning activities have been designed to reduce environmental impacts by terminating the source of contaminants or by instituting mitigative measures to minimize the quantity and/or rate of their release. The following sections identify those areas where changes have occurred during the operational phase and how decommissioning has mitigate or minimize the operational impacts. A description of the decommissioning approach and mitigation measures is provided in Section 4.

The detailed modeling calculations used to predict the effects of the project on the environment have not been reproduced in this section. These calculations can be found in the complete set of Cluff Lake Project - Comprehensive Study for Decommissioning documents referenced as COGEMA 2000a through e, COGEMA 2001 and COGEMA 2002a and b. Similarly, results from the routine monitoring and follow-up monitoring programs are not included in this section, however they will continue to be reported in the Annual Reports and in reports specific to the Follow-Up Program.

Effects of the environment on the project are also presented in this section. Potential effects from unusual events are identified. Contingency plans are discussed within Section 8.

6.1 Land Disturbance

Of the 1631 hectares that remain in the surface lease that was renegotiated in July 2004, 634.78 hectares have been developed or disturbed. Following decommissioning and revegetation, the end state will be of similar land use capability to that which existed before mine development. The timeframe for this recovery is anticipated to be 10 to 15 years.

6.2 Air Quality

The most significant increases in both Total Suspended Particulate (TSP) and radionuclide content during the operational phase were generally associated with the mill and the TMA. Decommissioning involved the covering or removal of major sources of radiological dust (e.g. demolition of the mill, removal or covering of waste rock piles, and the covering of the tailings management area with till material), and revegetation of disturbed lands. These decommissioning activities reduced and/or eliminated future emissions of radioactive dust and the corresponding concentrations of uranium and other radionuclides.

6.3 Ambient Radiological Levels

In the post-closure period, levels should be comparable to background levels throughout most of the site, and casual use of areas with slightly elevated rates (such as the D-Pit) will not be significant in terms of expected dose.

Radon flux will be reduced by a factor of 2 for each 0.5m of soil cover, so levels at the TMA and Claude waste rock pile will be greatly reduced. Predicted incremental concentrations of radon will fall to near background levels within a few hundred meters of the TMA.

6.4 Groundwater Quality

Appendix A of the Comprehensive Study provides a detailed assessment of the changes in groundwater quality over the operational phase, and Supporting Documents #1 and #2 predicted future changes for the TMA and waste rock areas. These predictions are being refined and validated through the Follow-up Program.

The groundwater plume at the TMA is limited in spatial extent given the proximity of the main dam to Snake Lake. The installation of wells for potable water use, irrigation or livestock watering is unlikely given the abundance of surface water in the local study area and the relative isolation of the site. The institutional controls necessary to control development on the TMA will need to include provisions to prevent inappropriate use of contaminated groundwaters within the impacted areas. This will further mitigate the risks to human and non-human biota resulting from inadvertent use of contaminated groundwaters for consumption or irrigation.

As a result of decommissioning, the hydraulic containment of the pits and underground mines will cease. This may lead to adverse changes in groundwater quality which were not present during operations. In addition, the backfilled material in Claude Pit and the adjacent waste rock pile will continue to be sources of groundwater contamination in the foreseeable future.

Elevated concentrations of major ions, trace metals and radionuclides exist in the groundwater wells adjacent to the CWRP. These concentrations make this water unsuitable for human consumption, irrigation or livestock watering without prior treatment. The existing groundwater plume near CWRP, which is limited in spatial extent, may expand to cover an area of approximately 2.5 square kilometers to varying depths predominantly within the overburden and fractured bedrock where the most elevated hydraulic conductivities exist. The plume is being more thoroughly delineated, and remediation methods explored, as part of the Follow-Up Program.

The population of the region is very low and is expected to remain as such for the foreseeable future. Based on traditional land uses and the abundance of surface water in the area, any water usage can be reasonably assumed to originate from surface water bodies. To further mitigate this potential, institutional control measures administered by the Province of Saskatchewan, will be put in place to control land development and water usage.

6.5 Surface Water Quality

6.5.1 Island Lake Watershed Surface Water Quality

Snake Lake will receive virtually all seepage and surface runoff from the TMA. A simple till cover is anticipated to be effective in maintaining surface runoff water quality, which will be directly discharged to Snake Lake. Modeling has predicted that contaminated groundwater will move from the TMA to Snake Lake but in limited volumes and reduced concentrations such that all SSWQO parameters and Municipal Drinking Water Quality Objectives for Uranium (MDWQO) can be consistently met in the lake over the modeled period of 10,000 years. Thus no impacts on water quality in Snake Lake are anticipated. A summary of the modeling results is presented in Table 6.5-1 below.

**Table 6.5-1
Summary of Contaminant Transport Predictions**

Solute	SSWQO or MDWQO	Peak Snake Lake Load	Peak Snake L Outlet Conc.
Radium 226	0.11 Bq/L	0.035 MBq/d	0.039 Bq/L
Arsenic	0.05 mg/L	0.002 Kg/d	0.002 mg/L
Chloride	250 mg/L	75 Kg/d	84 mg/L
Sulphate	1000 mg/L	125 Kg/d	141 mg/L
Nickel	0.025 mg/L	0.004 Kg/d	0.005 mg/L
Uranium	0.1 mg/L	0.002 Kg/y	0.002 mg/L

Water quality in Island Lake will improve since the STS has been shut down and no further water treatment is expected. Overall, water quality improvement will be slowed through the process of contaminant release from the sediments back into the water column; however, improvements are expected to be continual. Monitoring of Island Lake suggests that recovery started in 2003 and is ongoing for many constituents, including uranium, radium-226, conductivity, etc. Within 100 years, all contaminants are anticipated to be at background levels

At no time after decommissioning is contaminant water concentrations expected to exceed those reached during peak operational releases or those predicted to occur at the time of cessation of releases. The time to recovery for Island Lake and environs is based on the cumulative effects of conditions resulting from the operational releases, and natural recovery mechanisms (e.g., the rate of reflux from the sediments and the rate of flushing from Island Lake). The cumulative assessment indicates that post decommissioning water quality is initially adverse (due to operational releases), however, with the removal of the major source term (effluent), relatively rapid improvements in water quality are predicted with pre-mining levels attained within 50 to 100 years. Under the worst case conditions observed during operational releases, a functioning aquatic system has been maintained with the primary effect being a shift in aquatic community composition. Thus at no time during the post-decommissioning phase would the magnitude of any effects be considered severe. The geographic extent of the adverse

water quality has been and should continue to be restricted to Island Lake with little transport beyond the fen.

An additional factor is the influence of treated effluent releases on winter oxygen concentrations in the area localized around the point of release. Island Lake is relatively shallow and quite biologically active, key characteristics of lakes that periodically experience winter fish kills. Over the operational period, it is likely that treated effluent served as a source of oxygenated water, especially through the ice covered period. This may have minimized the incidence of winter fish kills in the lake. This conclusion is supported by the winter-kill events that occurred in the late winter of 2002 and 2003, when no effluent was released during the ice-covered period. Winter-kills may become more frequent post-decommissioning with the cessation of effluent releases. This may result in a lower fish carrying capacity for the lake, consistent with pre-mining conditions, and a corresponding decrease in the fish over-wintering population.

The potential changes in fish carrying capacity are expected to reflect similar conditions which existed prior to operations. The follow-up program and the environmental monitoring program will specifically monitor the fish population, the reflux of sediment contaminants into the water column, and the continued performance of the fen to ensure that the downstream water quality remains below the Decommissioning Surface Water Quality Objectives.

6.5.2 Cluff Lake Watershed Surface Water Quality

Upon completion of decommissioning, groundwater seepage from the open pits and underground mining areas, in combination with the associated waste rock piles, will drain to small streams or rivers which discharge to the north end of Cluff Lake. The Claude Pit and waste rock pile will drain to Claude Lake/Creek and the Peter River. The DJX pit will seep directly to Cluff Lake while D-pit and the D waste rock pile will contribute loadings to Boulder Creek.

The predicted concentrations for all key parameters including nickel, uranium, selenium, molybdenum and cobalt are all below the DSWQO (Table 3.1). The increase in certain water quality parameters for Claude Lake, the Peter River and Cluff Lake are predicted to remain below the DSWQO. For uranium, the conclusions about the likelihood of measurable ecological effects were identified as being dependent on the relationships between uranium toxicity and hardness. Refinement of the uranium toxicity hardness function is one of the objectives in the Follow-up Program (section 8).

Predictions indicated that decommissioning surface water quality objectives were to be achieved in the upper 50% of the water column in the flooded DJX pit and that similar conditions that currently exist in D-pit will also establish in DJX pit. The flooded pit objectives apply to the upper 50% of the water column only. Based on 2007 data, all constituents at surface were within the established DSWQO for flooded pits. All constituents except for nickel met the flooded pit DSWQO at 1/6 of total depth. Nickel, zinc, Ra-226 and cobalt exceeded the DSWQO in samples collected at both 2/6 and 3/6 total depths. All other constituents met the DSWQO in

the top 50% of the water column. The assessment of risks to biota based on the experience at D-pit, indicated that the water quality will not pose a substantial risk, a conclusion supported by the documentation of a naturally established aquatic community consisting of plankton, benthic invertebrates and aquatic macrophytes in D-pit. The risk to wildlife utilizing the pit for drinking water was also found to be negligible.

These predictions are being refined and validated through the Follow-up Program. This work extends to consideration of the continuing appropriateness of the originally established, hardness-based DSWQO for uranium.

6.5.3 Sandy Lake Confluence Surface Water Quality

Sandy Lake integrates the flows from Island Creek and Cluff Creek systems. Modeling shows negligible long-term impact, with changes in water and sediment quality so low for all contaminants that they would be difficult to differentiate from background levels.

6.6 Sediment Quality

Post decommissioning sediment concentrations in Cluff and Snake Lakes are anticipated to increase as a result of groundwater-based inputs from the mining and TMA respectively, as discussed in Section 6.5. Island Lake, however, has been previously impacted by the effluent discharge through the operational period and sediment concentrations are expected to reduce in the short-term.

6.6.1 Snake Lake Sediment

Operational activities only marginally influenced sediment quality in Snake Lake. The operational impact was restricted to minor increases in sediment-bound uranium and radium-226, neither of which were determined to be elevated enough to significantly affect biota. With the decommissioning of the TMA, additional releases to Snake Lake are predicted to occur. Seepage from the decommissioned TMA will result in a slow increase in a number of sediment contaminants followed by stabilization or a gradual decline as seepage rates decrease.

The median and the 95th percentile predictions for both uranium and zinc are within or below the lower boundary ranges provided by the guidelines as presented in Table 3.2. In addition, the median predicted concentrations for arsenic, copper, lead, molybdenum, nickel, uranium, and zinc are near or below the lower guideline boundaries and/or within regional background concentrations. The only contaminants with predicted 95th percentile values not substantially below the lower guideline boundaries are arsenic, nickel, and molybdenum. However, the predicted values for these contaminants are substantially below the upper boundaries calculated by Thompson et al. (2005) from a database restricted to uranium mining regions in Canada using the same analytical procedures used to generate the Ontario MOE guidelines. In addition, the peak arsenic prediction is below the upper range documented for regional

background (23 µg/g) in the Cluff Lake area. Hence, sediment quality in Snake Lake is not expected to be significantly impaired with the decommissioning of the Cluff Lake mine.

6.6.2 Island Lake Sediment

Operational releases to Island Lake have resulted in sediment contaminant accumulation to levels that are considered adverse and have altered the benthic macroinvertebrate community. With the cessation of effluent release to Island Lake, contaminant concentrations in the surficial sediments are predicted to decrease. Molybdenum, nickel, uranium and selenium levels were identified as the primary contaminants of potential concern (COPC). Hence, it is the rate of recovery for these contaminants that is of specific interest.

Modeling suggests that substantial decreases should be observed for all of these contaminants within the first 50 years. Molybdenum median concentrations are predicted to decrease by approximately 50% to less than 100 µg/g, substantially below the SEL guideline of 1239 µg/g developed by Thompson et al. (2005). The 95th percentile is expected to decrease to approximately 500 µg/g also well below the SEL. Nickel median concentrations (approximately 10 µg/g) are predicted to decrease to below the proposed low effects boundary with the 95th percentile (approximately 30-35 µg/g) also being in the range of the low effects boundaries (Table 3.2). Recovery to background conditions for both these contaminants is predicted to occur between the 50 to 100-year time period.

Like molybdenum, the median sediment uranium concentration is also predicted to decrease by approximately 50% by 50 years post-decommissioning, to approximately 200 µg/g. In the same time interval, the 95th percentile estimate decreases from an excess of 800 µg/g to approximately 500 µg/g. Hence, within the first 50 years post-decommissioning uranium concentrations, while potentially detrimental, will have substantially improved and will remain substantially below the severe effect level calculated by Thompson et al 2005. Recovery to less than the low effects boundary (104 µg/g) is achieved within approximately 100 years to 150 years for the 50th and 95th percentile estimates, respectively.

It is expected that the presently impacted benthic communities will gradually recover as sediment quality improves through the first 50 years post-decommissioning. The community that develops will be more complex than the present community (greater taxonomic richness and diversity). The benthic community will likely continue to consist of more metal tolerant species similar to those established in naturally metal enriched waterbodies such as Zimmer Lake at the Key Lake mine area, until more representative background conditions are established for all contaminants as is predicted for approximately 100 years post-decommissioning.

Predictions of Island Lake sediment recovery will be refined and validated through the Follow-Up Program.

6.6.3 Cluff Lake Sediment

The model predictions suggest there will be a relatively small increase in sediment concentrations for cobalt, copper, lead, molybdenum, selenium, and zinc. The contaminants exhibiting the greatest increase in concentrations, in order of increasing rate of concentration are arsenic, nickel and uranium.

The 1998 field sediment sampling program demonstrated that natural arsenic concentrations can exceed the lower and even exceed or approach the upper guideline boundaries proposed by the CCME (e.g., Lac Phillip mean = 23.4 µg/g). The elevated arsenic concentrations in Cluff Lake are also assumed to be natural as dewatering activities during operations restricted contaminant migration to the pits and underground mines. This conclusion is supported by exploration sediment chemistry that documented a sediment arsenic anomaly located downstream from the Cluff Lake ore body encompassing an area that included the northern portion of Cluff Lake. The highest arsenic concentration measured in this area was 56 µg/g, collected from the northeastern tip of Cluff Lake. These natural arsenic concentrations indicate that the low threshold guidelines are not applicable to this region of naturally elevated arsenic concentrations. The predicted peak 50th and 95th percentile arsenic concentrations are well below the SEL of 5874 µg/g proposed by Thompson et al. (2005). This suggests that any effects arising from elevated arsenic concentrations will not be severe in magnitude and likely restricted to those portions of Cluff Lake containing naturally elevated concentrations.

Nickel concentrations, like those of arsenic are naturally elevated in the Cluff Lake drainage. Nickel sediment concentrations may be greater than 3 times the regional median value (>36µg/g). This conclusion is supported by the 1998 sampling; where a mean value of 37.7 was measured. Hence, this area naturally exceeds the proposed low effects guidelines. The benthic community that will be exposed to increased nickel concentrations as a result of the proposed decommissioning is one that has been established in an elevated nickel environment. This pre-exposure, and the fact that the predicted 50th and 95th percentile concentrations are substantially lower than the upper guideline boundaries proposed for uranium mining regions, means severe alteration of the benthic community would not be expected.

Uranium sediment concentrations are predicted to show the greatest increase with the proposed decommissioning activity. Despite this, uranium may have less of an effect on the benthic community than the previous two metals, as the predicted 50th percentile concentrations is below the proposed low effect guideline. Only the 95th percentile has the potential of exceeding the low effects guideline. However, this predicted concentration of 222 µg/g is well below the SEL of 5874 µg/g proposed for uranium mining regions. Hence, any effects on the benthic community would not be expected to be severe, especially in light of the potential for pre-adaptation of the resident community to high uranium concentrations as the Cluff Lake drainage is identified as a high uranium bearing region.

6.7 Ecological Risk Assessment for Non-Human Biota

The previous sections compared water and sediment quality predictions in waterbodies impacted by the decommissioning project with generic guidelines and regional or site-specific objectives to determine the nature of any residual effects. This section focuses on the risks to non-human biota, for both radioactive and non-radioactive contaminants, based on a comparison of estimated exposure through time relative to selected critical toxicity benchmarks. Representatives of both aquatic and terrestrial non-human biota have been selected for evaluation.

A series of risk assessments have been done by AREVA beginning with a very conservative Tier 1 assessment using generic parameters and conservative critical toxicity values (No Observed Affect Levels). The following discussion focuses only on the final Tier 2 realistic assessment incorporating site-specific data where available, less conservative parameters and critical toxicity benchmarks indicative of low-level effects.

Another ecological risk assessment was planned as part of the Follow-up Program to verify the adequacy of the initial predictions. This time, however, model output will be generated using data (water quality, sediment chemistry, plant chemistry) compiled after major decommissioning works, thus decreasing the uncertainties in the predictions. The ecological risk assessment update is only briefly discussed in this licensing document in regard to uranium as it is the constituent for which toxicity benchmarks are the most likely to evolve and impact predictions.

6.7.1 Selection of Non-Human Biota – Valued Ecosystem Components

To facilitate assessment of the overall operational impacts, a Valued Ecosystem Component (VEC) framework was used. A VEC is defined as “an environmental attribute or component perceived as important for social, cultural, economic or ecological reasons, and identified through consultation with affected people and through scientific opinion” by the Joint Federal-Provincial Panel on Uranium Mining Developments in Northern Saskatchewan. Thus, VECs can support ecosystem structure and function as well as significant cultural, social and subsistence values. The VEC framework identifies relevant issues of human concern through which ecological endpoints can be identified. This framework provides a structure for the evaluation of significant ecological effects.

For this assessment, VECs were selected based on a species list prepared for the Saskatchewan Uranium Mine Review Panel, or due to their biological importance. The VECs used for this assessment are presented in the following tables. Muskrat was added at the request of the CNSC.

**Table 6.7-1
Summary of the Selected Ecological Receptors for the Aquatic Environment**

Lake	Aquatic Environment VEC						
	Pond Weed	Phyto-plankton	Benthic Invertebrate	Zoo-plankton	Northern Pike	Lake Whitefish	White Sucker
Snake Lake	√	√	√	√	√		√
Island Lake	√	√	√	√	√		√
Fen	√	√	√				
Agnes Lake	√	√	√	√	√		√
Sandy Lake	√	√	√	√	√	√	√
Cluff Lake	√	√	√	√	√	√	√

**Table 6.7-2
Summary of the Selected Ecological Receptors for the Terrestrial Environment**

<p>HERBIVORE</p> <ul style="list-style-type: none"> • Woodland caribou • Moose • Ptarmigan • Snowshoe hare • Muskrat
<p>OMNIVORE</p> <ul style="list-style-type: none"> • Black bear • Ducks <ul style="list-style-type: none"> - Scaup - Mallard - Merganser
<p>CARNIVORE</p> <ul style="list-style-type: none"> • Wolf • Bald Eagle • Otter

6.7.2 Risks to Aquatic Organisms

The objective of an ecological risk assessment is to evaluate the potential effects on a population basis. The risk to ecological receptors is assessed through the development of a screening index value which is simply the ratio of the predicted exposure or dose concentration divided by a critical toxicity benchmark, which has been selected from scientific literature. If the value exceeds unity, it indicates that there may be some potential for a long term effect.

6.7.2.1 Water Related Risk – Non Radionuclides

The detailed results of the water related risk assessment may be found in Tab 3.7, Section 2.2 of COGEMA, 2002b; a summary of the key results are presented here.

Generally, the assessment indicated that aquatic ecosystems are at little risk of adverse effects in either the Cluff Creek or Island Creek watersheds. Island Lake water and sediment will be recovering following the cessation of effluent release. All contaminants are predicted to return to stable, near background conditions within about 100 years. Modeling of Cluff Lake predicts that waste rock and flooded pit source terms will contribute to a very small increase in concentrations of most parameters, which may be largely indistinguishable over background. Uranium and, to a lesser extent nickel, will show detectable increases in 200 to 300 years.

A Tier 2 risk assessment of potential chemical toxicity in the aquatic environment, for Island Lake, Cluff Lake and Sandy Lake, was conducted as part of the Comprehensive Study. Results of the assessment indicated that there are no adverse effects from the presence of ammonia, arsenic, cobalt, lead, selenium and zinc in the water.

The screening index values suggested that the 95th percentile concentration of copper may have the potential to impact primary producers and northern pike in all three lakes. The 95th percentile screening index values for copper were marginally above 1 for lake whitefish in Cluff Lake. From the screening index values for background, it was evident that copper levels in these lakes are naturally above the toxicity benchmark levels for primary producers and northern pike. Given that biological monitoring data for the study area have not found evidence of impairment of biological communities, copper may not be readily bioavailable or the toxicity benchmark may be overly conservative.

For molybdenum, zooplankton and northern pike may be potentially impacted in Island Lake at the 50th and 95th percentile concentrations. However, by the year 2050, impacts are not expected for any of the receptors. In Cluff Lake and Sandy Lake, concentrations of molybdenum are below toxicity benchmarks for all aquatic species.

Screening indices for nickel in Island Lake are less than 1 for all aquatic species except primary producers. By 2009, only the 95th percentile concentration of nickel is above 1 for primary producers. A marginal exceedance at the 95th percentile occurs by 2050. In Cluff Lake, screening index values for both the 95th percentile background concentration and Cluff Lake outlet concentration are above one for primary producers. Nickel concentrations in Sandy Lake are not predicted to impact any of the aquatic receptors considered in the assessment.

Screening index values based on predicted uranium concentrations in Island Lake are above 1 for primary producers and zooplankton. The elevated screening index values are predominantly a function of the very low benchmark values applied. The quoted study was based on multiple species of primary producers and zooplankton found in tropical areas of Northern Australia and was conducted in very soft water (2 to 4 mg/L as CaCO₃). Discussions between COGEMA Resources Inc (now AREVA) and the Canadian Nuclear Safety Commission (CNSC) have noted and attempted to quantify the reduced uranium toxicity resulting from increased water hardness.

Hardness levels in Island Lake watershed are artificially elevated as a result of effluent inputs, however, natural hardness values in the system range between 35 and 45 mg/L as CaCO₃ (based on 2001 values in the North Diversion Ditch). Thus, the benchmark values for primary producers and zooplankton were considered to be highly conservative (about 8 times higher than would be expected after applying a qualifying factor for increased hardness) resulting in a similarly conservative estimate for the screening index for uranium.

It is important to recognize that the potential impacts predicted by screening index values above 1 for uranium are indicative of a lake immediately downstream of the effluent discharge point that has been receiving effluent, consistently within the concentration limits set by Federal and Provincial operating licences, over a 22 year operating period. The potential impacts during the recovery period following cessation of operation are to be expected. These impacts are related to the operational period, not the decommissioning period. Applying a factor of 8 based on the increased hardness of Island Creek water, as suggested in the previous paragraph, would reduce the screening index values for uranium in the Year 2050 to a value below 1 and indicate that the potential impact from the operational period may be eliminated within 15 to 20 years after decommissioning. Periodic monitoring of biological systems during this period will assess the accuracy of these predictions and the rate of ecological recovery.

It is also important to note that the screening indices used in the Tier 2 assessment are based on laboratory toxicity studies for test species. The use of laboratory toxicity bioassays to assess the impacts of pollutants does not usually provide an adequate basis for extrapolating the effects on populations, communities or ecosystems. Effects at higher orders of organization (i.e. populations, communities and ecosystems) can only be predicted with a detailed knowledge of the interactions among species, and the connections between biota and the biochemical processes that maintain ecosystems. Thus it becomes difficult to measure impacts due to species specific tolerance levels, which are unknown and complex interactions of biotic and abiotic components. Both the Canadian Surface Water Quality Guidelines and the Saskatchewan Surface Water Quality Objectives attempt to provide criteria that are protective of aquatic systems and thus are used in this discussion to provide a context for the elevated screening indices. The uranium benchmark has been slightly revised for the second ecological risk assessment by taking into account some recent information on toxicity thresholds on other species. This modeling may need to be further updated in light of the results generated from the speciation modeling work which is discussed in the Follow-up Program. This may impact our predictions of the rate of recovery of aquatic ecosystems in regard to uranium.

As discussed above, predicted copper concentrations in the three lakes resulted in screening indices greater than one for a number of aquatic species. The predicted copper concentrations in all these systems are below the DSWQO and 1997 SSWQO (10 µg/L) and thus aquatic life in these lakes should not be impacted by the presence of copper. Additionally, the 50th percentile copper concentrations in these lakes are at or below the Canadian Water Quality Guideline or the 2006 SSWQO (2 µg/L for water with a hardness of <120 mg/L as CaCO₃).

There is no SSWQO for molybdenum, however the CCME provides a concentration of 73 µg/L for molybdenum. The 50th percentile and 95th percentile concentrations of molybdenum in Island Lake are currently above this value, but are predicted to fall below this value approximately ten years following the cessation of milling, as a result of the load reduction in this lake.

Nickel concentrations in Cluff Lake (which resulted in screening indices greater than 1) are below both the 1997 and 2006 SSWQOs and the Canadian Water Quality Guideline and the DSWQO, which are all at 25 µg/L for softer waters. Additionally in Sandy Lake and Island Lake, the maximum predicted 95th percentile values for nickel (5 and 10 µg/L, respectively) are also well below these regulatory values. Therefore it is not expected that primary producers in these lakes would be impacted.

In summary, the Tier 2 risk assessment indicated that there is a possibility for impacts in Island Lake due to current concentrations of molybdenum and uranium. However, as time passes and the loads to Island Lake diminish, conditions will improve such that aquatic species are unlikely to be impacted in Island Lake by 2050.

6.7.2.2 *Sediment Related Risk – Non Radionuclides*

A detailed discussion of the sediment related risks are presented in Section 3.3 of Appendix B of COGEMA, 2001. No impacts are anticipated for sediment dwelling organisms in Sandy Lake as all contaminants are predicted to remain below benchmark toxicity values.

In Cluff Lake, copper, lead, nickel and zinc remain below the CCME Probable Effects Levels (Table 3.2) and, thus, no impact is anticipated for benthic organisms. Predicted arsenic concentrations are in the range of natural background for the area. In the event that uranium reaches a level of 200 µg/g or higher, which is the 95th percentile calculation (within the probabilistic assessment, only 5% of the 100 trials in the simulation exceed this level), there may be a possibility that some benthic organisms could be impacted.

The Island Lake values predicted for arsenic, copper, lead, nickel and zinc are generally below the benchmark value for toxicity, while nickel is marginally above. These elements are not expected to be problematic to benthic communities in Island Lake. Both molybdenum and uranium exceed benchmark values for toxicity, however, bioavailability of these metals has not been considered in establishing these benchmarks and an impact may be questionable. Biological monitoring data in the study area have not been found to indicate impairment of the ecosystem which suggests that these metals in sediments may not have a significant effect on benthic invertebrates within Island Lake. Also, sediment quality recovery will occur relatively quickly during the post closure period, as mentioned earlier, so the potential impact is only short term and significantly less than the potential impact from sediments during the operational period.

6.7.2.3 Risks from Radionuclides

Aquatic receptors are not expected to be impacted by the presence of radionuclides in the water column or sediments in the Cluff Lake and Island Lake watersheds.

6.7.3 Risks to Terrestrial Organisms

A Tier 2 risk assessment was carried out to determine whether wildlife foraging for food, drinking water and ingesting soil/sediment around the Cluff Lake and Island Lake watersheds may be impacted by metal concentrations in the water, vegetation, sediment or soil. The detailed results of the water related risk assessment may be found in Tab 3.7, Section 2.3 of COGEMA, 2002b; only a summary of the key results are presented here.

6.7.3.1 Risks from Non-Radionuclides

In Island Lake, concentrations of arsenic, cobalt, copper, lead, nickel and zinc result in screening index values below 1. This indicates that these metals should have no adverse effects on the wildlife in the area.

Both the 50th and 95th predicted concentrations of molybdenum result in screening index values above 1 for species such as ducks, bear, muskrat and otter. However, the screening index values decrease with time as a result of a reduction in the load input to Island Lake following shutdown of the mill. By 2050, the screening index values are predicted to be below 1.

The 95th percentile concentrations predicted for selenium and uranium results in screening index values greater than 1 for mallard, scaup (selenium only), muskrat and otter (selenium only). For uranium, no screening index values are predicted to be above 1 by the year 2009 and for selenium, only the 95th percentile screening index values are above 1 in 2009 and fall below 1 in 2050.

The mallard and scaup receive the majority of their dose from benthic invertebrates, while the pathway of greatest exposure for the merganser and otter is the ingestion of fish. Sediment ingestion is the most significant pathway of exposure to molybdenum and uranium for the muskrat, and the ingestion of aquatic vegetation is the greatest pathway of exposure to selenium for the muskrat.

It must be highlighted that an ecological assessment focuses on the protection of populations as a whole. Given that by 2050 any exceedance of the screening index value of 1 disappears and the fact that Island Lake represents only a small portion of the entire watershed, no long-term adverse impacts are expected in the duck, muskrat and otter populations after the closing of the mill.

For Cluff Lake, all calculated screening index values were below one.

6.7.3.2 *Risks from Radionuclides*

Doses to terrestrial species were calculated for terrestrial receptors with the highest exposure in the area, as they spend all or the majority of their time in the Island Lake watershed. Terrestrial species in the Cluff Lake system are less exposed, since Cluff Lake has lower predicted radionuclide concentrations in both water and sediment.

The mallard was the only terrestrial receptor that might be affected by the presence of radionuclides at the maximum 95th percentile concentration in the water column and sediments. The screening index value for the mallard drops below 1 in the year 2009.

6.7.3.3 *Incremental Effects from Drinking Water in Flooded Pits*

To further supplement the Tier 2 assessment, an evaluation of the incremental effects from the D and DJX Pits as a source of drinking water for terrestrial receptors was completed. The detailed results of the assessment may be found in Tab 3.7, Section 3.2 of COGEMA, 2002b; only a summary of the key results are presented here.

The assessment of ecological receptors at the flooded pits considered the following receptors: black bear, caribou, bald eagle, hare, ptarmigan, moose and wolf. Aquatic birds were not considered, since it is unlikely that they will use the flooded pit as habitat. The terrestrial receptors chosen for the assessment were expected to use the area around the pits for food and habitat, and it was conservatively assumed that they would drink water from a pit.

The incremental effects associated with terrestrial species drinking water from D or DJX Pit did not result in any changes to the conclusions of the Tier 2 assessment for both radionuclides and non-radionuclides. The most significant increase in the screening index was associated with uranium as it applied to moose. The index rose from 0.188 to 0.227, still below the index of 1.

6.8 **Human Health Assessment**

A Tier 2 risk assessment was carried out for two hypothetical trappers assumed to reside year-round on Sandy Lake and Cluff Lake respectively and to obtain drinking water and fish from these respective lakes and hunt for small game and large game within the Island Creek watershed. Conservative assumptions for these receptors were used. The detailed results of the human health assessment may be found in Tab 3.7, Section 2.4 and 3.3 of COGEMA, 2002b; only a summary of the key results are presented here.

6.8.1 *Risks from Non-Radionuclides*

The assessment considered the human health effects of arsenic, cobalt, copper, lead, molybdenum, nickel, selenium, uranium and zinc. Exposure to these metal species by both direct and indirect pathways does not result in any health risks to the trappers. The 95th percentile concentrations of predicted zinc concentrations result in a hazard quotient marginally greater than 1; however it is unlikely that zinc will be a cause for concern. The predicted arsenic

intakes and risk levels for incidence of skin cancer are well within the range of those typically measured for background exposure to arsenic levels across Canada (typical intake levels 1.2×10^{-4} to 7×10^{-4} mg/(kg d) and risks of 7×10^{-4} to 1.1×10^{-3}).

6.8.2 Risks from Radionuclides

Incremental dose estimates (50th and 95th percentiles) for three periods following decommissioning (years 2009, 2050 and 2100) were calculated. The incremental dose estimates include the contributions from inhalation of radon and dust, consumption of drinking water, ingestion of berries and consumption of small and large game. The largest predicted incremental dose rate is $170 \mu\text{Sv/yr}$ (at the 95th percentile for the Cluff Lake Trapper). This is well below the $1000 \mu\text{Sv/yr}$ incremental limit recommended by the CNSC for protection of members of the public.

6.8.3 Short Term Risks from the Flooded Pits, Island Lake and Snake Lake

Potential acute effects to human receptors were considered for short-term exposure through the drinking water pathway to contaminants in the flooded pits, Island Lake and Snake Lake.

Three adult receptors were assumed to collect sufficient water from each water body to sustain them for 20 days at a rate of 2 L per day. The Sandy Lake Trapper was considered for the assessment of short-term effects from drinking water in Island Lake and Snake Lake. The Cluff Lake Trapper was considered for the assessment of short-term effects from drinking water from the D Pit (and DJX Pit).

6.8.3.1 Risks from Non-Radionuclides

Exposure to arsenic results in the highest hazard quotient value for the Cluff Lake Trapper consuming water on a short-term basis from the D Pit. It is important to note that it is not appropriate to add short-term and chronic exposures together since arsenic is rapidly eliminated from the body (< 1 day). As such, after short-term exposure to arsenic, the arsenic levels in the body will be very low and not significant with respect to long term cumulative exposure.

Thus, the short-term exposure to contaminants in the D Pit should not result in any significant changes to the chronic exposure of the Cluff Lake Trapper. Similarly, drinking 40 L from the DJX Pit, with better water quality than the D Pit, will result in no significant changes to the Cluff Lake Trapper. This is an unlikely scenario, since that Cluff Lake Trapper can obtain an unlimited supply of water from Cluff Lake.

The Sandy Lake Trapper was assumed to drink water from either Island Lake or Snake Lake. The water quality in Snake Lake is better than Island Lake and therefore, any predicted impacts would be lower than for Island Lake. The highest hazard quotient was related to the short-term exposure of the Sandy Lake Trapper to molybdenum present in Island Lake. The incremental hazard quotient for molybdenum is 0.789. As with arsenic, molybdenum is also rapidly excreted

from the body. Thus, there is little likelihood of cumulative effects from the different exposure scenarios (chronic vs. acute).

The assessment showed that it is unlikely that the Sandy Lake Trapper will be impacted from drinking 40 L of water from either Island Lake or Snake Lake. Furthermore, it is stressed that this exposure scenario is highly unlikely given that the Sandy Lake Trapper is located on Sandy Lake, which is a better water supply.

6.8.3.2 Risks from Radionuclides

The incremental dose to human receptors associated with the use of water from the D Pit, Island Lake and Snake Lake as short-term supply of drinking water were calculated. The predicted incremental doses were all below the CNSC recommended dose of 1000 $\mu\text{Sv/yr}$ indicating that short-term exposure to radionuclides in these water bodies will not result in significant adverse effects for the Cluff Lake or Sandy Lake trappers.

6.9 Potential Effects of the Environment on the Project

6.9.1 Major Precipitation Event

Since the inception of operations, the largest 24-hour rainfall event recorded at Cluff Lake was 62.2 mm recorded on July 7, 1981. This 24-hour duration rainfall has a probability of occurrence of between 0.05 to 0.02 in any given year resulting in a return period of 20 to 50 years, respectively. Probable Maximum Precipitation (PMP) is used in the design of structures, the failure of which would result in environmental or physical damage or the loss of human life. PMP's are used to test and revise preliminary return-period designs to substantiate that the final design will function properly under the most extreme conditions. The annual point PMP estimate provided by the Canadian Climate Centre for the Cluff Lake station, over a 24-hour duration, is 266 mm.

Drainage diversion ditches, sized to accommodate a PMP event, have been constructed around the TMA. This has effectively limited the catchment area of the TMA to as small an area as possible. The final reclaimed surface of the TMA has been designed with a low overall gradient with runoff channeled toward Snake Lake. A strong vegetative cover with a well-developed root mass has been established and will minimize erosion on the TMA surface. Also, outlet channels have been constructed at a low gradient and lined with riprap to accommodate a severe runoff situation. A major rainfall may cause some local erosion but is not anticipated to compromise the cover.

The situation is similar for the CWRP, where the surface was contoured to direct the top surface runoff to a central rip rap-lined channel. The side slopes of the pile were resloped to 4:1, a significantly higher gradient than for the TMA. In addition to ground cover vegetation, the stormwater management design for the CWRP includes riprap armoring in high velocity segments as necessary to prevent channel erosion.

The remaining rehabilitated features of the Cluff Lake site will not be significantly impacted by major precipitation events and, in the event that some damage were to occur, the consequences would be minimal.

6.9.2 Extended Drought Event

To define whether a drought exists and what its severity is, Standard Precipitation Index (SPI) values were calculated and applied to Cluff Lake seasonal (winter, spring, summer and fall) precipitation data.

The 100-year, low precipitation values for winter, spring, summer and fall are 2.8 mm, 41.7 mm, 57.2 mm and 30.2 mm, respectively. According to the SPI, the 100-year precipitation value for the winter, spring and summer corresponds to an extreme drought, whereas the 100-year precipitation value for the fall corresponds to near normal conditions. The variance for fall precipitation values from 1981 to 1998 is sufficiently low resulting in near normal (SPI) conditions throughout this period.

When applying return periods to design models, it must be recognized that the 100-year low precipitation value may not correspond to the beginning of an extreme drought. Precipitation values alone cannot describe drought, therefore, the existence and severity of a drought can only be determined by establishing boundary conditions (as in the SPI). Based on the assessment of the data, the return period for an extreme drought in the Cluff Lake area is approximately 25 years for the winter, spring and summer periods.

Cover modeling for both the TMA and CWRP have included sensitivity analysis for dry periods and show low sensitivity to these events. As the primary purpose of these covers is to restrict water entry, a drought period has no consequence other than reducing the amount of dilution water available in the downstream system and stressing the vegetative cover which is the major feature controlling erosion under wet conditions. For the CWRP, reduced water content within the cover will temporarily increase the amount of oxygen entering the pile and could result in a short term increase in the rate of acid rock drainage production. None of these potential problems are expected to seriously impact the predicted concentration of contaminants in downstream surface water receptors or have any long-term effect on the integrity of the decommissioned areas.

6.9.3 Major Seismic Event

The tectonic stability of the Canadian Shield has been extensively researched and deemed to be very high. Therefore, seismic activity will likely not be an issue for the decommissioned Cluff Lake mine due to the low probability of significant activity in the region.

The Main Dam of the TMA is the only engineered structure that will remain following decommissioning for which there would be any associated potential risk. Owing to the

consequence of failure and to ensure this risk is minimal, the downstream slope of the Main Dam was buttressed with till material to give a 4:1 final slope and additional material was placed at the outfall locations to further reduce the final slope. Natural till slopes of this magnitude are found within the Cluff Lake area; thus, the Main Dam is expected to show long-term stability.

6.9.4 Forest Fire

Forest fire frequency in the northern boreal region of western Canada have mean fire cycles of approximately 39 years for jack pine or aspen-dominated forests, 78 years for black spruce-dominated forests and 96 years for white spruce-dominated forests.

In the event of a forest fire, reduced interception because of the burned canopy will cause more precipitation to reach the ground, potentially increasing water availability to the soils and runoff. Soil storage opportunity is reduced because of reduced transpiration losses of soil moisture. This results in wetter soils in burned areas, higher water tables in areas of shallow groundwater and increased zones of saturated soil near stream channels. Fire may consume forest floor materials, which also reduces the soil water storage capacity and exposes mineral soil to erosive forces.

These concerns have consequences primarily to the TMA and CWRP where the efficiency and long-term sustainability of the cover material is largely based on successful revegetation. A grass-legume crop dominates the vegetative cover. This vegetative type is generally favored by wildfires and should lead to vigorous re-growth.

With time, ecological succession will result in the move toward natural vegetation and ultimately to the establishment of jack pine, the climax species. It is anticipated that the grass-legume varieties will maintain an understory presence for a significant period of time, even after the establishment of intermingled woody vegetation. This continued presence, along with earlier succession species such as poplars, willows and alder, will ensure a quick recovery in the event of a forest fire. It is also notable that jack pine itself is a fire successional species that will regenerate quickly from such events. The recurring nature of forest fires in Northern Saskatchewan is not expected to have a detrimental effect on the Cluff Lake decommissioning.

6.9.5 Global Warming

General Circulation Models (GCMs) are used to simulate radiative effects of various concentrations of greenhouse gasses on the global climate. Though numerous reputable GCMs have been developed, they do differ somewhat in terms of the mathematical and physical formulations used in their development. Consequently, they do yield somewhat different results in terms of the climate change scenarios produced. While they tend to produce similar results on a global scale, the fact that different GCMs produce different results, particularly on a regional scale, is indicative of the uncertainty inherent in the models ability to predict future climatic conditions.

Under the doubling of CO₂ scenario, recent GCM estimates suggest that the global annual average surface temperature will increase between 1.0 and 4.5 °C. On regional or subcontinent scale, there is greater inter-model uncertainty in the predicted results. Consequently it is not possible to know with certainty the finer details of how the climate will change (EC, 1997). Despite the uncertainty associated with predicted results from GCMs, they currently provide the best estimates of climate change under the simulated doubling of CO₂ scenario.

GCMs have not been used to predict climate changes for smaller areas such as northwestern Saskatchewan (Cluff Lake area) due to further uncertainty associated with predicting change for small areas. However, predictions for the prairies have been made using GCMs, under the CO₂ doubling scenario. The prairies are subdivided into the prairie and the northwestern forest region. In terms of predicting what climatic changes may occur for the Cluff Lake area, results for the northwestern forest region provide the best available estimates and are assumed appropriate for use in the Cluff Lake area.

6.9.5.1 Precipitation and Temperature

Table 6.9-1 summarizes the projected changes in seasonal temperature and precipitation produced by three different GCMs for the prairie and northwestern forest regions. The lower and higher values in each category represent spatial variability in projected changes over the regions. The temperature values are the amount that the predicted temperature differs from the present normal temperature. The precipitation values are the percentage change that the predicted value differs from the present normals. Although the temperature values are quite variable, it is noted that in all cases they are positive. Precipitation is more difficult to model, and as a result, these predictions are more variable than temperature.

Table 6.9-1
Predicted Seasonal Temperature (°C) and Precipitation (%) Changes for Northwest Forest Region by Three General Circulation Models for a doubled CO₂ Atmosphere

Northwestern Forest					
		Temperature Range (°C)		Precipitation Range (% change)	
Season	Model	Lower	Higher	Lower	Higher
Winter (DJF)	CCC	4.5	7.0	0	30
	GFDL	2.5	4.0	5	20
	GISS	2.5	3.0	0	15
Spring (MAM)	CCC	3.0	5.0	-5	25
	GFDL	2.5	3.5	5	15
	GISS	1.5	2.0	5	20
Summer (JJA)	CCC	3.5	5.5	-15	10
	GFDL	2.0	2.5	-10	15
	GISS	0.5	1.0	10	40
Fall (SON)	CCC	2.5	3.5	5	30
	GFDL	3.5	4.5	-5	10
	GISS	1.5	2.5	0	20

Note:

- CCC is the Canadian Centre for Climate Modeling and Analysis
- GFDL is the Princeton University's Geophysical Fluid Dynamics Laboratory
- GISS is NASA's Goddard Institute of Space Studies

6.9.5.2 Evaporation and Evapotranspiration

There does not appear to be any specific references that quantify predicted changes to evaporation and evapotranspiration for the northwest forest area. In general, the specific effects of climate change on evaporation are not well known.

However, evaporation and evapotranspiration generally increases with temperature. In a 20 year investigation at the Experimental Lakes Area (ELA) in northwestern Ontario, the relationship between temperature and evaporation was quantified in small boreal lakes. Over the experiment period, air temperature increased by 1.6 °C and annual lake evaporation increased by 35 mm/1.0°C increase in annual air temperature (EC, 1998).

Given that a doubling of CO₂ results in higher air temperatures for most of Canada, evaporation and evapotranspiration are expected to increase, though higher precipitation is also expected for many areas of Canada. Studies suggest that higher evapotranspiration will offset higher precipitation in climate change scenarios in the Great Lakes and Mackenzie River Basin (EC, 1998).

The effects of global warming on the Cluff Lake decommissioning project are uncertain. The models do predict higher average annual temperatures, with more noticeable increases in the fall and winter periods. Increased winter precipitation may lead to more intense runoff events, however, by designing the facilities to handle the more serious PMP event, these potential increases can be easily accommodated.

7 PROGRAMS

There are ten key programs which have been developed for the Cluff Lake Decommissioning Project. These programs are described in detail in the Integrated Quality Management System manual. They have been summarized here to identify the key elements of their content.

7.1 Quality Assurance Program

The quality assurance program has been developed to conform to the requirements of the ISO14001 standard and the CNSC's draft document R-213 (1999). It is believed that this is the most suitable standard to apply to the decommissioning of a minesite given the emphasis on environmental management. The standard has been adapted to our operations incorporating additional requirements for safety and radiation protection. In addition, the requirements of the QA (Quality Assurance) program for decommissioning are consistent with the G-219 (2000) from the CNSC.

The core elements of the QA system are listed below.

- Policies
- Aspects
- Training and Development
- Communication
- Document Control
- Procurement
- Process Planning and Control
- Verification
- Non-conformance, and Corrective and Preventative Action
- Change Control
- Records
- Audits
- Management Self-Assessment

The program ensures consistency in all Cluff Lake activities and provides assurance that the key objectives of the decommissioning project will be met. Details of these program elements are provided in the Cluff Lake IQMS Manual.

7.2 Radiation Protection Program

AREVA is responsible for the overall protection of workers from radiation. In particular, AREVA ensures that worker exposures to radiation: (1) do not exceed the regulatory dose limits, and (2) are kept As Low As Reasonably Achievable (ALARA); for both AREVA and contractor employees. AREVA is committed to the establishment and maintenance of a radiation protection program that will:

- Effectively train on-site staff and contractors in radiation protection
- Measure radiation exposures of monitored individuals
- Report all relevant information
- Safely ship radioactive materials off-site, and
- Generally contribute to the continuous improvement of radiation safety.

The Radiation Protection program is designed to meet the requirements of the Canadian Nuclear Safety Commission (CNSC), the Saskatchewan Labour Code (mining regulations) and of the Cluff Lake Project. The elements are:

Administrative Elements:

- Program documentation
- Structure and responsibility
- Qualifications and training
- Facility Change and document control
- Management review
- Designation of Nuclear Energy Workers (NEW)
- Dose Limits and Dose Levels
- Obligations of NEW
- Pregnant Workers

Program Elements:

- ALARA
- Dosimetry monitoring
- Radiological levels monitoring
 - Area Monitoring
 - Radioactive Contamination Control
- Shipping Radioactive Materials

Details of these program elements are provided in the Cluff Lake IQMS Manual.

A comprehensive gamma clearance survey was conducted on the entire site by AREVA, using ground based gamma survey equipment for disturbed areas and airborne radiometric surveys for undisturbed (forested) areas to ensure that all surficial radiation sources associated with the Cluff Lake operations are within acceptable levels and that guidelines and criteria have been met. Procedures and results were submitted to CNSC. CNSC has since contracted and completed a third party gamma clearance study; initial results indicate that the clearance criteria have been met.

7.3 Environmental Management Program

AREVA. has implemented an Environmental Management System (EMS) at Cluff Lake that is based on the ISO 14001 standard and draws from the experience gained while implementing

the EMS program at AREVA's McClean Lake Facility. The EMS is designed to meet the requirements of the CNSC, Saskatchewan Ministry of Environment and ISO 14001, as well as internal requirements. The main elements closely follow the elements of ISO 14001 which include:

- An Environmental Policy
- Planning the EMS
 - *Environmental aspects*
 - *Legal and other requirements*
 - *Objectives and targets*
 - *Environmental management programs*
- Implementation of the EMS
 - *Organizational structure and responsibilities*
 - *Training and awareness*
 - *Communication*
 - *Documentation and document control*
 - *Operational control*
 - *Emergency preparedness and response*
- Checking and corrective action
 - *Environmental monitoring program*
 - *Nonconformance, corrective and preventative actions*
 - *Records*
 - *Audits*
- Management review

The Cluff Lake IQMS Manual provides a complete discussion of these elements and provides details of the environmental monitoring program for the post closure decommissioning phase.

7.4 Occupational Health And Safety Program

The Occupational Health and Safety Management Program is designed to meet legislated requirements, internal standards of the Cluff Lake Project and to provide a healthy and safe workplace for all employees. The program components and the associated activities represent how the policy is implemented. The program components are:

- The Health and Safety Policy
- Structure and responsibility
- Safety training
- Communication and promotion of safety
- Inspections and monitoring activities
- Employee health and wellness
- Reporting requirements

Cluff Lake Project is committed to establishing and maintaining a comprehensive occupational health and safety program aimed at accident prevention and risk management. Personal injury

accidents, untoward incidents, property damage and occupational illnesses are not the inevitable costs of doing business. The health, safety and wellness of our employees constitute an unchanging priority at Cluff Lake, which is not only a moral and legislated requirement but also impacts on the financial viability of the organization.

Responsibility and ownership for personal safety is based on the concept of the Internal Responsibility System (IRS). The IRS is a model framework, which describes in general terms the accountabilities, responsibilities and work relationships of workers and management to ensure a safe and healthy workplace. The IRS encourages all employees at all levels of the organization to take personal ownership for safety performance and the resolution of safety concerns without third party involvement.

The 5 Point Safety System provides the basis for a professional management approach to safety that will prevent accidents and minimize loss. The points of the Five Point Safety System are very concise and precise; they embody the many facets of the total safety program. The five points are:

- Check conditions of your workplace.
- Check conditions of your equipment.
- Are employees (you) working properly?
- Do an act of safety.
- Can and will employees continue to work properly?

The Five Point Safety System is the cornerstone of the IRS.

7.5 Emergency Response

Emergency response at the Cluff Lake Project is managed as described in the Cluff Lake IQMS Manual. Generally, the Environment group manages environmental and safety emergencies. Environmental emergencies will be considered secondary to personal threat.

In the event of an offsite spill, the emergency response will be coordinated through the corporate office in Saskatoon. The *AREVA Emergency Response Assistance Plan* details the organization, responsibilities, procedures and mitigative measures to be followed in the event of an offsite emergency. Transport Canada has approved the *Emergency Response Assistance Plan*.

The key elements of the program include:

- Organizational responsibilities
- An emergency response plan
 - *On site emergencies*
 - *Off site emergencies*

Further explanation of these program elements are provided in the Cluff Lake IQMS Manual.

7.6 Training

AREVA provides necessary training to all its employees and contractors to ensure worker safety and protection of the environment at the Cluff Lake Project. The training programs provided are designed to meet the requirements of the federal *Uranium Mines and Mills Regulations* and the provincial *Occupational Safety & Health Act* and *Occupational Safety & Health Regulations*. Training at the Cluff Lake Project is managed as described in the Cluff Lake IQMS Manual.

The primary objectives of the training program are to:

- Identify the training needs of the project.
- Provide training to personnel performing activities affecting quality and EH&S.
- Ensure qualified personnel perform specific assigned tasks on the basis of appropriate education, training and/or work experience.
- Document and maintain appropriate training records.

Training is required in four major areas including radiation protection, environment, safety and operations. Additionally, training may be required for select employees in the areas of quality assurance, supervisory skills and transportation of dangerous goods. Training may be offered by qualified on site employees, may be conducted by qualified contractors or may require off site attendance to a training institution.

7.7 Site Security Program

Site security during operation and decommissioning of a uranium mining facility is a regulatory requirement of the CNSC. Therefore, site security measures currently in place at the Cluff Lake Project will remain in place throughout the decommissioning process.

An identification system for all personnel within AREVA requires the use of identification tags by everyone accessing the Cluff Lake Project site. Visitors will receive numbered visitor tags with no photo and are required to sign in at the beginning of the visit and sign out at the end of the visit.

Since the majority of the physical decommissioning work has been completed, the site monitoring and personnel requirements have been significantly reduced. As well, mine visitations and freight has been significantly reduced. A camera located at Southgate provides continuous monitoring of activities at Southgate. Security of the site and access control will be the responsibility of site staff responsible for the entire site during the monitoring period.

7.8 Water Treatment Program

The water treatment program currently includes the remaining STS facility and salvaged pipeline to convey any contaminated water from the TMA. However, with the TMA physical decommissioning completed, contaminated water is not expected to occur.

8 FOLLOW-UP PROGRAM

8.1 Introduction

The Comprehensive Study Report concluded that the environmental effects of the project over its life cycle, while adverse, with respect to the original baseline are not considered significant. This conclusion, however, relies on the success of the various decommissioning designs, the natural recovery of Island Lake and the confirmation that ecological effects are as predicted. The environmental monitoring program will continue to evaluate current environmental conditions and identify changes over time.

This section outlines the Follow-up Program which supplements the current environmental monitoring program and has been established to verify that the mitigative measures proposed for the decommissioning project are adequate and effective in achieving the decommissioning objectives. It deals with the primary decommissioning activities, specifically the decommissioning of the TMA and the decommissioning of the Claude and DJ waste rock piles and pits. Furthermore, the program addresses other issues which arose during the public and regulatory review phase of the Comprehensive Study process.

For each component of the follow up program, the monitoring approach is defined. Additionally, a specific action or contingency is identified in the event that the monitoring indicates that the current mitigation does not achieve the anticipated result. AREVA first proposed to undertake a complete review five years following the issuance of the initial decommissioning licence to assess the success of the mitigation efforts, with a re-assessment of future follow-up based on the results of that review. The Follow-up Program presented as part of this Detailed Decommissioning Plan renews this commitment for another five years, as such will be re-assessed mid-way through the licensing term. This section is a summary of the Program, full details can be found in the Follow-up Program document submitted with this document.

For Cluff Lake decommissioning, there is a specific need for a Follow-up Program to: (1) address public concerns raised during the consultation process such as the current status of the temporary tailings vault storage area; (2) verify the accuracy or conservatism of the predictions, primarily for long-term water and sediment quality in the Island and Cluff Lake watersheds, and the risks to biota; (3) assess the effectiveness of mitigative measures, primarily the soil covers proposed for the TMA and Claude waste rock pile; and (4) continue pertinent research to more fully understand natural processes, specifically the contaminant removal process for Claude Lake sediments and uranium toxicity testing using Cluff Lake water.

8.2 Pre-Decommissioning Baseline Characterization

8.2.1 *Characterization of Wildlife Community*

A wildlife decommissioning baseline is required as a benchmark for assessing the success of decommissioning activities. A survey conducted in 1978 provided AREVA a one-time snapshot of wildlife in the area. In addition to conducted a new regional survey, it was important to determine the presence of moose and muskrat, the two species considered the most at risk in the study area. The results of the wildlife assessment will be used to assess the health of the Cluff Lake residents under current contaminants exposures (see section 4.3). A description of the various surveys conducted at the Cluff Lake site to satisfy this requirement can be found in the Follow-up Program.

AREVA considered all of CNSC's comments on the proposal of the terrestrial wildlife survey conducted. Major comments were that field activities should (1) attempt to record how often moose feed on aquatic vegetation in impacted areas, e.g. in the Island Lake/Fen area, and (2) sample small mammals during the spring/summer period as opposed to the fall. Since sampling during the 2005 and 2006 field campaigns was modified to consider the comments provided by the CNSC experts, AREVA believes that the surveys reports meet the quality standards expected by the CNSC.

A second terrestrial wildlife survey is planned as part of the long-term environmental monitoring program in 2014.

8.2.2 *Characterization of Aquatic Community*

Similar to the need for an updated wildlife community baseline, an updated aquatic baseline was required after operations had ceased. This database was intended to be used as input for an Ecological Risk Assessment for the aquatic residents in the study area. An aquatic decommissioning baseline was required in the mine's lifecycle so that recovery of the environment can be adequately assessed during post decommissioning monitoring. Both abiotic (i.e. sediments, lake water) and biotic (benthic macroinvertebrates, fish) components required surveying and contaminants concentrations determined in each of these components of aquatic ecosystems. To fulfill this requirement, a number of environmental monitoring programs were conducted in 2004, 2005 and 2006. These are described in the Follow-up Program.

A second aquatic survey is to be conducted in 2009 as part of the Follow-up Program. The third aquatic survey will be conducted in 2014 as an item of the long-term environmental monitoring program, as described in the Detailed Decommissioning Plan.

8.3 Special Studies to Confirm/Refine Ecological Risk Assessment Modelling

Two primary potentially adverse effects have been predicted within the Comprehensive Study: (1) seepage from the mining area, specifically waste rock piles, underground mines, and backfilled pits, which may adversely affect downstream groundwater quality and surface water quality in the Claude Creek and Peter River systems draining to Cluff Lake, and (2) seepage from the TMA, which may result in adverse effects to groundwater quality, and surface water quality in Snake Lake and downstream waterbodies. These may further result in adverse effects on sediment quality and potential risks to human and non-human biota.

The success of the preferred decommissioning approaches for these major areas rely on effective covers that will reduce infiltration, and passive removal mechanisms which will remain effective and reliable in the longer term. In addition, the source term, such as tailings porewater and waste rock backfill porewater concentrations, must be verified and confirmed. The following sections briefly summarize the Follow-up Program proposed to evaluate the various items noted above and identify any contingencies to be considered in the event that expectations are not met.

8.3.1 Mining Area

The modeling conducted for the mining area, which includes the Claude and DJN/X pits, associated waste rock piles and DJ and OP/DP underground mines, was complex. There are a number of key issues and assumptions which could impact the modeling results including: the source terms for waste rock in submerged and above ground conditions; the rate of infiltration through the cover on the Claude waste rock pile; the utility and potential effectiveness of the peat trench; the effectiveness of contaminant removal by the Claude Lake sediments.

Additionally, it is important to determine whether or not the quality in the upper water column of the flooded DJX pit will meet and remain within decommissioning objectives. Groundwater monitoring downgradient of the mining area (for hydraulic head and water quality) is being conducted as part of the ongoing post-decommissioning Environmental Monitoring Program, supplemented by some additional requirements within the Follow-up Program, to further verify that the decommissioning approach is working as designed.

8.3.1.1 Source Term Verification and Model Validation

The source terms used for the contaminant transport modeling in the mining area were based on all available waste rock leaching tests (i.e. modified BC SWEP tests, humidity cell tests, partially saturated column tests and saturated tank leaching tests). For the CWRP specifically, source terms were also derived from the observed concentrations in the groundwater monitoring wells immediately downgradient from the Claude pile. The requirement to verify this information has been discussed several times with the CNSC Wastes and Geosciences Division and were the focus of discussions during a re-licensing meeting held on October 10, 2008

In addition to validating the source terms, it is important to refine the understanding of water flow paths around the Claude waste rock pile. An improved conceptual model of water flow paths of the area can be developed by conducting a thorough analysis of the groundwater and surface water quality database. This information can then be used in combination with modeling to reduce the uncertainties associated with long term predictions of water quality in Claude Lake, Claude Creek, Peter River and Cluff Lake.

Groundwater Quality Monitoring

Within the current Environmental Monitoring Program, wells located in the Claude waste rock pile and DJN waste rock pile areas are sampled periodically to assess source term trends as well as assess the efficiency of the Permeable Reactive Barriers (PRB) to remove contaminants. Well data in the CWRP area suggest that the areas most impacted by the leaching of acids and metals are south and southwest of the pile. The well data around the former DJN waste rock pile indicates that the area is recovering quickly since the removal of the waste rock. Details on the groundwater contaminant plumes can be found in the Follow-up Program.

Surface Water Quality Monitoring

The mining area includes eight surface water locations that are sampled periodically as part of the Environmental Monitoring Program. Claude Creek is presently being sampled at the outlet of Claude Lake (CDE1000S) and above the confluence with Peter River (CDE2100S), whereas Peter River is being sampled north of the airstrip (PTR1000S - beyond any influence of the Claude waste rock pile), at the northern and southern edges of the former DJN waste rock pile (PTR1500S and 1600S, respectively), above and below the confluence with Claude Creek (PTR1900S and 3000S, respectively) and the outlet into Cluff Lake (PTR4000S). Sampling locations PTR1500S and 1600S were integrated into the Environmental Monitoring Program in 2007. Current surface water quality generally is within decommissioning objectives. Spatial and temporal trends are discussed in the Follow-up Program.

Source term verification

Three geochemists/consultants, who were not previously involved in the Cluff CSR, conducted a technical assessment which included the following tasks: (1) to review and comment on all waste rock characterization data available for the DJN waste rock, DJN special waste and Claude waste rock; (2) to review and comment, based on the theory and their experience, all assumptions used to date to determine submerged source terms for the DJN waste rock, DJN special waste and Claude waste rock; and (3) to determine what type of additional leaching test could be undertaken for the determination of other submerged source terms for the DJN waste rock, DJN special waste and Claude waste rock. The reviews generally support the source terms utilized in the original modeling as being both relevant and appropriate. Additional waste rock testing (column, tank and extraction (SWEP and Tessier) tests) of material collected from

five trenches in the Claude waste rock pile were carried out to test for the alternative option of using the DJX pit to dispose of additional problematic waste rock below ground surface. The purpose of this study was to assess the behavior of the Claude waste rock under submerged conditions (i.e. DJX flooded pit).

Modeling

The results of these tests were used to model contaminant transport assuming backfill of the DJX pit with Claude waste rock. The modeling included a sensitivity analysis to assess the effects of different source terms (high and lows) on Cluff Lake water quality. Additional modeling work indicated that the CWRP was the preferred waste rock management scenario for the protection of surface water quality. Details are provided in the Follow-up Program.

The proposed modeling in the previous version of the Follow-up Program included:

- three phases (2005, 2007 and 2009) of update and, if required, re-calibration of models as data continues to be collected;
- three phases (2005, 2007 and 2009) of re-simulation of the decommissioned mining area to account for, if required, changes in the calibrated parameters;
- one final phase (2009) of validation.

The first phase (2005) of modeling was completed on time and reported in 2006 (AREVA, April 2006). AREVA is currently compiling the groundwater and surface water database for use as input to the model, or calibration and validation data and a final report using data collected to the end of 2008 will be submitted in 2009. AREVA proposes that the third and final phase of modeling be conducted in 2014 (report in 2015) so that a detailed analysis of the groundwater, surface water and net infiltration data is done prior to the modeling. Emphasis will be placed on recently collected data to test for any effects of the cover. AREVA suspects that at least 5 years of monitoring will be needed before benefits of the cover can be shown in wells located at the toe of the CWRP. In combination with modeling, a thorough understanding of the empirical data will support future decisions regarding the path forward and the need for further consideration of additional mitigation. A second ecological risk assessment for the mining area (as in the TMA) may have to be conducted, depending on the final contaminant transport modeling results.

8.3.1.2 Borrow Pit Northeast of DJN Waste Rock Pile

The contamination of the pond water located in the borrow pit NE of the current DJN pile was detected in January 2004. It was proposed to pump the water for treatment and backfill the pit in 2005 as part of the final grading of the DJN pile area. It was also proposed to sample twice from the current time to the summer of 2005 for a class 'A' analysis. The pit was backfilled and quarterly visits to the pit are done to sample water from well HYD0321G.

AREVA believes that the area is safe for wildlife as no water accumulates at the soil surface. Trees are establishing well and the area will not require further modification and/or

maintenance. It is suggested that the area can now enter a post-decommissioning phase, with well HYD0321G now included in the routine environmental monitoring program and that this item is removed from the Follow-up Program.

8.3.1.3 Infiltration through the Claude Waste Rock Pile Cover

The Comprehensive Study identified the CWRP as being a source of heavy metals and acidity released from the weathering of the rocks that it contains. Weathering reactions are triggered from atmospheric waters infiltrating the pile and coming into contact with the rocks and minerals. These waters eventually reach the groundwater system that discharges to surface water systems. By limiting the amount of water infiltrating the pile, weathering of rocks and minerals can be significantly reduced, thus lowering the transport of contaminants to groundwater and surface water. In order to slow the rate of contaminants release from the pile and to meet the surface water quality decommissioning objectives, the strategy was to reslope the pile (mostly to control gully erosion), compact the upper layer of the waste rock and place a soil cover over the entire area. In 2007 and 2008, this cover was transformed into an “evaporative” cover by seeding the pile with grasses and legumes. The establishing of a dense vegetative cover will further prevent water from infiltrating the till cover due to water losses to the atmosphere (re: plant water uptake, growth and evapotranspiration).

Contaminant transport from the CWRP and water quality of Claude Lake, Claude Creek and Peter River were modeled for the Comprehensive Study using estimated/modeled infiltration rates obtained from the test cover plots of the constructed waste rock pile experiment developed in 1997/1998 in the DJN area. It was argued, however, that actual measurement of the infiltration rates with the evaporative cover in place was needed to validate the CSR modeling assumptions.

Equipment was installed to monitor infiltration rates. A description of that equipment can be found in the Follow-up Program. Data has been collected since the fall of 2006 and will continue to be collected until 2013 to capture variability over time (wet vs. dry years; high vs. low vegetation growth). The runoff in the discharge channel will be calculated and the data analysed to conduct an annual water balance on the cover system, yielding infiltration to waste rock. The flow and contaminants transport models will be recalibrated in 2009 and 2014 using the new net infiltration measurements. Vegetation will also be monitored until 2013 to show the vigour and overall growth of the plants as well as the beneficial effects of legumes on soil nutrient availability and plant nutrient uptake. Sampling of the plots will be done on an annual basis until 2011 and then re-sampled in 2013 to confirm early results. Correlation between the vegetative and infiltration will be assessed. Details of the sampling plots and analyses are provided in the Follow-up Program.

8.3.1.4 *Peat Trench*

The Comprehensive Study identified the potential for contaminants transport in seepage coming from the CWRP and migrating to the west, towards Claude Creek. This item of the Follow-up Program aimed at testing a permeable reactive barrier (PRB), in the form of a trench using peat and other constituents, as a potential structure to remove the contaminants before they reach aquatic environments. Consequently, two PRBs were installed in 2006 and 2007. A comprehensive summary of the results can be found in the Follow-up Program. Overall, the PRBs are not acting as large sinks of contaminants in the long-term.

As part of the Environmental Monitoring Program, AREVA will continue sampling wells in and around the PRBs for water quality until 2013. Claude Creek at the outlet of Claude Lake and above the confluence with Peter River will be concomitantly monitored. The success of the PRBs at intercepting contaminants and buffering their loading into Claude Creek will be evaluated on a yearly basis. Mineralogical studies of the PRBs material and, subject to specific project approvals, injection of carbon sources in upgradient wells will be conducted to further the understanding of removal mechanisms and determine the potential for long-term contaminant sinks. This information will be of great value in the case that contingency measures involving such structures are needed for northern Saskatchewan mines.

8.3.1.5 *Porewater Quality in the Backfilled Claude Pit*

The Claude pit backfill was conducted with all the DJX waste rock contained in the DJN pit above the 314 masl elevation, site cleanup and mill demolition waste, the DJN waste rock pile, some waste rock from the Claude pile and waste rock generated from the clean up of the DJN ore pads. The Claude pit was then partially capped with 1 m of clean glacial till. The backfilled Claude pit represents a potential source of contaminants for surface water receptors, re: Claude Lake. Consequently, a specific source term for the Claude pit was included in the contaminants transport modeling to account for all materials in the pit. However, the modeling results were particularly sensitive to the concentrations of the pore water of the Claude pit. Monitoring of the Claude pit pore water flowing towards Claude Lake was thus required to see whether it would stabilize at or near the CSR modeling assumptions. In that respect, a new well was installed in 2007 in the Claude pit.

Quarterly monitoring of the new well will be done until at least 2013. The contaminants transport model will be recalibrated in 2009 and 2014 using the new pore water source terms.

8.3.1.6 *Contaminant Removal by Claude Lake Sediments*

The backfilled Claude pit along with the CWRP represent a potential source of contaminants for transport by groundwater to surface water receptors, including Claude Lake and Claude Creek. The groundwater in the immediate vicinity of the Claude waste rock pile is acidic due to the weathering of sulphidic rocks that it contains. The groundwater collected from wells at the toe of

the pile also shows elevated U and Ni concentrations. A portion of this groundwater moves from the pile to the backfilled Claude pit and eventually into Claude Lake, located immediately downgradient of the pit. The connection between Claude Lake and Claude Creek means that these contaminants could reach downstream water receptors, including Cluff Lake. However, AREVA identified the potential for these organic sediments to intercept and remove most of the contaminants in the groundwater through processes such as complexation and sulphide precipitation. Laboratory testing to study the removal of contaminants from the organic sediments in Claude Lake was thus required to test if the CSR modeling assumptions were accurate. Two column tests were conducted. The results are summarized in the Follow-up Program.

Detailed analyses of the breakthrough curves, sediment chemistry, pore water chemistry and mass balance of the phase 2 testing will be done to fully elucidate potential attenuation of metals (and processes of attenuation) by the Claude Lake sediments. Mass balancing will also be conducted at the lake level to estimate the time period for which the organic sediments can act as a sink of contaminants. A final report will be issued before the end of 2009. The contaminant transport model will be recalibrated in 2009 and 2014 using the new metal removal rates obtained from the final column testing.

8.3.1.7 Water Quality in the Flooded DJX Pit

Past water quality studies of flooded open pits in western Canada, including the D pit at Cluff Lake, have shown that a stable chemocline is formed. This means that poorer water quality is permanently maintained at the bottom of the water column, whereas the water in the upper parts of the column achieves surface water quality guidelines. The contaminants transport modeling assumed that a chemocline will also form in the DJX pit once flooded. The source terms used in the modeling thus requires validation via a fully detailed monitoring program of the water column. Two chemoclines are establishing in the DJX pit. These are leading to the development of surface water that meets original decommissioning objectives. This is explained in more detail in the Follow-up Program.

As detailed in the Environmental Monitoring Program, monitoring of elevation and quality of the water column will continue until 2013 to show whether water quality is continuing to improve. Sampling of the water column will be done at the same periods and depths. Water samples will be subject to class 'B' analysis. Dissolved organic carbon analysis will also be ordered in addition to the full suite of constituents included in the class 'B' analysis as it is an important parameter for determining Al toxicity levels to aquatic life forms. Future water quality trends will be evaluated with the existing data (2006-2013) for all constituents studied.

8.3.2 Tailings Management Area

Between 2001 and 2007, an engineered till cover was placed on top of the tailings with the goals of eliminating direct surface exposure of tailings, establishing a vegetative cover and

minimizing water percolation through the tailings. Efforts to transform this cover into an “evaporative” cover were made in 2007 and 2008 by seeding the TMA with grasses and legumes. It is intended that, by establishing a dense vegetative cover, the water already stored and/or infiltrating the till cover will be efficiently absorbed by the plants and then reemitted to the atmosphere, via plant growth and evapotranspiration, as water vapour. A minimum 1-m cover thickness was targeted as it will not promote too much water infiltration and will allow roots from grasses and legumes to establish well once seeded. Deep-rooted species were not considered for the seed mixtures to prevent the roots from reaching the tailings. A decrease in the amount of water flowing through the tailings would therefore minimize the long term impacts of pore water drainage from the TMA to Snake Lake, immediately downstream of the TMA.

Using assumptions, contaminant transport from the TMA and water quality of Snake Lake with a till/vegetation cover over the tailings were simulated during the Comprehensive Study. First, the rate of water infiltration through the cover was modeled using historical climatic data at the site (e.g. rainfall, net radiation, relative humidity of the air and soil surface, etc.), measured soil (and tailings) physical properties and an assumed vegetation growth which affected the evaporation flux. Secondly, the pore water source term had to be estimated from toe sump water, well waters from the base of the tailings area and Lower Solids Liquids Pond because of the difficulties in accessing the tailings area and collecting a pore water sample without any disturbance to the tailings. Third, the steady state groundwater flow system at, and around, the TMA after decommissioning was an approximation based on a regional model of hydrodynamic flow boundaries surrounding the TMA. The flow model was presented in the form of a groundwater divide and was developed using the geologic and piezometric (hydrogeologic) data. A local flow model was calibrated based on an estimated regional net infiltration rate as well as hydraulic conductivity and piezometric head data collected at the TMA, and then modified to replicate hydraulic conditions anticipated after decommissioning of the site. Monitoring of the infiltration rates, pore water chemistry and hydraulic heads was thus required to see whether CSR model assumptions were near field observations.

8.3.2.1 Cover Infiltration

New equipment was installed in 2006 to monitor infiltration rates. This equipment is described in the Follow-up Program. Data has been collected since the fall of 2006 and will continue to be collected until 2013. The data will be analysed to conduct an annual water balance on the cover system, yielding infiltration to the tailings. The flow and contaminants transport models will be updated on an interim basis with a final recalibration in 2014 using the new net infiltration measurements. Vegetation will be monitored until 2013 to show the vigour and overall growth of the plants as well as the beneficial effects of legumes on soil nutrient availability and plant nutrient uptake. Sampling of the plots will be done on an annual basis until 2011 and then re-sampled in 2013 to confirm early results. Correlation between the vegetative and infiltration will be assessed. Details of the sampling plots and analyses are provided in the Follow-up Program.

8.3.2.2 *Pore Water Source Term*

Four wells were installed in the Upper and Lower Solids Areas in 2006 (after grading of the TMA). Collection and chemical analysis of the water in those wells is done on a quarterly frequency as part of the Environmental Monitoring Program. Collection and chemical analysis of the water samples in the wells will continue until 2013. The contaminants transport model will be updated on an interim basis, with final recalibration in 2014 using the new pore water source terms.

8.3.2.3 *Groundwater Flow System Characteristics*

The above-mentioned wells were also installed in the Upper and Lower Solids Areas in 2006 (after grading of the TMA) for continuous monitoring of groundwater levels using pressure transducers and dataloggers. Continuous monitoring of groundwater levels in the wells will continue until 2013. The groundwater flow model (and subsequently the contaminants transport model) will be updated on an interim basis, with final recalibration in 2014 using the new hydraulic head data.

8.4 **Special Studies to Confirm/Refine Ecological Risk Assessment Modelling**

8.4.1 ***Toxicity Testing for Uranium***

At the time of the Cluff Lake decommissioning environmental assessment, there were no Saskatchewan or Canadian surface water quality guidelines for uranium. Hence, a uranium water quality decommissioning objective for Cluff Lake was developed based on an assessment of the available scientific literature. This led to a DSWQO of $2 \times (\text{hardness})$, which, for Cluff Lake, translates to an objective of $\sim 140 \mu\text{g U/L}$. To ensure that the proposed uranium toxicity objective was consistent with the determination that there are “not likely significant adverse effects” and, thus, no unreasonable risk to the environment, toxicity tests were designed using species representative species present in Cluff Lake and using Cluff Lake waters. As part of the Follow-up Program, resident species toxicity thresholds are to be compared to the predicted post-decommissioning water quality for Cluff Lake to confirm no unreasonable risk to the environment. Toxicity testing results on invertebrate and algal species are summarized in the Follow-up Program. In the meantime, SMOE developed an interim SSWQO of $15 \mu\text{g U/L}$, but recognized that site-specific investigations may be required where uranium concentrations exceed that value. A surface water quality objective for uranium is also understood to be under development by the Canadian Council of Ministers of the Environment (CCME).

As part of the Environmental Monitoring Program, monitoring of surface water uranium concentrations (i.e. creeks, rivers and lakes) will continue until 2013. Uranium speciation modeling is to be updated/completed in collaboration with CNSC experts. Dissolved organic carbon analysis of the surface water samples will be conducted as part of the Environmental

Monitoring Program to fulfill requirements for speciation modeling. When all of the empirical and modeled data is available, AREVA will evaluate uranium trends in surface water and compare concentrations against hardness-related DSWQO. This will help assess if further site-specific consideration of uranium-related risk is required.

8.4.2 Implications of Selenium to Fish Reproduction

Elevated Se levels (above tissue residue guidelines) have been measured in fishes associated with Island Lake. As part of the Follow-up Program, studies have been undertaken to assess the implications of these levels to fish reproduction in Island Lake. Several laboratory (teratogenic deformities testing on embryos and larvae) and field studies (sediment chemical analyses) were conducted and results are summarized in the Follow-up Program. Overall, selenium appears to have little impact on deformities and selenium levels in sediments are only slightly more elevated than background levels in the area.

Monitoring of the recovery of the Island Lake white sucker population, with respect to potential selenium effects, will be accomplished by continuing to collect information on selenium egg concentrations in Island Lake white suckers with each future State of the Environment (SOE) program (i.e. 2009 and 2014) and comparing the concentrations to those observed in the 2002 study. Because of the low selenium levels measured in 2004 in Duck Lake sediments, AREVA proposes no further study in Duck Lake. Reports of the Island Lake surveys will be issued for both field programs in 2010 and 2015.

8.4.3 Risks to Wildlife Resulting from Chronic Exposure to Uranium and Molybdenum in the Island Lake Drainage

Environmental pathways analysis, as well as human health and ecological risk assessments were conducted in 2000 as part of the Cluff Lake Project Comprehensive Study for Decommissioning. The modeling indicated potential adverse effects to wildlife exposed to the current levels of uranium and molybdenum in Island Lake. The model was particularly sensitive to input parameters such as receptor exposure (e.g. occupancy, dietary composition), concentrations of contaminants within the diet and associated transfer factors. While the adverse effects were not considered significant, this section of the Follow-up Program was developed to verify parameters used as input in the model so that uncertainties with the modeling results are reduced.

The first step in carrying out the pathway analysis of exposure of valued ecosystem components (VECs) to constituents of potential concern will involve adding the new VECs to the database. The VECs will then be linked to each of the exposure and reference areas, and parameter distributions will be defined to carry out the analysis in a probabilistic fashion. At that stage, the pathways analysis can be carried out to assess intakes and doses for each of the ecological receptors (e.g. Island Lake, Island Lake Fen, etc.). The modeling will consider exposure to both metals and radionuclides associated to food sources specific to each VEC. Measured and

predicted mean and 95th percentile values will be used in the ecological risk assessment to reflect both expected (mean) and maximum (95th percentile) conditions. The estimated intake rates/doses will be compared to the toxicity reference values already identified.

Model simulations will be conducted and results will be reported in a final report in 2009.

8.4.4 Island Lake Fen

The Island Lake Fen is located immediately downstream of Island Lake. Since the onset of effluent discharge, the fen has acted as a filter of contaminants. The potential to significantly lower contaminants loadings downstream of the fen in the long term has been proposed by AREVA. Possible key processes leading to contaminant retention in the fen include absorption by plants, reductive precipitation of sulphur minerals containing contaminants (metal sulphides), and adsorption onto organic functional groups. Once mining ceased, wetlands may release some of the metals that have accumulated if water is no longer supplied to them and their vegetation dies out, or clean water flowing through wetlands favours desorption of the metals. This item of the Follow-up Program aimed at better understanding the long-term retention of contaminants by the Island Lake Fen.

A series of analyses and studies were conducted, including (1) mass balance calculations of key contaminants such as uranium, molybdenum, selenium and nickel, (2) chemical analyses of fen sediments and plants, (3) studies of the speciation of contaminants to better assess the stability of these contaminants to changing environmental conditions, notably drying and oxidation of the peat in the context of a warming climate, and (4) analysis of hydraulic heads at the Island Lake outlet and at the Agnes Lake inlet as a surrogate for fen hydrology and water levels. Results for each study are summarized in the Follow-up Program, but, as a whole, the fen has been acting as a significant sink of contaminants.

The Island Lake fen research program is extensive and only a brief summary is presented here. The reader can find more detail in the Follow-up Program. The sediment monitoring program will be modified so that vertical movement of contaminants is examined. This will involve sampling of sediments in the fall of 2009 and 2014 to a depth of 60 cm in order to capture all vertical contamination in the sediments. Pore water chemistry will also be assessed for understanding how contaminants migrate, by diffusion mostly, vertically within the fen. Testing for the activity of contaminants in relation to the ionic strength of the pore waters will further help assess mass transfer effects between soil and water as the contaminants migrate within the fen.

In addition, contaminant levels in vegetation and hydraulic heads will continue to be monitored. Cattail tubers and shoots will be sampled during the 2009 and 2014 sediment collection campaigns. The demonstration that the fen is an ecosystem that is naturally fed by groundwater discharge will be made by continuing monitoring of four wells until 2013. This will help assess whether the hydraulic heads measured in 2006 and 2007 have stabilized and are well buffered against low precipitation years.

Finally, the potential for an acid flush to occur in the spring during snowmelt or in the summer during a rain event due to the oxidation of sulphide minerals that have accumulated in the organic sediments during the years of operation will be assessed by sampling throughout the year in 2009, 2011 and 2013 at various locations downstream of the fen for chemical analysis.

8.5 Other Follow-Up Studies

8.5.1 Leach Vault Temporary Storage Area

The leach vault temporary storage area was used between 1980 and 1983 to store concrete vaults containing tailings produced from the processing of the high grade U ore coming from the D pit. During storage, however, some of the vaults tipped over and/or cracked, causing tailings to contaminate the soil. The area was cleaned-up after the tailings were reprocessed through the mill (for their gold and residual uranium contents) and the empty vaults deposited in the TMA. However, concerns were raised during the Comprehensive Study Report review by members of the public regarding the adequacy of the clean-up (re: soils, vegetation and risk to wildlife). This item of the Follow-up Program planned field sampling of soil and vegetation as well as gamma surveys to reassure that the leach vault storage area does not pose a risk. Analyses revealed that contaminant levels do not pose a problem to human and non-human biota. More details are provided in the Follow-up Program.

In combination with the gamma survey, by AREVA and the independent verification by CNSC, it is believed that the soil and vegetation study provides sufficient information to warrant that reclamation of the area was done to a standard that does not present any further risk to wildlife or humans. The report submitted to CNSC in October 2006 was accepted in December. No follow-up monitoring is thus deemed necessary in the area and AREVA can now enter the post-decommissioning phase for the area. AREVA proposes a second and final gamma survey in 2014 as part of the long-term environmental monitoring program, described in the Detailed Decommissioning Plan.

8.5.2 Groundwater Near Landfill Areas

Waste management at Cluff Lake has been by the trench method, which involves excavating an initial trench in which wastes are deposited and covered with a thin layer of soil. When the trench has been filled to capacity, a second trench is excavated and the excess soil is used to complete backfilling of the first trench, with the excess stockpiled for use during filling of the new trench. This process continues until the landfill is no longer required. Subsequent concerns were expressed with respect to groundwater contamination of large and smaller landfill areas on site.

Wells have been installed to monitor groundwater quality at the four landfills on site, i.e. Cluff Centre, Mill road, Domestic and Industrial. These are described in the Follow-up Program. The

most recent monitoring results (2007) generally suggests that concentrations are equal or less than baseline conditions. Phenol, toluene and the F1 carbon fraction were detected in a few wells, but the levels were well below the Tier 1 hydrocarbon criteria for groundwater.

AREVA proposes that groundwater be monitored routinely from all landfill wells until 2013 as part of the Environmental Monitoring Program. Analyses of water quality will continue, including metals, radionuclides and hydrocarbons. These data will be analyzed to assure that contaminant levels remain low and that no contingency measures are necessary.

9 LONG-TERM MONITORING PLAN

9.1 Background

A long-term observational monitoring plan was proposed initially in the Follow-Up Program, to follow the intensive monitoring period associated with the Follow-Up Program. The goal would be to confirm that mitigation measures continue to be effective and that transfer of the site to the Province may be considered by AREVA in the foreseeable future. The program was intended to be minimal in scope, and to be conducted by access to the site by float plane or helicopter so that closure of all site infrastructure could be undertaken as soon as possible. This was predicted on the assumption that there would be no outstanding issues requiring either extensive monitoring of areas, or intensive monitoring over time, after the first several years of monitoring defined in the initial Follow-Up Program.

With current exploration and potential for future mining development at Shea Creek, 20 kilometres south of Cluff Lake, the Germaine Camp will continue to operate indefinitely. Moreover, as outlined in the revised Follow-Up Program, a number of items will require further monitoring on a regular basis.

In this context, AREVA proposes to move this item from the Follow-Up Program to the Detailed Decommissioning Plan, under the topic Long Term Monitoring Plan.

9.2 Approach and Scope

The conceptual basis of the Long Term Monitoring Plan has also evolved, in that the focus will be on ensuring that all information, all collection and analysis of data, and compilation of records is organized towards supporting a future application to transfer the Cluff Lake site to the Province under the *Reclaimed Industrial Sites Act*. This will include eventually developing a recommended scope for the on-going monitoring which will continue after transfer of the site.

The transition from the current Follow-Up Program and Routine Environmental Monitoring Plan to the Long Term Monitoring Plan is thus expected to be gradual rather than the sharp transition originally described. As well, completion of various elements of the Long Term Monitoring Plan, when viewed in the context of compiling the information to support future transfer of the site, is expected to be sequential. For example, as-built reports are an important element, and these are already completed for previous operational areas.

A key attribute of the Long Term Monitoring Plan will thus need to be flexibility in adding or removing monitoring locations and optimizing the frequency, and scope of laboratory analysis, for sampling various locations. That is, the approach will become one of adaptive monitoring,

with the principles described in the regulatory approved program, but detailed schedules of locations, frequencies and scope of sample analysis generally will no longer be included. The underlying principles are proposed to be that sampling will be driven by either of two requirements:

- Required to assess compliance against a specific environmental performance criterion. For example, surface water quality at designated locations (see Table 3.1) will be the primary requirement
- Required to assess or periodically confirm the data trend at a specific location. Sampling frequency will commensurate with the expected rate of change from the known or predicted data trend, and scope of analysis will be limited to the minimum required for the purpose

A cyclical program is thus expected whereby periods of relatively intensive collection and detailed analysis of data (for example, data associated with Status of the Environment (SOE) reports every five years, or with periodic updates of groundwater modelling) will be interspersed with periods of relatively low intensity collection of data. The focus during the latter periods will be on confirming trends and reacting to any unanticipated results. Collection of redundant information will be minimized. This cyclical approach is considered appropriate by AREVA, given the lengthy response time of the natural groundwater systems to changes in the key parameters (for example, installation of a cover which will change infiltration rates). A decision will be made during the initial phase of each cycle as to whether to continue the adaptive monitoring approach, or to focus on implementing the transition of the site to the Province, during the remainder of the cycle.

2009 is logically Year 1 of the first cycle, since SOE data is to be collected, and cycles are logically tied to future SOE reports required at 5 year intervals.

10 PUBLIC CONSULTATION

An effective public consultation program has been developed for the Cluff Lake decommissioning project, one which recognizes all stakeholders, including First Nations and Métis people in both Saskatchewan and Alberta, with interests in the Cluff Lake site specifically, or the Cluff Lake Project more generally. The program has been reviewed and approved by the CNSC staff.

AREVA proposes to move this item of the initial Follow-up Program into the Detailed Decommissioning Plan (DDP). The rationale for moving this item into the DDP is that public consultation, with respect to the Cluff Lake Decommissioning Project is not limited to just the Follow-up Program, but extends to all aspects of the project. AREVA remains committed to informing the public about its activities, monitoring scope and results, and future plans and to create opportunities for the public to provide feedback and to discuss any concerns. This commitment will extend beyond the Follow-Up Program and continue indefinitely while AREVA remains the licensee. For example, site visits and discussions continue to take place annually with the Environmental Quality Committee (EQC), representing Saskatchewan based communities. A similar program of annual visits and discussions was initiated with the Athabasca Chipewyan First Nations (Fort Chipewyan, Alberta) in 2005, in response to the interest expressed during the CSR and licensing processes.

The following sections provide further detail.

10.1 Goals of AREVA's Public Involvement Plan

After more than twenty years in northern Saskatchewan, through the course of planning for and operating the Cluff Lake Project, AREVA has developed a wide array of methods and a continuous program for ongoing contact between the company and the public. In particular, AREVA has developed long-standing relationships with many residents of the designated impact communities on the West Side of northern Saskatchewan. They include members of the West Side Environmental Quality Committee (which is formally designated to represent affected publics in impact communities), community and First Nation leaders, current and former employees and their families, business people, those representing community and recreational organizations and others.

The broad goals of AREVA's consultation program are presented in *The Cluff Lake Mine Decommissioning Project, Decommissioning Plan and Comprehensive Study – Final Public Involvement Plan, June 1999*. They were as follows:

- Early and meaningful public consultation: The program focuses on providing clear project information to the public through a variety of methods and a variety of practical means to receive their feedback. It also focuses on communicating effectively with those who are likely to have an interest in the development, particularly in northern Saskatchewan, but also outside of the north as well.

- Consultation at more than one stage of the project: The program is iterative, focusing initially on issues and later on resolution of issues and conclusions about project effects.
- Consultation in a timely fashion, allowing for input to recommendations and decisions:
The public have been and continue to be engaged in dialogue early enough in the planning process to influence the project. Equally important, the results of public consultation are communicated to project planners inside AREVA in such a way as to be clear about concerns, issues and perspectives raised by the public. Although the focus of consultation has evolved from planning decommissioning to assessing outcomes of the work, the broad goals remain the same.

10.2 Description of the Program

The following stakeholders, in impacted communities on the West Side, are the focus of the public involvement activities:

- West Side Environmental Quality Sub-Committee (of the Environmental Quality Committee)
- Municipalities – Northern Villages, Hamlets and Settlements
- First Nations
- Metis organizations
- Elders
- Private sector
- Community groups
- Local residents

In addition, AREVA includes representatives of other EQC subcommittees (Athabasca and South-Central) in public consultation events organized for the West Side EQC representatives. Key project information and feedback mechanisms are provided to all individuals and organizations in northern Saskatchewan through *Opportunity North*, a northern magazine provided free of charge to all households, and through radio and print advertising for community meetings.

Outside of the project area, AREVA identifies groups or individuals in Saskatchewan thought to have an interest in northern uranium development (i.e., environmental organizations and businesses associated with the uranium industry). These organizations receive invitations to participate. In addition, general advertising is provided for a Saskatoon-based event so interested members of the general public would have an opportunity to participate.

10.3 Ongoing Consultation

AREVA continues to communicate with stakeholders about the Decommissioning Plan as it evolves. These include:

- Regular contact with the West Side EQC members, as well as EQC representatives of the Athabasca and South-Central regions; contact typically includes several meetings and one site visit annually.
- Regular contact with AREVA's Northern Affairs staff through the office in La Ronge. Northern Affairs staff visit West Side impact communities frequently to deal with matters pertaining to employment and business matters as well as other topics.
- Monthly *Community Update* newsletters sent to all communities in northern Saskatchewan.
- Quarterly *Communiqué* publication.
- Web site (www.avevaresources.ca) containing Cluff Lake Project decommissioning information
- Toll-free, in Saskatchewan, phone number: 1-866-99AREVA.

In addition, AREVA will provide monitoring information on a regular basis. Detailed information is reported in the Annual Reports to regulating agencies, which are publicly available. It is expected that monitoring information will be reported and discussed with EQC and ACFN and will form the basis of further communication with impact communities. AREVA has already stated at public meetings and elsewhere in correspondence its willingness to attend or host further public meetings if requested.

11 SCHEDULE

The active phase of decommissioning has essentially been completed, with the exception of some remaining infrastructure (Ancillary Facilities) required to carry out a limited range of onsite activities and to maintain the remaining camp facility. Monitoring required for routine purposes and to support the Follow-Up Program (FUP), is being performed. As described in Section 9, the current program is expected to gradually transition into a Long Term Monitoring Plan. Major steps in this transition will be completed in 2009/2010:

- data collection and submission of the 2009 SOE report
- substantive progress on resolution of the current issue resulting from the contaminant plume from Claude waste rock pile impacting Claude Creek, as per the FUP
- update of hydrogeological and contaminant transport modeling for the mining area, and installation of the remaining data collection systems at the TMA, as per the FUP
- completion of the assessment of site radiological conditions for the long term. Independent assessment, by the CNSC, of site gamma radiation conditions measured by AREVA is in progress, and expected to be satisfactorily concluded in 2009. Extension of the assessment of radiological conditions to include other potential exposure pathways can then subsequently be completed, with a final submission to the regulatory agencies planned for 2010.
- Discussions with regulatory agencies on the adaptive monitoring program approach, and design of the program are planned for 2009, with regulatory approval program detailed implementation planned in 2010

The Long Term Monitoring Plan will extend until the Cluff Lake site has been transferred to the Province under the *Reclaimed Industrial Sites Act*, and all licences held by AREVA terminated.

The first opportunity for AREVA to decide whether to apply for this transition, or to continue with the next cycle of adaptive monitoring program, is 2014, with subsequent opportunities likely on about a five year basis. The scope, and costs, for each cycle of the adaptive monitoring program are expected to progressively reduce. AREVA anticipates that the decision will be taken to proceed towards this transition within three five-year cycles or less. Should that not be the case, AREVA expects to continue as the licensee, with the subsequent amount of monitoring, and perhaps infrequent minor maintenance, to be minimal.

12 COSTS AND FINANCIAL GUARANTEES

The majority of decommissioning activities have been completed since the CNSC Decommissioning licence was issued in 2004. The financial assurance amount associated with that licence was 33.6M\$, in the form of irrevocable letters of credit, approved by both CSNC and SE (now SMOE) and issued to the Government of Saskatchewan.

Although the majority of the amount of 33.6M\$ was allocated for physical work which has now been done, AREVA proposes to leave the Financial Assurance (FA) at 33.6M\$ for at least the first part of the requested 10 year licence period. This amount is expected by AREVA to be more than required to cover the costs of the remaining decommissioning activities and transfer of the Cluff Lake site to the Province. However, AREVA does not believe that there is, at this time, a reliable basis for estimating a specific lower amount, and thus propose to leave the existing FA in place. An automatic review of the FA amount is required by the Province every five years, and if warranted, AREVA would pursue a reduction then.

The following paragraphs summarize the analysis that support the argument that 33.6M\$ is an adequate ceiling for the “cost to completion” to AREVA for Cluff Lake decommissioning. The major components of these costs are:

- i. The costs for the Long Term Monitoring Plan
- ii. The lump sum amount required to transfer the Cluff Lake site to the Province
- iii. The costs to complete final decommissioning
- iv. Should AREVA remain the licensee for an indefinite period, the Net Present Value (NPV) amount for perpetual oversight of the site, in lieu of item ii.

The following table summarizes these costs. It can be noted that in an extreme case, whereby AREVA completes no further work, the total future costs remain well below 33.6M\$. In practice, AREVA expects to reduce the “cost to completion” over the next few years, such that the Financial Assurance (FA) can then be reduced. Ultimately, the FA should approach the amount required to transfer the site to the Province and furthermore if that should not happen, it should make little difference in cost for AREVA to remain the licensee indefinitely (that is, the long term NPV cost to remain the licensee should approximately be equivalent to the cost for transferring the site).

Note: supplementary information providing more details on this estimate is being drafted for direct submission to CNSC and SMOE staff.

Table 12.1 Remaining Costs for Cluff Lake Decommissioning

ITEM	Scenario		
	1 cycle	2 cycles	3 cycles
Long Term Monitoring Program			
Cycle 1 = 7 M\$	7M\$	7M\$	7M\$
Cycle 2 = 5 M\$	-	5M\$	5M\$
Cycle 3 = 3 M\$	-	-	3M\$
End of Long Term Monitoring Program	2013	2018	2023
Cumulative Cost (M\$)	7	12	15
Final Decommissioning			
Physical Work	≤2 ¹	≤2 ¹	≤2 ¹
Transfer Application	2	2	2
Transition Period Monitoring ²	0.5	0.5	0.5
Cumulative Subtotal	≤4.5	≤4.5	≤4.5
Transfer of Payment			
• Institutional Control Monitoring and Maintenance Fund (M\$)	4	4	4
• Institutional Control Unforeseen Events Fund (M\$)	1	1	1
Total Cost to Completion (M\$)	16.5	21.5	24.5

(1) Amount of work at beginning of each cycle, escalated to end of each cycle with no credit for work done during that cycle

(2) Based on 2 years

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