Saskatchewan Environmental Society

DECOMMISSIONING THE CLUFF LAKE TAILINGS MANAGEMENT AREA:
A CRITICAL REFLECTION BY THE SASKATCHEWAN ENVIRONMENTAL SOCIETY

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1. EXECUTIVE SUMMARY

This report provides the results of a review by the Saskatchewan Environmental Society (SES) of the decommissioning of the Tailings Management Area (TMA) at the Cluff Lake uranium mine/mill site in northern Saskatchewan. The study was undertaken with the support of Orano Canada Inc., with the aim of identifying any differences of opinion between SES and Orano about the adequacy of the decommissioning, and, where differences were found, to define the basis of the disagreement. As the first attempt at collaboration between SES and a uranium mining company, this was an experiment that tentatively tests the feasibility of such collaboration between organisations with very different goals.

SES has reviewed much of the documentation produced by Orano to support the company's claim that the site is ready to be released to the Government of Saskatchewan's Institutional Control Program and has commented on Orano's responses to a number of issues and concerns about the condition of the TMA that have been raised by the public. SES recognises the commendable work that Orano has done in assessing risk and responding to concerns.

The causes of concern or disagreement that have been identified fall into six general categories: Ambiguity resulting from use of vague language; Assumptions used in drawing conclusions; Lack of consensus on values; Actual limitations of knowledge; Lack of faith that future regulatory regimes will be able to act reliably over the long-term future; and Trust.

2. BACKGROUND AND PURPOSE OF THE STUDY

In 2020 the Saskatchewan Environmental Society celebrates 50 years of working towards a sustainable future. Energy, water and nuclear issues have been prominent in much of this work, which has involved education, practical demonstration projects and participation in public decision-making processes.

The Saskatchewan Environmental Society has a long history of participation in environmental assessment reviews and licensing processes related to Saskatchewan's uranium industry. The Society has intervened in many Canadian Nuclear Safety Commission (CNSC) hearings, including the Cluff Lake Licence Renewal hearings in 2019, and has presented comments on Regulatory Overview Reports and the Cluff Lake Annual Report 2015. During these processes the Society has had significant interaction with Orano staff, who have been generous with their time and assistance in tracking down information. SES has also had frequent contact with concerned citizens who have sought the Society's support in calling for action on perceived environmental problems at the Cluff Lake site. There are particular concerns about the Tailings Management Area (TMA).

Orano hosted representatives of SES on a site tour in the fall of 2017. Following that tour, a discussion started between SES and Orano representatives about the possibility of a joint project to examine and attempt to clarify the diverse understandings of the long-term risks associated with the TMA.

After lengthy discussion, a Memorandum of Understanding was signed in January 2019 between the Saskatchewan Environmental Society and Orano Canada Inc. The Preamble and Objectives of this agreement form the background and basis of the present work. From the beginning of the Cluff Lake Uranium mine/mill operation, concerns have been raised about the effectiveness and reliability of the management of the radioactive and chemically toxic tailings from the mill process. From the time of the original 1977/78 Cluff Lake Board of Inquiry to the 2019 CNSC Licence Renewal hearing, interveners in regulatory processes have voiced their concerns about the potential long-term human and ecosystem impacts of the tailings and their questions about the wisdom of decisions made about tailings management at the Cluff Lake site.

Despite a mountain of technical studies carried out by, or on behalf of, the proponent, Orano Canada Inc. (previously known as Areva, Cogema and Amok) that claim to demonstrate the safety of the tailings site – a claim that has consistently been accepted by the regulators – there remains a significant level of anxiety among some watchers who have followed the process over the years.

The bases of this anxiety have been mixed, and not always clear. For some it is a lack of confidence that the proponent's studies and reports are unbiased or properly conducted. For others there are questions about the independence of the regulators from the interests of the uranium industry. Some may accept the technical findings but disagree with the judgements about what level of long-term risk is acceptable. And for many, the sheer complexity of the technical issues and the processes used to evaluate risk means that, by and large, the public is asked to simply trust the proponent and its technical experts. Orano's somewhat heroic efforts to gain such trust have not been universally successful, and a degree of scepticism remains.

As a long-time observer of, and participant in the regulatory processes concerning the Cluff Lake site, the Saskatchewan Environmental Society has maintained respectful relationships with concerned interveners, with Orano staff and with federal and provincial regulators. SES is interested in clarifying the nature and basis of concerns about the tailings site, discovering how these concerns have been, or are being addressed, examining available data and reports, and possibly providing suggestions for building a reporting and regulatory system that deserves a better chance of creating public confidence.

Discussions between SES and Orano throughout 2018 led to the signing of a memorandum of understanding in January 2019. SES is to review technical documents and other relevant information in assessing the predicted long-term performance of the Cluff Tailings Management Area. The aim is to identify areas of agreement between SES and Orano, as well as areas where agreement has not occurred. In the latter case, the nature or category of disagreement will be explored. Although the focus is on technical documents, it is clear that the issues are often broader and more fundamental than simply technological. It is our hope that this collaborative endeavour might contribute to a more transparent and honest discussion of differences in understandings, in values and in priorities.

3. NATURE OF THE AGREEMENT BETWEEN SES AND ORANO

The SES/Orano Memorandum of Understanding defines the responsibilities of the parties to the agreement.

<u>Preamble to the MOU:</u>

A. *Whereas the Saskatchewan Environmental Society ("SES") and Orano Canada Inc. ("Orano") are interested in information sharing with a mutual goal of advancing the meaningful engagement of civil society in regulatory reviews of resource development and decommissioning;*

B. *Whereas SES has actively participated in the Cluff Lake Project (the "Project") regulatory process and is interested in the upcoming regulatory process related to completion of decommissioning and provincial institutional control;*

C. *Whereas SES and Orano have identified the value of a greater shared understanding of the Cluff Lake Tailings Management Area (TMA) performance, including the primary influences that drive performance, and secondly, the evaluation of risk associated with the placed tailings in the context of ecosystem function and sustainable development;*

D. *Whereas SES and Orano agree that the accurate communication of risk is important, both to appropriately inform the public and also to minimize inaccurately perceived risk which can have negative consequences; and*

E. *Whereas SES and Orano intend to cooperate and collaborate to the benefit of both parties with benefits extending to community and regulatory stakeholders while maintaining independence.*

Therefore, the Parties agree as follows:

Objective of this MOU

> *The objective of this MOU is to foster continued collaboration between SES and Orano, provide transparency of the collaboration, build a foundation from which continued stakeholder collaboration may grow, and ultimately, advance the meaningful engagement of civil society in regulatory reviews.*

Orano representatives who have been most closely involved in the development of the project are Dianne Martens and Dale Huffman. SES is represented by Ann Coxworth (the author of this report) and Allyson Brady, SES's Executive Director.

4. SES APPROACH TO THE STUDY

In this study we hope to make progress on clarifying the bases of differing views of the adequacy of plans for management of the Cluff Lake Tailings Management Area over the long term.

Many agencies, organizations and individuals have been involved in the planning, undertaking, approving and reviewing of the management of the TMA. These include:

- Orano Canada, who are, understandably, eager to bring closure to their involvement with the site;
- Orano's sub-contractors who have carried out much of the data collection and analysis;
- The regulators (CNSC and Saskatchewan's Ministry of Environment), who are mandated to ensure that the site is left in a safe condition and who have defined technical criteria for judging whether this is the case;
- Saskatchewan's Ministry of Energy and Resources, which hosts the Institutional Control Program that is expected to eventually assume responsibility for the site;
- Some local residents and some members of the general public, who may have limited technical knowledge, but who do not necessarily trust the company or the regulator, and whose criteria for judging the acceptability of the condition of the TMA may differ from those of Orano and the regulators;
- Other local residents who readily accept the technical judgement of Orano and the regulators, and are generally ready to see the site declared safe;
- Yet others who are still unsure about whom to trust, and who seek clarity and assurance;
- "Outside observers" such as SES, who have some capacity to review the bases of the conclusions presented by Orano, to identify questionable conclusions, and who see it as their responsibility to examine issues from the perspective of sustainability, environmental protection and long-term social justice.

Our intention is to first review the literature that describes the natural environment of the TMA site, including its geology and hydrogeology. We will briefly describe the history of the TMA during its development, operation and decommissioning phases, and the objectives and criteria that were used to shape decision-making. The plans for long-term management of the tailings site will be reviewed.

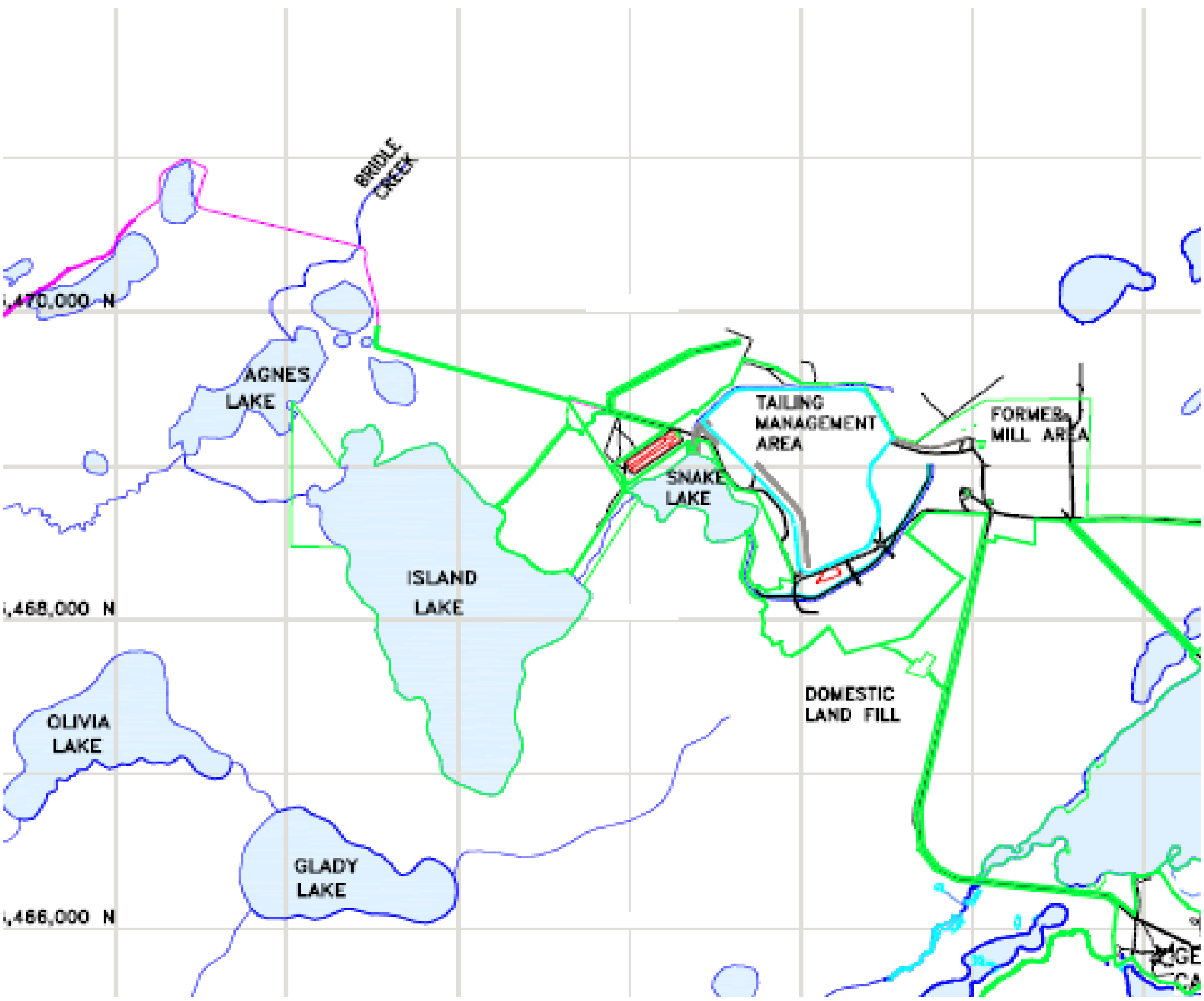
We will then identify a number of concerns, questions and challenges that have been raised about the effectiveness of the past and future management of the tailings and review how these have been addressed in the many studies, reports and regulatory processes concerning the site. In each case we will attempt to evaluate the basis and nature of any disagreements. The focus will be on identifying whether disagreements are based on the validity of reported data and its interpretation, on a general lack of trust in the company's integrity or in the regulator's lack of bias, on actual gaps in basic knowledge and understanding, or on differences in fundamental values that shape our attitudes and priorities.

Finally, we will summarize the conclusions that we have drawn as a result of undertaking this exercise. This document generally represents opinions which the writer believes would be supported by most SES members. These are attributed to SES. There are also a few comments expressed as personal opinions; these are generally based on the writer's personal experience and interaction with Orano staff people.

Sections 5 through 8 provide a descriptive background which sets the context for the sections that follow.

5. BRIEF HISTORY OF THE TAILINGS MANAGEMENT AREA (TMA)

Map from Detailed Decommissioning Plan v2



5a. The TMA Location and Surroundings

The TMA is an above-ground facility located in an unlined, topographic low area, with tailings solids and liquids retained behind a clay-core dam structure.

It is located over a sandstone bedrock body that is bounded to the northeast by lower hydraulic conductivity basement rock, to the southwest by lower conductivity Douglas Formation dolomite and siltstone, and the northwest and southeast by regional fault structures. The primary materials in the vicinity of the TMA consist of overburden over sandstone. The overburden consists of a glaciofluvial sand over a sand matrix till. The pelitic sandstone (i.e. sandstone containing over 66% silt grain with particle size 0.004 – 0.063 mm, thus part way between fine-grained sandstone and muddy clay) which underlies 2/3 of the TMA acts as a (deep) low permeability barrier to groundwater flow. *(ref. 7)*. It is assumed *(ref. 7: 6.3.4.2)* that at greater than 200 m depth, (which is much deeper than the bottom of the tailings), the rock has such a low permeability that the underground flow from below this depth is close to zero.

The regional groundwater flow regime in the vicinity of Cluff Lake is governed by topography. Groundwater moves downwards and laterally through the overburden and shallow bedrock, ultimately discharging locally in low-lying areas and regionally into the bottom or along the shoreline of major lakes and streams. Snake Lake and the TMA lie within the Island Lake drainage basin, and Snake Lake forms a major groundwater discharge for the watershed. In the TMA, groundwater moves from east to west towards Snake Lake.

The majority of the groundwater wells in the TMA show a seasonal evolution of the water table with the highest water levels occurring at the end of the summer and during the fall, and the lowest occurring during the winter period.

5b. Development and Use of the TMA

The following brief description of the TMA is taken from information found in refs. 8, 17, and 22.

The TMA contains tailings left over from milling operations throughout the life of the mine. The TMA contains approximately 2.67 Mm^3 of tailings and consisted of four major components: a solids containment area, water decantation area, water treatment facilities and settling ponds, and diversion ditches. The containment and decantation areas were located in a topographic low, and tailings solids and liquids were retained behind a main dam. Most of the tailings were deposited in slurry form from spigots located along the eastern perimeter of the TMA. The TMA was also used throughout the operational period as a receptor for all contaminated mine water and site runoff. The main TMA dam was constructed in 1979, then extended and raised in 1993. The main dam is about 1.24 km long, with a maximum height of 7 m. It was constructed of sandy, gravelly till and has a soil bentonite core that extends to bedrock. During operation, internal dykes allowed for forming of various cells, with tailings discharged into the southernmost cells and water decanted into cells towards the north.

Treatment of contaminated water involved a two-stage process primarily designed for the removal of radium-226. The contaminated water was first treated in a primary treatment system prior to discharging to two settling ponds and a liquids pond in the TMA for the settling of radium precipitates. Water from the liquids pond was fed to the secondary treatment system for further treatment. Treated water was again held in settling ponds prior to final discharge to a point at the outlet of Snake Lake. North and south diversion ditches around the TMA were constructed to convey uncontaminated water from the drainage basin surrounding the TMA to Snake Lake, minimising infiltration of clean water into the TMA. The ditches are designed with the intention of diverting a probable maximum precipitation event around the tailings area.

5c. Movement of Contaminants from the TMA

The TMA contains tailings in different forms (coarse, medium and fine) in two contaminant source areas (solids and decant ponds). A third contaminant source area, the Liquids Pond, contains no actual tailings, but is composed of a layer of water treatment sludges overlain by a till backfill *(ref 17, p.139/335)*.

The key contaminants of particular concern (COPCs) in the TMA are uranium and radium *(ref 7, p.22/333)*. Contaminants in solution move into the wider environment by seepage and flow of contaminated groundwater around, through and under the main dam into Snake Lake. Fig. 5-12 in *ref 7, p. 92/333* shows three plumes of seepage from different areas of the TMA into Snake Lake. It is noteworthy *(ref 7, p. 89/333)* that the solubility of uranium depends on its chemical format, and the variation in reducing conditions in the different parts of the TMA mean that the concentration of uranium in the tailings pore water is not uniform.

Particulate material also moves, albeit very slowly, along ground and surface water flows. It is estimated from modelling that it will take 400-500 years *(ref 7, p.198/333)* for all particles from the medium and fine tailings to reach Snake Lake. Coarse particles will require 1200 to 1600 years. Particulate material *(ref 17, p. 96 and 140/335)* from the liquids pond gets to Snake Lake both directly by groundwater discharge through the lake sediments and indirectly (via the North Diversion Ditch and the cobble outflow channel). Particles travel through both the underlying till and sandstone. Most particle pathlines go under the main dam and through several different types of geological materials before arriving at Snake Lake.

At Snake Lake, much of the contaminant mass ends up in the lake sediment rather than in the surface water.

"Sediment attenuation" refers to the transfer of COPCs into the lake sediment *(ref 17, p.154/335)*, thus preventing or reducing further downstream movement of the contaminants. For the TMA model it is assumed that the contaminant load removed by Snake Lake sediments is permanently sequestered by the deep sediments. An important factor determining the degree of sediment attenuation is the organic carbon content of the sediment. Column studies on sediment from Claude Lake led to a conclusion that the sediments are capable of substantially sequestering select contaminants over the long term. It was concluded that uranium and arsenic are 90% attenuated. Attenuation of Ra^{226} was assumed to be zero although it is believed that in practice it is above zero. Selenium is assumed to be 70% attenuated, lead 60%.

The 2015 Hydrogeology and Groundwater Technical Information Document *(ref 7, p.212/333)* indicates that, depending on assumptions made about sediment attenuation of contaminants, levels of arsenic, molybdenum, selenium and uranium could all rise above Saskatchewan Surface Water Quality Objectives (SSWQO) in some downstream waters (but still remain below decommissioning design objectives). The model developed in 2000 suggested that Ra^{226} levels in Snake Lake would increase over the next 5,000 years to a level slightly above SSWQOs. The 2019 Hydrogeology and Groundwater TID *(ref 17, p.159/335)* reports that for the majority of the COPCs, the peak flux to Snake Lake is expected to occur approximately 2000 years after decommissioning, with the exception of uranium and molybdenum which are expected to peak approximately 1,000 years after decommissioning. Lead and vanadium have late predicted peaks at more than 7,000 years. The radionuclides peak at approximately 5,000, 2,000 and 150 years for Th^{230}, Ra^{226} and Pb^{210} respectively.

The long-term predictions of surface water quality in the Island Creek watershed indicate that Decommissioning Surface Water Quality Objectives (DSWQOs) will be achieved at the "future maximum expected values (mean)" *(ref 7, p.312/335)*.

While the vast majority of groundwater flow from the TMA reports underground to Snake Lake, there is also the possibility of intermittent groundwater "daylighting" (i.e. reaching the surface) of the TMA cover, resulting from seasonal and climatic influences on the water table *(ref 17, p. 161/335*). The modelling considers the likelihood of this occurring to be low, and that, should it occur, it would be localized and intermittent. Nevertheless, there is some evidence of daylighting occurring, which may be a source of minor incremental loading to Snake Lake.

In addition, water (possibly contaminated) above and surrounding the tailings is drawn towards the surface by evapotranspiration processes, where it has the potential to be absorbed by plant roots, to move laterally into groundwater, or to interact with ponded surface water.

As of 2015, *(ref 7, 41/333)* no evidence had been found of a salinization process above the solids pond area. Furthermore, the short growing season coupled with flushing events from spring snowmelt and summer storms were considered favourable for reducing the potential impact of upward migration of water.

Finally, radon gas emissions from the tailings could potentially reach the surface. Surveys indicate that levels at the surface do not exceed regulatory requirements.

Concerns raised regarding these conclusions are discussed in Section 9 below.

5d. Establishment of Decommissioning Objectives

We are provided with a broad statement of the principles that guided Areva (a previous name of Orano) in the establishment of objectives for the decommissioning of the TMA site as follows:

"The common objective of decommissioning or closeout of a uranium tailings management area is to ensure that the resulting social, health and environmental impacts are limited

(IAEA, 1994). In particular, desirable objectives include long-term stability of retaining structures, isolation of wastes, and restricting the release of contaminants to the environment to acceptable levels while minimizing the reliance on long-term active maintenance by the operator, regulatory agencies or society in general." *(ref 12, Ch3)*

To evaluate the success of the decommissioning program, site-specific objectives were developed in consultation with federal and provincial authorities as well as through public consultation processes. The following criteria are taken as indicators of decommissioning success *(ref 19, p.42/590)*:

- Achieving decommissioning surface water quality objectives (DSWQO) and other accepted decommissioning objectives at surface water …locations;
- Levels of gamma, radon and long-lived radioactive dust (LLRD) pose no unacceptable risk to traditional land use;
- A stable, self-sustaining landscape;
- Reduction of infiltration rates around the TMA…to levels that adequately restrict contaminant movement to groundwater and are suitably protective of downstream surface water receptors;
- The return of the site to an aesthetically acceptable state, similar in appearance and land capability to that which existed prior to mining activities and that poses no unreasonable risk to humans or to the environment…

The Comprehensive Study Report (CSR) for Decommissioning 2003 Section 7 *(ref 26, p.85/266)* describes the decommissioning objectives as follows:

"The objectives of decommissioning activities are to remove, minimize, and control potential contaminant sources and thereby minimizing 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."

There are three concepts here that will require discussion:

i. The concept of minimization;
ii. Future land use assumptions;
iii. Consideration of socio-economic factors.

Ref 26 CSR for Decommissioning 2003, section 7.1 describes clearly how Orano determined their numerical decommissioning objectives, which were accepted by the regulators. For some locations, these exceed provincial or federal regulatory guidelines. See section 9c for this discussion.

5e. Choosing a Decommissioning Option

While, in retrospect, SES very much regrets that the original decision was made to place tailings in a site from which significant leakage was inevitable, once that decision was made, a choice was necessary about how to best manage the hazardous site that had thus been created.

"A detailed hydrogeology and contaminant transport modelling study was completed in the CSR to assess various decommissioning options (for the whole Cluff Lake site). The CSR predicted …seepage from the TMA, which may result in adverse effects to groundwater and surface water quality in Snake Lake and downstream water bodies in the Island Creek drainage" *(ref 9, p8/12)*

Three general approaches to decommissioning the Cluff Lake TMA were considered:

i. Decommissioning in place;
ii. Reprocessing of tailings; and
iii. Tailings relocation.

During the selection process the following constraints were considered:
- Radioactive and non-radioactive contaminant releases to the environment should be as low as reasonably achievable (ALARA) taking into account social and economic factors;
- Reliance on institutional control in the long term must be minimized; and
- Passive maintenance features, either natural or engineered, should be encouraged while options that require frequent maintenance should be avoided.

Evaluation of decommissioning options was also based on the following factors:
- Environmental effects and disturbance of new areas;
- Public safety;
- Worker health and safety;
- Feasibility, ease of implementation and technology availability; and,
- Cost.

These considerations led to a decision to decommission the TMA in place. <u>SES would not argue with this decision.</u>

Decommissioning in place could have potentially involved:
- no cover (base case for comparison only);
- a water cover;
- a zoned engineered cover; or
- a simple engineered cover.

The water cover option was rejected for the following reasons:

From ref 12, sec 3.3.3.2.: Placement and maintenance of a water cover would require considerable construction modifications to the existing TMA. Reinforcing and raising the Main Dam would be required to maintain adequate water depths. A considerable risk of failure exists with long term maintenance of a wet cover. The single most significant threat arises from the potential failure of the Main Dam. The possibility of such a failure increases as long-term maintenance on the dam decreases.

In addition to Main Dam reinforcement, water retaining perimeter structures would be required and would pose considerable risk of failure if not maintained properly. A minimum two to three-meter water depth would be required to ensure endurance of the water cover during extended dry periods. Alternatively, ongoing care and maintenance would be required to ensure adequate water levels are maintained. Internal berm construction would likely be necessary to accommodate the flooding of the final sloped tailings surface. Engineering design and construction costs would be excessive.

The elevated water level above the tailings surface would increase the head within the tailings and increase the downward flow velocity of water infiltrating through the tailings, which in turn would result in increased long-term solute flux and contaminant loadings into the local surface and groundwater regime. The hydrological and hydrogeological containment is therefore considered poor. SES would support the decision to reject this option.

The rationale for rejecting the "Zoned cover with low-permeability barrier" approach is definitely less convincing.

From ref 12 sec 3.3.3.3:

This option assumes the tailings would be decommissioned in place with a dry cover consisting of natural materials and also incorporating a low permeability barrier to reduce infiltration to the underlying tailings.

"The successful construction of a zoned cover would require diligent geotechnical quality assurance and quality controls during construction. The size of the project (55 ha) would make this difficult. For the low permeability barrier, bentonite material would have to be mixed with a till material screened to a specific particle size range at a suitable moisture content. Either a pug mill or in-situ mixing would be required, either being subject to strict material and moisture specifications. In place compaction to achieve a pre-determined density would require constant engineering supervision and monitoring. Cluff Lake has a relatively short frost-free season. Construction during wet periods would be significantly hampered due to slippery operating conditions and quality control requirements for moisture specifications of the bentonite layer. As a result, construction of a zoned cover would require significant additional time, manpower and equipment.

The long-term performance of a potential zoned cover was open to question. The large surface area of the TMA is subject to differential settlement, much more pronounced in the slimes areas, which could result in shear zones and a non-uniform layer. Other factors such as desiccation, frost action and root penetration may cause disruption to the bentonite amended layer, resulting in increased infiltration over time.

Finally, incorporation of a low permeability barrier has significant costs. Bentonite suppliers are located in southern Saskatchewan and in Wyoming. The cost of purchase and transport of the bentonite alone significantly reduces the attractiveness of this option."

The constraints that refer to cost and to the requirements for quality controls, supervision, additional time, manpower and equipment are perhaps an example of the ambiguity concerning "*how hard are we expected to try in order to make the site marginally safer*?" It is not clear how decisions were made about what level of cost or inconvenience is justified.

One might guess that even though a low permeability barrier would be vulnerable to cracking, it would be likely to result in less infiltration than if it were absent. Perhaps a low-permeability barrier could have been placed directly on top of the tailings, below the 1 metre or more of till cover so it would not impair vegetation growth? This would have reduced the risk of infiltration of water into the tailings.

However, regrettably, the decision was made to not further pursue this option, but to use a simple till cover. SES would challenge the wisdom of this decision. However, it cannot now be reversed.

The selected approach to decommissioning is summarized in Supporting Document *1 (ref 12) ch4, p 5/21* as follows:

- Infill the Liquids Pond with till material,
- Recontour the tailings and liquids pond surface to provide positive drainage,
- Construct a dry cover over the tailings materials consisting of a minimum of 1 m of till material,
- Divert surface runoff from upstream of the TMA around the facility and into Snake Lake,
- Provide additional support to the containment structures to ensure long term integrity,
- Revegetate the final surface.

This decision is justified as follows:

From ref 12, 3.3.3.4:

"Considering the long-term stability of the perimeter structures, geotechnical containment of the tailings is considered good compared to other alternatives. Reductions in surface infiltration will reduce the long-term flux and contaminant loading to the environment. The risk of loss of hydrogeological containment is considered moderate to low compared to other alternatives. The presence of the north and south freshwater diversion ditches around the TMA substantially reduces surface water entering the TMA. The combination of surface water diversion and promotion of surface drainage patterns on the TMA surface minimizes the infiltration".

The following statement by former environment department leaders at Areva summarizes the philosophy that guided the decision-making:

From ref 1:

"We believe that the plan which has been accepted through the environmental assessment process *minimizes constraints on future land use to the extent which it is practical to do so."*

The limits of practicability are not defined.

6. HOW THE TMA WAS DECOMMISSIONED

Appendix C of the Oct. 2019 version of the hydrogeology and groundwater modelling TID *(ref 23)* neatly summarizes the main decommissioning activities.

Between 2001 and 2006, a minimum 1 m thick glacial till cover was placed over the tailings so that the top surface drained at 1.5% to 2.0% from the south-east to the north-west, and the divider dykes were excavated to match the elevation of the tailings cover. The upper and lower solids areas (both containing tailings) were covered in three campaigns.

The first campaign was the levelling course (using glacial till) which was applied in 2001 and 2003 and which produced most of the anticipated primary consolidation of the tailings and approximated the final topography.

The second campaign involved rough placement of the till cover to achieve the designed final topography over the tailings, while all surface water flow continued to report to the Liquids Pond for collection and treatment (until backfill of the Liquids Pond was complete). The third campaign included final placement and grading of the cover, with the intent of promoting a 1.5% slope away from the Upper Solids Pond towards the Lower Solids Pond.

The Liquids Pond was backfilled to an elevation above the anticipated post-closure phreatic surface and graded to minimize ponding water on the surface. The backfill was intended to be placed in such a way that the final surface would be graded smoothly and into adjacent topography with local and upgradient runoff flowing onto and over the former Liquids Pond. Small areas of both the Lower Solids Decant Area and the Liquids Pond were too soft to support final grading equipment, and final grading of these areas was deferred until the material had adequately dewatered to support construction equipment.

Settling resulted in low lying areas with temporary ponded water, most of which were backfilled in 2013. The cover surface was vegetated.

In 2006, the downstream slopes of the main dam were flattened to 4H:1V using glacial till and the surface was hydroseeded. The upstream face was shallowed from 3H:1V to approximately 10H:1V, and the liquids pond area was backfilled with up to 5 m. of glacial till.

During the 2006 works, a spillway was constructed by breaching the dam between Snake Lake and the Liquids Pond. To reduce total suspended solids (TSS) from migrating off the TMA into Snake Lake, a cobble dam was constructed within the spillway alignment with the intent that it would be removed after vegetation on the cover had adequately established. After removing the temporary cobble dam in 2017, it is understood that the spillway is designed to accommodate a Probable Maximum Flood (PMF) event.

In the summer of 2013, site clean-up activities included decommissioning of the secondary treatment system plant and settling ponds and the disposal of demolition waste and any potentially contaminated materials. As of the fall of 2013, AREVA no longer has a permanent site presence at Cluff Lake. The airstrip has been closed and site access restrictions have been removed.

7. MONITORING, REGULATION, AND INSPECTION

Over the years very extensive, detailed surface and groundwater quality measurements have been made at many specific locations in and around the TMA and downstream from the TMA. Sampling and analysis are generally carried out by Orano or its contractors.

The main regulator for the Cluff Lake project is the Canadian Nuclear Safety Commission. CNSC inspectors make brief, periodic visits to the site to check whether regulations are being appropriately followed. It is difficult for an outsider to evaluate the thoroughness and depth of these inspections; a request by a concerned member of the public to accompany an inspector on his site tour was refused. The Provincial government also has regulatory responsibilities related to worker health and safety and non-nuclear environmental protection.

With the intention of reassuring local residents of the safety of areas close to nuclear sites, the CNSC has also created an Independent Environmental Monitoring Program (IEMP). This program visited the Cluff Lake site in 2017 and analyzed samples of air, water, fish and vegetation at Sandy Lake (well downstream from the TMA site). To quote the IEMP website, "The IEMP results indicate that the public and the environment in the vicinity of the Cluff Lake Project are protected and that there is no unreasonable risk to health and the environment. These results are consistent with the results submitted by Orano, demonstrating that the licensee's environmental protection program protects the health and safety of people and the environment."

SES suggests that this seems like a rather ambitious conclusion to draw from very geographically limited data.

8. PLANS FOR POST-DECOMMISSIONING AND TRANSFER OF RESPONSIBILITY

The Cluff Lake site is currently described as a decommissioned site. Although Orano intends to progress quickly towards transferring the Cluff Lake property into Saskatchewan's Institutional Control Program (ICP), the company acknowledged in 2019 *(ref 18)* that additional time was needed for responsible parties to review and accept the long-term monitoring and maintenance plans and associated establishment of institutional control funds prior to transfer into the ICP.

It is our understanding that transfer of responsibility for management of the Cluff Lake property to Saskatchewan's Institutional Control Program will require a further Environmental Assessment and approval by the CNSC, acceptance by the Government of Saskatchewan, and transfer of sufficient funds from Orano to Saskatchewan to cover estimated costs for monitoring and maintenance in perpetuity. How such costs are estimated is discussed in Section 9r below. The responsibilities of the ICP in perpetuity are discussed in section 9q.

9. CONCERNS THAT HAVE BEEN RAISED BY INTERVENERS

In the following 22 sub-sections, 9a to 9v, we review specific concerns about the condition of the TMA, how Orano has responded to these concerns, and have added SES comments.

9a. What's in the Tailings and How Dangerous Are They?

We learn from Supporting document #1, sec. *3 (ref. 12)* that the tailings contain radium-226 (6–450 Bq/g), uranium (80–1100 µg/g) and thorium (17–4000 µg/g) in addition to varying amounts of heavy metals. Arsenic, nickel and molybdenum concentrations are relatively low, but tend to be highest in the slimes.

What kind of human health hazards do these elements represent? Some examples:

<u>Radium</u>
The use of differing units for measurement of radiation can cause some confusion. The figure quoted for the concentration of radium in the tailings is expressed as 6-450 becquerels per gram (Bq/g). 1 Becquerel is equivalent to 27 picocuries, so the radium level in the tailings ranges from 162 to 12,150 picocuries per gram.

For reference, the US EPA *(ref. 24)* requires clean-up of contaminated soil containing more than 5 pCi/g.

Radium, the EPA tells us, can enter the body when it is inhaled or swallowed. Radium breathed into the lungs may remain there for months; but it will gradually enter the blood stream and be carried to all parts of the body, with a portion accumulating in the bones.

Exposure to radium over a long period may result in many different harmful effects. If inhaled as dust or ingested as a contaminant, risk is increased for several diseases including lymphoma, bone cancer and hematopoietic (blood-formation) diseases such as leukemia and aplastic anemia. These effects take years to develop. If exposed externally to radium's gamma radiation, risk of cancer is increased in essentially all tissues and organs, though to varying degrees.

<u>Uranium</u>
Exposure to uranium can result in both chemical and radiological toxicity (*ref 25, US Department of Energy)*. The main chemical effect associated with exposure to uranium and its compounds is kidney toxicity. This toxicity can be caused by breathing air containing uranium dusts or by eating substances containing uranium, which then enters the bloodstream. Once in the bloodstream, the uranium compounds are filtered by the kidneys, where they can cause damage to the kidney cells.

Several possible health effects are associated with human exposure to radiation from uranium. Because all uranium isotopes emit alpha particles that have little penetrating ability, the main radiation hazard from uranium occurs when uranium compounds are ingested or inhaled. The primary radiation health effect of concern is an increased probability of an exposed individual developing cancer during their lifetime. Cancer cases induced by radiation are generally indistinguishable from other "naturally occurring" cancers and occur years after the exposure takes place. The probability of developing a radiation-induced cancer increases with increasing uranium intakes.

Arsenic

From ref.15: Long-term exposure to arsenic in drinking water can cause cancer in the skin, lungs, bladder and kidney. It can also cause other skin changes such as thickening and pigmentation. The likelihood of effects is related to the level of exposure to arsenic and in areas where drinking water is heavily contaminated, these effects can be seen in many individuals in the population. Increased risks of lung and bladder cancer and skin changes have been reported in people ingesting arsenic in drinking water at concentrations of 50 µg/litre, or even lower.

We see that the tailings clearly contain materials that need to be controlled in the biosphere. All occur to some extent naturally; the problems occur when exposure levels become too high. Impacts on fish, benthic organisms, insects and other life forms will often be more severe than those on humans. The exact composition of the tailings in different areas of the TMA, as well as the varying rate of movement of different elements into ground or surface water make it difficult to estimate the risk each presents to human and other life forms. Orano has undertaken extensive modelling exercises to generate predictions of the long-term concentrations of contaminants in downstream sites. They claim that these represent acceptable levels.

SES accepts that levels of human exposure to the hazardous materials in the tailings will probably be low (unless major unforeseen events result in a sudden, significant release of tailings). Present understanding would indicate that the chances of detectable harm to humans are small. However, a certain degree of uncertainty and risk remains, and the question of what is acceptable is unresolved. While I might personally be willing to accept such risk, that does not mean that anyone else should be obliged to do so.

9b. How are Potential Effects on Wildlife and Ecosystems Taken into Account?

Orano has gone to commendable lengths to estimate impacts that present and future levels of contaminants may have on aquatic and terrestrial creatures that ingest or are exposed to them.

Potential impacts of both radionuclide and non-radionuclide contaminants on both terrestrial and aquatic species are discussed in section 7 of the 2019 EP TID *(ref 19, p291/590)*.

For evaluation of potential effects of non-radionuclides on the aquatic community, a statistical representation of available toxicity data is used. Predicted concentrations of contaminants in water are compared to Toxicity Reference Values (TRVs) for each species.

TRVs are commonly based on literature-derived toxicity dose-response relationships examined through laboratory experimentation. They may be based on "No observable adverse effect levels" or "Low observable adverse effect levels". Due to the difficulty of measuring direct effects, "measurement endpoints", defined as "quantitative summaries of the results of a toxicity test, a biological study, or other activity intended to reveal the effects of a substance" are adopted (*2019 EP TID App D: 8/340)*. Measurement endpoints are typically based on exposure responses such a reproduction and abundance.

For terrestrial receptors and for exposure to radionuclides for both terrestrial and aquatic receptors, the potential for negative effects is based on calculation of a screening index value (SI). This is calculated by dividing the predicted concentration of a contaminant by the TRV for each receptor. An SI value greater than 1.0 suggests that there is a potential for adverse effects on a species. So even if a prescribed Water Quality Guideline for a particular contaminant is exceeded, as is the case for several contaminants in Snake and Island Lakes, this is regarded as acceptable as long as the SI values for all the selected species are below 1.0. It is noted *(ref. 19, p.293/590)* that several species of aquatic invertebrates are potentially affected by chloride levels in the Island Lake watershed, however concentrations are expected to decline to acceptable levels in the future. Similarly, two species of invertebrates and one kind of alga are potentially affected by uranium levels in Island Lake. Selenium levels potentially affect fish in Island Lake at present, but again, the concentration of selenium is expected to fall towards and eventually below the benchmark in the future.

Potential effects on the benthic community from contaminants in sediment are predicted to be localized and variable; widespread negative effects on the benthic community in the watershed are not expected by Orano.

As the 2015 EP TID Vol 2 *(ref 6)* pointed out, various major assumptions are made in this assessment process. For example,

Modelling is used to predict future concentrations of contaminants, based on our current understanding of future conditions. As stated in the 2015 TID *(ref 6, p.99/397),* "these are best estimates, but it is still a theoretical exercise… The modelling of future conditions has been completed using reasonable estimates, but it remains an illustration of what *might* happen, and may not be a reflection of what *will* happen".

The ecological exposure profiles used, we are told, are another source of uncertainty, as receptors tend to adjust and vary their diet according to the food sources available. The characteristics (food and soil consumption) of ecological receptors were obtained from the literature. These values have generally been obtained from animals in captivity or are estimated from data from other animals of similar size and physiology and may not be fully representative of free-range animals in the wild.

The transparency of these cautions is appreciated by SES. We also note the very limited discussion of potential interactive impacts, synergistic or antagonistic, of different contaminants in aquatic systems.

We note Orano's comment *(ref 19, p.294/590)* that "Several other species of invertebrates and algae/plants, in addition to fish, are not expected to be affected, which suggests negligible implications for the aquatic environment". This appears to suggest that because not all species are affected, the impact on those that are affected is unimportant from an ecosystem perspective. This may generally be a reasonable conclusion, but it does assume a detailed understanding of the subtle inter-relationships within an ecosystem that may not always be justified.

The assessment for terrestrial species looked at potential effects of eight COPCs on 12 species at various locations *(ref 19, p.297/590)*. 1% of these evaluations showed SI values exceeding 1.0, all related to selenium. SI values for moose were all below 1.0, thus no effects on moose are anticipated. A new study appears to confirm that forage associated with Island Lake does not pose molybdenosis risk for ungulates or any potential adverse effects in moose.

In general, Orano concludes that the ecological risk assessment completed as part of the CSR (and confirmed by later studies) identified only "non-significant" impacts to wildlife in the Island Lake drainage area." However, the assessment did show that there will be potential risks in Snake Lake for several receptors (particularly mink, yellowlegs and nighthawk) in the future as the groundwater loading from the TMA reaches this water body. For Island Lake, Island Lake Fen and Island Creek at the Dolomites, selenium is a potential risk now, but the aquatic system is recovering.

SES appreciates the very serious effort that Orano has made to identify ecosystem and wildlife risks. However, we note with some concern the cautions about the uncertainties of modelling assumptions, the limitations of knowledge about animal behaviour and feeding habits, and the fact that some contaminants are currently at levels expected to impact some species but that are deemed acceptable because they are expected to decrease at some time in the future. It is not clear to us that a high level of confidence should be placed in the prediction of only negligible effects on wildlife. The effects may not be large or widespread, but it is a matter of judgement as to whether that means that they are negligible, or from whose perspective they are acceptable.

9c. How Were the Decommissioning Objectives Set? Are They Appropriate?

9ci. Definition of the objectives

The CSR for Decommissioning 2003 Section 7 describes the decommissioning objectives as follows:

"The objectives of decommissioning activities are to remove, minimize, and control potential contaminant sources and thereby minimizing 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."

There are three concepts here that require discussion:

i. The concept of minimization;
ii. Future human land use assumptions
iii. Consideration of socio-economic factors

i. The concept of minimization: The Oxford dictionary offers 2 definitions of the word 'minimize': "Minimize means to reduce to the smallest possible amount, or to belittle or represent as worth less than is actually true." We have to believe that the first definition is the relevant one, and that no one is trying to misrepresent the facts. However, when we talk about "minimizing adverse environmental effects" and the "smallest possible amount", the limits of possibility are not defined. What is "possible" to achieve will depend on how much effort we are willing to invest in achievement. So, it can be argued that minimization is not an objective but would be better described as a desirable direction to be followed.

ii. Future human land use assumptions: "The decommissioning project is designed to…allow utilization (of the land) for traditional purposes and minimize potential constraints on future land use planning". These are certainly desirable goals; however, they imply an expectation that no significant changes in the type of land use and occupancy will take place in the future. In discussion of risk to humans Orano frequently refers to assumptions that no individual is going to spend more than a few days a year on the site. While this may reflect current practice, we have no way of knowing whether much more intense settlement of the area may take place in a climate-changed future. In the 2019 EP TID a modelled estimate is provided of the health effect on a hypothetical, full-time resident living a traditional lifestyle. This does not address the possibility of a different type or level of land use. It is acknowledged that land use restrictions will indeed be required if risks are to be managed (e.g. EP TID 2019, sec 11B). How such restrictions will be enforced over the long run is undefined. Neither Orano nor CNSC appear to have addressed this. It is apparently assumed that this is Saskatchewan's Institutional Control Program's problem to solve, not Orano's or the CNSC's.

iii. Consideration of socio-economic factors: From ref 12, sec 3 we learn that: "During the selection process (for a decommissioning option) the following constraints were considered:

- Radioactive and non-radioactive contaminant releases to the environment should be *as low as reasonably achievable (ALARA) taking into account social and economic factors;*"

How should this "taking into account" take place? This is where differences in values and priorities become important. Who is entitled to make the judgement about what cost is worth incurring in order to achieve a given improvement? How high a priority should be placed on the potential risk to future generations and non-human life forms compared to the economic well-being of present-day individuals? Orano and CNSC have conducted extensive public consultation activities which give individuals and organizations an opportunity to present their opinions and concerns. However, serious discussion of how to deal with competing ethical values appears to be beyond the scope of the regulatory system. It is not clear where this should take place.

9cii. Criteria for achievement of objectives

CSR 2003 (ref 26) section 7.1 describes clearly how Orano determined their numerical decommissioning objectives, which were accepted by the regulators.

"The decommissioning objectives and appropriate locations and timeframes for their achievement were established in consultation with federal and provincial authorities and through the proponent's public consultation process.

Where relevant, achievement of these qualitative decommissioning objectives was defined in relation to existing federal and provincial guidelines and taking into consideration site specific conditions.

For identified contaminants of potential concern, where federal or provincial guidelines were not available, information obtained from the scientific literature and site-specific conditions were evaluated to derive benchmarks for inclusion as decommissioning objectives. Locations chosen to meet the water quality decommissioning objectives for key surface water bodies were identified by the consideration of the locations, and the distances of potential contaminant sources in relation to potentially impacted natural surface water bodies, and in consultation with federal and provincial authorities".

The 2015 HG and GW modelling TID *(ref 7, 140/333)* compares in figures 6.1 and 6.2 the numbers for Areva's Decommissioning Surface Water Quality Objectives (DSWQO) and Saskatchewan Surface Water Quality Objectives. There are significant differences between these numbers for arsenic, uranium and molybdenum. Decommissioning objectives for uranium at different site locations range from 190 to 1,194 µg/L. These figures were based on water hardness criteria which are now considered inappropriate. The Saskatchewan Surface Water Quality Objective (SSWQO) figure is 15 µg/L. The DSWQO for arsenic is 50 µg/L, while the SSWQO standard is 5 µg/L. Molybdenum DSQWOs range from 73-500 µg/L in different locations, while the SSWQO is 73. Often the problem is that where federal or provincial guidelines have become stricter since the decommissioning objectives were approved, these objectives have not been revised to match the updated guidelines. Perhaps also, some of these discrepancies reflect the difficulty or cost of achieving updated guidelines, or a decision that some locations do not need to be as clean as is expected elsewhere.

With regard to sediment quality objectives, the 2003 CSR tells us that the *Canadian Sediment Quality Guidelines* (CSQG) 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. No sediment quality guideline was reported for nickel, uranium or molybdenum. A review of the scientific literature was undertaken to come up with decommissioning benchmarks for the project. 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 that additional study is necessary.

The decommissioning radiological objectives are based on a need to keep radiation doses below the regulatory limits and as low as reasonably achievable (ALARA).

The CSR 2003 *(ref 26, p.7-2)* referred to a Regional Water and Sediment Quality Working Group (RW&SQWG), consisting of representatives of Government (provincial and federal), University (University of Saskatchewan), and the uranium mining industry, formed to contribute to further research toward confirming or, for some parameters, developing appropriate regional objectives for Northern Saskatchewan. Currently I have found no record of this group's work.

SES is not convinced of the appropriateness of setting or retaining decommissioning objectives that exceed federal or provincial Water Quality Guidelines. Presumably the Water Quality Guidelines were established on the basis of ecosystem and human health safety. From a public perspective, and given the admitted uncertainties associated with modelling risk, it is not clear why regulators would allow weaker objectives to be acceptable.

9ciii. How are "safe levels" of chemical contaminants and radiation determined?

Toxicology is a constantly evolving science. Generally, the chemical toxicity of a material is measured by exposing living organisms to varying concentrations of the material and looking for the level at which impacts on the organism can be detected. These impacts may take the form of cancers, anatomical or physiological changes, reproductive malfunctions or death. There is always an element of probability involved.

Where harm to non-human species is concerned, the effect on a number of examples of different kinds of mammals, insects, birds, fish and benthic organisms may be used to predict the effect on similar organisms. In the case of species at risk, the effect on individuals is taken into account, while with more prolific species the concern may be limited to population impacts.

Effect levels may be defined as severe, probable, threshold or low effect levels. While in general, evolving information from new studies results in a lowering of allowable levels of contaminants, regulatory levels are generally very conservative in the light of current knowledge, which is continually evolving. At any given location, the harmful effects of any contaminant in the water, air or land depends on the degree of exposure of a person or other organism to that contaminant. Thus, the time spent in that location becomes relevant. At Cluff Lake and other sites decommissioning objective levels for some contaminants at some locations have been set at less demanding levels where the risk is considered low because of low population density and infrequent land occupancy.

From ref 19, p.180/590: Water and sediment quality predictions can be compared to, and screened against water and sediment quality standards, objectives and guidelines. Where generic guidelines are exceeded …potential risks are based on the comparison of predicted exposures of selected ecological receptors to measurement endpoints or toxicity reference values (TRVs), which are commonly derived through laboratory experimentation. Similarly, human exposure estimates are compared to toxicity reference values published by regulatory agencies such as Health Canada.

Table 5-1 in the 2019 EP TID (*ref 19)* lists Decommissioning Surface Water Guidelines that were set in Calendar Year (CY) 2000 for several COPCs, with notes comparing them to SSWQOs at the time (1997). Since the time of the CSR some water quality guidelines have been revised and others added. Table 5-1b shows updated guidelines.

Due to the uncertainty surrounding sediment quality guidelines or sediment toxicity benchmarks, a number of different guidelines have been considered *(ref 19, p.183/590)*. The national CCME guidelines provide "Interim SQGs", which represent the concentration below which adverse effects are expected to occur rarely, and "Probable Effect Levels", above which adverse effects are expected to occur frequently….The CCME notes that the use of Interim SQGs to the exclusion of other information (such as background concentrations of naturally occurring substances and biological tests) can lead to erroneous conclusions about the likelihood of biological effects.

It appears that there is still considerable uncertainty about the risk associated with COPCs in sediment.

Understanding of toxicity is still incomplete, and there is no societal consensus on what level of uncertainty is acceptable. Therefore, not everyone can accept that as long as the stated numerical decommissioning objectives appear to have been achieved, everything is OK. There will still be questions about degree of certainty, about the unknowability of future conditions, questions which will continue to cause unease about the acceptability of objectives. People tend to feel less comfortable with risks over which they have no control than those over which they feel they can have some control (i.e. we worry more about the risk of flying rather than the risk of driving to the airport.) See further discussion of risk in Section 9k.

9d. Is the Ponding of Water on the TMA Surface Hazardous?

Localized and intermittent ponding has been observed on the TMA cover (*ref 19, 301/590)*. Monitoring results showing generally low concentrations of COPC are taken to indicate that the majority of ponding is due to localized depressions holding fresh surface water; however, there is recognition of the possibility of intermittent groundwater daylighting on the TMA cover, driven by seasonal and climatic influences on the water table.

A detailed survey in 2016 *(ref 20, p.12/71)* showed that most of the former liquids pond area surface was wet, and there were still some areas with open ponds. Animals such as foxes, ducks and geese are expected to use, and have been observed on the TMA. CanNorth's Risk Assessment of Ponded Water *(Appendix J of 2019 EP TID) (ref 20)* provides the ecological risk assessment for this ponded water.

Due to their shallow nature and varying duration, it is concluded *(ref 12, p.10/71)* that the areas of ponded water are insufficient to support populations of aquatic biota such as fish.

…The Valued Ecosystem Components selected for the assessment were: aquatic plants, phytoplankton, zooplankton, aquatic invertebrates, northern leopard frog, hare, muskrat, fox, moose, mallard and nighthawk.

Water from various ponds was sampled from 2012 to 2016 *(ref2, p.12/71)*. SES notes that "data from CLTMAPOND8 were not included as more recent data from the same area has shown much lower concentrations". Is this an example of outlier data being discarded? There seems to be some confusion about the levels of uranium and radionuclides in the pond water. The 2019 EP TID *(Ref 19, p.302/590)* states that concentrations of uranium in samples from the transitory ponded water for the TMA are generally low, with an average concentration of 50 µg/L, with the exception of one localized area which has elevated uranium concentrations averaging 4650 µg/L. (Note that the SSWQO for uranium is 15 µg/L).

This reference then quotes the "weighted average" of uranium concentrations in the sampled ponds as 287 µg/L. *Wikipedia defines weighted average as "a method of computing a kind of arithmetic mean of a set of numbers in which some elements of the set carry more importance (weight) than others. Example: Grades are often computed using a weighted average. Suppose that homework counts 10%, quizzes 20%, and tests 70%"*. If the 287 µg/L figure was derived by weighting certain elements of the data differently, we should be told the basis on which this was done. Meanwhile, in CanNorth's Appendix J, Table 3.1, 285 µg/L is reported as the *maximum* uranium concentration, with a mean value of 50 µg/L and 95% Upper Confidence Level of the Mean (UCLM) of 97 µg/L. This implies that the risk assessment was based on a uranium level approximately one third of the weighted average level. It is unclear whether this is appropriate.

The EP TID concludes that a U concentration of 287 µg/L would indicate that some sensitive valued ecological aquatic species may be affected, but there are many species that would be unaffected (does this mean it's OK?). The ponds, Orano points out, represent a spatially limited habitat, are ephemeral in nature, and are able to support a range of invertebrates, thus the impact to these ponds is considered acceptable. Therefore, the conclusions from Appendix J. are considered to remain valid.

We are also puzzled by the following comment in Appendix J (13/71):

"The only radionuclide with a water quality guideline is radium 226 (0.11Bq/L), and the Exposure Point Concentration (EPC) is below this value. In addition, radionuclides have not been consistently detected in the water samples. For these reasons the uranium series radionuclides were not carried forward through the risk assessment".

Although the "upper confidence level of the mean" level of radium 226 detected in the water samples is, at 0.07 Bq/, below the 0.11 Bq/L guideline, the maximum observed level as reported in the CanNorth study (Appendix J of the 2019 EP TID) was well above the guideline, at 0.19 Bq/L.

Moreover, Table 3.1 in Appendix J shows that although there are no official water quality guidelines for other radionuclides, significant levels of Pb-210 and Po-210 were detected in some samples of the pond water.

But perhaps the most worrying thing is the fact that *"radionuclides have not been consistently detected in the water samples"* is used as a reason for not carrying forward the uranium series radionuclides through the risk assessment. Obviously, the data show that radionuclides have indeed been detected in at least some of the samples. It seems that the argument is being made that, because radionuclides were not detected in *every* sample (i.e. not consistently detected), we don't need to worry about the samples in which they were detected. We find this argument inexplicable.

As far as chemical toxicity goes, the ecological effects assessment concluded *(Appendix J, p.15/71)* that for cobalt, while the Exposure Point Concentration (EPC) is above the species sensitivity level for the most sensitive species, "over 90% of aquatic species are not expected to be affected by measured cobalt concentrations…and thus population effects are not expected." The same conclusion is reported for copper. Should we be concerned that up to 10% of aquatic species are apparently expected to be affected? It is reported that there may be a potential for nickel concentration to be an issue for toads (but this is not expected to have a population effect, so it is not treated as a problem).
17/71: While no adverse effects are expected for terrestrial VECs that use the TMA (*Appendix J, p17/71)*, it is acknowledged that there is some uncertainty in the data on which this conclusion is based.

The ambiguities and inconsistencies that we have noted in the risk assessment for the ponded water leads us to question the conclusion that the ponds do not present an unacceptable ecological hazard.

9e. Will Contaminants Be Drawn Up from the Tailings into Plants Growing on the TMA, Potentially Creating Risk to Wildlife?

There has been some discussion of the potential for the TMA cover to be impacted by tree roots. In App B of the 2019 GW TID *(ref 22, p.6/221)* we read that modelling was based on a maximum rooting depth of 0.30 m, which is described as an approximation of the current vegetation conditions observed in the TMA cover in 2018. (Confusingly, the same study p.100/221, Table 5.4 shows a modelling root depth of 0.5 m.)

From Orano's 2019 written submission *(ref 18, p.72/111)* we learn that as native vegetation progressively invades the cover surface, the soil binding capabilities of the grass/forb understory will persist and be supplemented by the rooting systems of native species. The predominant native vegetation at the site in upland, sandy soil areas is jack pine, with moss, lichen and blueberry as a predominant understory.

Rowe and Acton *(ref 21, p. 647)* reported that "Jack pine is robustly tap-rooted. Deep root development begins in the seedling stage and is maintained to maturity. On deep, well-drained soil, jack pine tap roots may penetrate as deep as 9 feet according to Fowells (1965). SNC Lavalin *(ref 22, 211/221)* reports on an Alberta study that showed tap roots in the boreal forest reaching a maximum of 2 metres in depth. Pointing out that roots this deep are most likely to occur under dry conditions, SNC anticipates that "very few roots of native woody species growing on the TMA cover system will extend below the base of the cover system".

SES would appreciate some discussion of the possible impacts on animals (including insects) that may feed on needles, buds or seeds of jack pines whose tap roots do indeed reach the tailings.

9f. Is the Cover on the TMA Resilient to Damage? Will Burrowing Animals Get into It?

The most recent geotechnical inspection appears to have been completed in the fall of 2018 and no stability or erosion concerns were noted at that time.

SNC Lavalin *(ref22, 209/221)* in App B identifies potential processes that may influence the long-term integrity of a cover system as Soil erosion, Frost action, Consolidation/settlement, Extreme climate events, Root penetration, and Burrowing animals.

This consultant concludes that soil erosion is not a significant issue here *(p.46/221)*. This is attributed to the relatively shallow surface gradient and the "robust surface drainage system". As the grass-forb vegetation cover has matured, supplemented by native species, the resistance of the cover system to erosive forces has increased. It is regarded as highly unlikely that erosion will have a significant effect on the long-term integrity or performance of the TMA cover system. SES accepts this. It is noted, however, *(p. 57/221)* that between 2011 and 2014, the percentage of bare soil on the cover increased from 5.7 to 10.5% after falling consistently over the previous 3 years. The reason for this is not indicated, nor is its potential impact.

SNC also reports that no evidence has been reported to date that frost action has compromised the cover, and that any further consolidation that takes place resulting in further ponding of water on the surface would not pose unreasonable risks to ecological receptors. SES has raised concerns about the ponded water in section 9d.

SNC also concludes that the likelihood of an extreme climate event significantly influencing the long-term performance of the cover is extremely low. SRK's study "TMA Closure Report" *(ref 23)* which appears as Appendix C of the 2019 GW TID discusses the potential impact of flooding of the two diversion ditches. SRK concluded that probable maximum flood conditions would cause some overflowing of the north diversion ditch but that this would not cause inundation within the TMA itself. The south diversion ditch would not be expected to over-top its banks at all.

SNC claims that animal burrows established in the TMA cover do not pose an unreasonable risk to human and ecological receptors (although they claim no expertise in this area). However, in a February 2019 letter to Rod Gardiner, Dale Huffman of Orano reported that: "About 35% of the TMA area, or about 28 hectares of the "upper solids area", may be susceptible to animals burrowing deeper than 1 meter and contacting tailings. Other areas of the TMA have cover depths beyond the maximum known burrow depth of animals in the area and/or are areas with a water table high enough to discourage animals from establishing burrows in these wet areas.

The 28 hectares of the upper solids area are not preferred denning habitat for many burrowing species. For example, wolves dig dens in soil types that lend themselves to digging, but the TMA cover has been packed to reduce infiltration rates. *(SES note: Mr. Gardiner, who worked on the decommissioning, claims that the cover material was not packed)*. Similarly, black bears prefer hillsides for denning rather than flat surfaces.

- Woodchucks and chipmunks may burrow in the 28 hectares of available, dry cover and their maximum burrow depths can, but are unlikely to, exceed 1 meter.

In the 12 years of monitoring and inspections, no signs of woodchuck burrows have been noted on the TMA. Burrows or signs of burrowing activity have not been observed on the TMA cover.

The closest observed and recorded burrowing activity was noted in 2011, with a fox den observed in the TMA south diversion ditch.

- Considering a) that there is ample available habitat for burrowing which would be preferred over the 28 hectares of available dry TMA cover, b) the abundance of woodchucks and chipmunks in the area is uncommon (Banfield 1974)i, and c) the absence of burrowing evidence over the last 12 years, the presence of burrowing animals in the TMA cover is unlikely.
- Aboriginal Affairs and Northern Development Canada (AANDC) commissioned a report evaluating Failure Modes and Effects Analysis (FMEA) of soil cover systems designed in cold regions. Within the analysis, the risk of burrowing animals rated as 'low'. "

SES would agree that the risk of serious damage by animal burrowing appears to be low given present conditions of animal land use. However, it is possible that this could no longer be the case in the future if climate change results in species migration and a different pattern of land occupancy.

On the issue of root penetration, Rowe and Acton (ref 21) quote Chrosciewiwicz as reporting that in sandy soils in boreal Quebec, the deep jack pine roots can penetrate and break up an existing "soil iron pan". Rowe and Acton refer to windstorm situations where jack pines have been uprooted, revealing tap-root lengths from 40 cm. to over 100 cm and creating significant surface disturbance. Could this happen on the TMA?

The 2019 GW TID (ref 17) addresses the question of what would happen to infiltration rates if a part of the tailings cover were damaged. They modelled three cases in which 10%, 20%, or 30% of the TMA was assumed to allow net percolation at a short-term extreme rate and the remainder of the TMA (90%, 80%, and 70%, respectively) was assumed to maintain the base case net percolation rates. Figure 7-7 (293/335) shows the modelling results for peak mass flux of arsenic, molybdenum, uranium and radium-226 to Snake Lake as a function of percent cover damage. As expected, a stepwise increase in flux is predicted for all contaminants as the extent of damage increases. It indicates that, for example, uranium levels would approximately double with 30% of the cover failing. The report then claims (273/335) that the results shown in Fig 7-7 are not realistic in that they represent a *chronic* decreased net percolation performance that would likely never be experienced. This conclusion is presumably based on the assumption that any damage that did occur would be fairly promptly repaired. SES is not totally persuaded that this assumption can be relied upon. (See section 9q)

9g. Is the Main Tailings Dam Strong Enough?

Groundwater flow and contaminant transport modelling assumes the continued geotechnical stability of the site (*ref 17, GW TID, p.316/335)*.

According to the 2019 EP TID, re*f 19, p.492/590*, the main dam of the TMA and the Claude Waste Rock Pile are the only notable landforms remaining following decommissioning for which there would be any potential risk associated with possible seismic activity. Owing to the consequence of failure and to ensure that this risk is minimal, the downstream slope of the main dam has been buttressed with till material resulting in a final slope of 4:1 with additional material placed at the swale outfall locations to a final 6:1 slope. The main dam is thus expected to be stable in the long term. It is categorized as being in a state of 'Closure – Passive Care' as defined by the Canadian Dam Association (CDA) as it is "a stable structure with low maintenance requirements" (See GW TID Section 9.2.1.2)

"The probability of a dam failure is considered highly unlikely based on having achieved the criteria outlined in CDA 2014, the demonstrated stability of the dam, the design for closure under passive care, and the proposed inclusion of ongoing geotechnical inspections in the Long-Term Monitoring and Maintenance Plan (ref 19, p.473/590). Should a dam failure occur, it is assigned an environmental severity rating of moderate, assuming repair within an Institutional Control monitoring period (i.e. 10-year time period), with impacts being limited to Snake and Island Lakes. While the tailings are saturated, their flow rate would be limited due to their consolidated state. The effort to remediate a dam failure is rated major as a large earthworks program would be required. The overall risk ranking…is very low and is not assessed further."

<u>SES accepts this conclusion.</u>

9h. How Fast and by what Routes Are Contaminants in the TMA Moving into Groundwater and Moving Downstream? Will They Eventually Reach Surface Water?

The major area of concern about the future of the TMA is the gradual movement of contaminants out into the wider environment, either dissolved in groundwater or carried in particulate form. Very extensive data collection has been carried out to determine present locations and levels of different contaminants, and advanced modelling has predicted what we might expect in terms of contaminant movement and ecological effects in the future.

Interpreting the modelling predictions is complicated. Various studies and documents refer to expectations at different future dates. The modelling generates a range of possible maximum concentration levels, and we are told that it is predicted that the decommissioning objectives will be achieved throughout the Island Lake watershed at future "expected maximum values (mean)".

Groundwater loads to Snake Lake are predicted to peak sometime between calendar year (CY) 2100 to CY 7000 for most COPCs (*ref 19, p. 203/590)*. Surface water and sediment levels in Snake Lake are expected to correspond roughly with peak groundwater loads. Surface water and sediment quality in Snake Lake is influenced by removal of contaminants from the water column to sediment. Model predictions estimate that at peak surface water COPC concentrations, on average, there is approximately 20% removal of COPCs to the sediment.

In Island Lake COPCs were at peak concentrations at cessation of operations in 2006, and Island Lake is already demonstrating strong recovery, with radionuclides being the sole COPCs with a predicted future increase due to groundwater contaminant transport. However, over the intermediate term, the existing COPC inventory within the sediments of Island Lake is predicted to be a gradual source to the surface water of Island Lake until the inventory in the sediment is buried or otherwise depleted through desorption.

The long-term predictions of the modelling show that there are a number of areas where the surface water quality is expected to exceed, or currently exceeds Water Quality Guidelines *(ref 19, p. 205/590)*. This includes Se and U in Island Lake. Predictions indicate that by CY 7000, most COPCs in Island Creek surface water will have substantially declined at modelled locations; exceptions include locations with longer-duration groundwater loads (i.e. arsenic and selenium in Snake Lake. These last two do eventually decrease, but over a longer time period (10,000 years).

Within the Island Creek watershed, future exceedances of Lowest Effect Levels in sediment are predicted for As, Mo, Ni, Se, U, Ra 226, Pb-210, and Po -210 at some locations *(ref 19, p.206/590)*; no *mean* levels are expected to exceed the Serious Effect Level except in the case of Mo and Se at the beginning of the modelled period. Predictions indicate that by the end of the modelled period (10,000 years) most of the COPCs at most modelled locations will have dropped below the applicable guidelines. We do not find all of this very reassuring. Because of the way decommissioning objectives were defined, there are no mean exceedances of DSWQG in the Island Creek Watershed.

High natural levels of iron in the region are used as a partial explanation of the excessive levels found downstream of the TMA. Fig 6-1(g) in the 2019 EP TID shows that the level of iron in Snake Lake starts off low, at or below SSWQO, then rises steeply until about CY 3000. This seems to indicate that high iron levels are not solely due to high natural levels of this element, a factor that is recognised as a complication in describing the movement of iron from the TMA.

Predicted concentrations of contaminants have been used to estimate human health and ecological risk (see section 9k).

There have been 3 major iterations of post-decommissioning surface water, ecological and human health risk assessment modelling *(ref 19, p.74/590)*. The long-term predictions of surface water quality indicate that DSWQO will be achieved at future maximum expected values throughout the watershed. Levels are predicted to drop below current WQGs by CY 7,000 *(p.44/590).* (Note: This seems a long time to wait).

The current conditions in Island Lake are at their maximum for most COPCs with continued improvement predicted into the future *(ref 19, p. 46/590)*. Potential effects are indicated for invertebrates in Island Lake and Island Lake Fen, with improvements in water and sediment quality and therefore recovery of benthic invertebrates expected over time. Water quality in Snake Lake in the future will be affected due to slow groundwater contaminant transport from the TMA. However future water quality in Snake Lake is not predicted to have negative population-level effects in the aquatic community, with the potential exception of effects on benthic invertebrates due to sediment Se …Potential effects on invertebrates and fish were indicated for Island Creek at the Dolomites due to predicted iron concentrations; however, the results for iron are complicated by the fact that iron levels are naturally quite high…the weight of evidence suggests that even though there are elevated levels of some COPC in the Island Creek Watershed, the system is recovering and will continue to improve in the future.
SES would comment that a condition in which guidelines are currently exceeded but which are expected to be achieved in 7,000 years is not what one would hope for in a decommissioned site.

9i. Would Adding More Cover in the TMA Increase its Effectiveness?

Questions have been raised about whether a thicker cover on the TMA would improve its environmental performance. Orano's position is that a thicker cover would result in poorer protection. Their argument goes as follows:

Quoting from 2019 GW TID ref 7, p.40/*335: "The selection of the TMA cover thickness (a minimum of 1 m.) is an optimization of several important design considerations, which include groundwater performance (i.e. minimizing groundwater contaminant transport) and surface performance (i.e. erosion control, surface water management, vegetation growth, burrowing animals, and radiation protection). Over-designing for surface performance would diminish groundwater performance and vice-versa as described below:*

- *Focus on groundwater: Net percolation at the TMA is limited by the low hydraulic conductivity of the tailings and the location of the TMA in a groundwater discharge area. If the cover were designed for net percolation alone, the best performance would be obtained if no cover was present, as the cover results in the storage of water over an already relatively impermeable surface. The absence of a cover would be unacceptable for other reasons, as a cover is necessary to isolate waste from surface, provide a medium for vegetative growth, provide a buffer for burrowing animals, and prevent the transport of contaminants from the tailings surface during runoff.*

- *Focus on surface performance: If the cover were designed to focus on isolation of the tailings from the surface, an increase in thickness would result in a higher net percolation due to the greater amount of water being stored above the tailings. Increasing the thickness of the cover would provide limited additional benefit on* *surface, as a minimum 1 m cover provides sufficient rooting depth for vegetation (including climax species), provides a suitable buffer for burrowing animals, minimizes erosion and effectively routes surface water and provides the conditions for radiological clearance.*

- *The TMA cover must achieve both surface and groundwater performance objectives, and the selection of a minimum 1 m cover achieves all objectives.*

Basically, they are saying that 1 m provides an *adequate* surface performance. They do not comment on whether, or to what extent, a deeper cover would improve the surface performance. It would seem likely that it would do so, but we don't know by how much it might improve. Some of the quoted factors (e.g. tree rooting, burrowing, erosion,) are probably hard to quantify.

One might want to consider the possible effect of a deeper cover on the surface ponding issue. Retention of meteoric water on the surface and its settlement in surface depressions would not be expected to change with a deeper cover, but presumably the problem of daylighting of groundwater would diminish.
The modelling apparently indicates that a thicker cover would lead to more percolation of water into the tailings and thus more contamination of groundwater. While this feels quite counter-intuitive, we are not in a position to technically argue with the modellers. However, an instinctive reaction would be to assume that with minimal depth of coverage, close to 100% of the total precipitation would reach the tailings surface. With a deeper cover, one would assume, some of the precipitation would move laterally through the cover before reaching the top of the tailings, and some (the more, the deeper the cover) would be held in the upper layers of the cover before gradually being removed by evapo-transpiration. This, it would seem, would leave less of the total precipitation encountering the top of the tailings. In addition, we could challenge Orano's statement that 1 meter provides adequate rooting depth for native vegetation (see section 9e).

If we assume the model is correct, it would still seem to be an open question as to whether the predicted negative effect of a thicker cover on net percolation would be greater than the positive effects on surface performance. We understand why there is some hesitation to accept Orano's conclusion that a deeper cover would produce an overall negative result.

9j. Are Long-Term Projections of Behaviour of the Tailings, Movement of Groundwater etc. that Are Largely Based on Modelling Reliable? Do We Know Enough about the Hydrogeology of the Site?

The major area of concern about the future of the TMA is the gradual movement of contaminants out into the wider environment, either dissolved in groundwater or carried in particulate form. Very extensive data collection has been carried out to determine present locations and levels of different contaminants, and advanced modelling has predicted what we might expect in terms of contaminant movement and ecological and human health effects in the future. The amount and detail of work that has been dedicated to this task is indeed impressive. 74/590: There have been 3 major iterations of post-decommissioning surface water, ecological and human health risk assessment modelling (*ref 19, p.74/590)*. The first, CSD 2000 was used as a planning tool for the design of decommissioning. An update in 2015 incorporated a lot of new data and revised groundwater modelling. This version assumed in its human health risk assessment a residency time of 11 days, compared to 8 days in the earlier assessment. The most recent assessment, EP TID 2019, capitalized on further modelling refinements, re-examined flows through the watershed system, incorporated yet more monitoring data and other factors, added new scenarios and assessed effects for a potential full-time resident who continues to basically live a hunter-gatherer lifestyle.

The difficulty for a reviewer is that specialized expertise and resources are required to express a meaningful opinion on the reliability of the modelling. We assume that it is very likely that Orano used high quality expertise to develop the models. A level of uncertainty is acknowledged, and this is dealt with by the use of a probabilistic approach which allows for a range of potential outcomes based on a range of potential inputs. Results are presented both as a mean value of possible results and as a figure that would include 95% of projected results. The latter would presumably exclude the 5% of outlier results, whether favourable or otherwise, but would include most potential outcomes that are quite divergent from the mean.

For the general public, then, there are two choices. One is to simply trust that the science of modelling and those who practise it are reliable and that their conclusions are valid. The other is to suggest that the acknowledged degree of uncertainty associated with the modelling is sufficient to challenge confidence in its conclusions. SES leans towards the latter position.

In terms of understanding of the hydrogeology of the site, we would again comment on the impressive amount of work that has been done by Orano over the past two decades to learn about what is going under the ground. It is clear that knowledge has evolved over that period of time. Estimated levels of the phreatic surface have changed significantly. They may continue to change. We cannot tell whether present conditions will remain unchanged indefinitely. It would be very surprising if significant changes were to occur or if significant new information were to be discovered. SES is prepared to cautiously accept that the hydrogeology of the site is as well understood as is possible at present.

9k. How is Risk Calculated? What Degree of Risk/Uncertainty is Acceptable – By Whom?

There are two questions here: "Is the method of risk evaluation valid?" and "What degree of risk is acceptable, by whom?"

Orano tells us (*ref 19, 465/590)* that the project risk assessment was conducted by a cross-disciplinary team based on the following: knowledge of the Cluff Lake Project; experience with decommissioning of mining projects, and expertise in the following areas: health and safety, hydrogeological sciences, radiation protection, geotechnical, stakeholder engagement and concerns, and environmental risk assessment (e.g. ecology, toxicology).

The approach was comprised of the following steps:

- Discuss each component of the Project and brainstorm potential accidents and malfunctions.

- For each identified accident, malfunction or effect of the environment:
    i. Assess the likelihood of the event occurring based on criteria shown in Table 10-1;
    ii. Assess the potential consequences of the event.
    iii. Assign a risk rating.

Consequences are categorized by risk factors numbered from 1 to 5, depending on whether the consequences are regarded as negligible (1), minor (2), moderate (3), major (4) or severe (5). For each category, a description is provided in the 2019 EP TID, Table 10-1 of the kind of consequence that could be expected in terms of public health and safety, environment, and effort required to remediate damage. For example, a 'moderate (3)' consequence would be exemplified by "Ill health leading to disability or impairment resulting in extended recovery or lost limb injury, Nuclear Energy Worker dose limit being exceeded, measurable geographically localized environmental effects, monitoring data expected to exceed predicted surface water quality thresholds for multiple years, or earthworks required to remediate with heavy equipment."

Table 10-2 categorizes the likelihood of the accident, malfunction or effect of the environment occurring. Again there are 5 categories, with level 1 as 'highly unlikely' (less than 1 in 1000 years), level 2 as 'unlikely' (1 in a 100 to 1 in 1,000 years), level 3 'likely' (1 in 10 to 1 in 100 years), level 4 'almost certain' (over 1 in 10 years) and level 5 'certain' (over 1 in 1 year).

The overall risk is calculated by multiplying the consequence level number by the likelihood level number. Table 10-3 demonstrates that if this product is greater than 12, the overall risk is regarded as major. If it is below 5 it is regarded as very low risk. This apparently assumes that "likelihood" and "consequence" carry equal weight. Does it not seem possible that there could be situations in which the consequence would be so severe that even a very low likelihood of it occurring, giving a product of 5x1, would be unacceptable? Orano provides examples of potential mishaps that would have severe consequences but low likelihood of occurring (e.g. an aircraft accident) and which were not further assessed as the overall risk rating is deemed "moderate" at 10.

Once the risk rating had been thus established, some scenarios with higher overall risk were further studied to better quantify the consequences. Potential mechanisms that could cause the incident to occur and the type of mitigation and design features in place were reviewed.

So, this is an attempt to systematically evaluate risk situations. However, we cannot ignore the fact that knowledge of consequences and likelihoods is imperfect. We have to make decisions based on the current understanding which may turn out to be inaccurate. There may be factors that we have not recognised that could affect outcomes. Moreover, the question of the acceptability of a given level of risk is not addressed, nor is it obvious who should have the power to make such decisions.

9l. Are There Local Radioactive Hotspots on the TMA Surface?

Radiation exposure at the surface of the TMA could result from release of radon gas from buried uranium decay products, from Long-Lived Radioactive Dust (LLRD) or from gamma radiation.

Version 3 of the Detailed Decommissioning Plan (ref 2, p.21/75) tells us that among criteria indicating decommissioning success is "*Levels of gamma, radon, and long-lived radioactive dust which pose no unacceptable risk to traditional land use, and which are consistent with application of the ALARA principle*".

The 2003 CNSC version of the decommissioning plan *(ref 26, p.90/266)* explained that the potential exposure to gamma radiation is assumed to be the primary exposure pathway. "For gamma exposures, gamma surveys, conducted at a height of one meter above ground surface, will be undertaken in disturbed areas that are potentially contaminated. Areas illustrating average dose rates from gamma exposure in excess of 1 µSv/h above background (averaged over a 100 m x 100 m surface, or a 10,000 m^2 surface), or with a maximum spot dose in excess of 2.5 µSv/h above background, will be remediated.

The limit on annual effective dose to a member of the public under the CNSC's Radiation Protection Regulations is 1 mSv/yr above natural background levels *(ref 2, p.24/75)*. Orano reports that sufficient cover materials were applied to eliminate LLRD, and to reduce radon progeny levels to near background conditions, where source terms existed. Post de-commissioning LLRD and RnP levels are near background and, it is claimed, did not require specific decommissioning objectives. The potential exposure to gamma radiation is assumed to be the primary exposure pathway…A submission demonstrating achievement of radiological objectives was provided October 2014.

These results are reassuring. However, they do not exclude the possibility that, within a 10,000 m^2 area over which readings were averaged, there may be isolated spots where gamma levels are above guideline figures. We have not seen the data and do not know if this is the case, nor do we know on how many readings the averages were based. Obviously, it is not possible to measure every square cm. of the surface, so that small doubt is unavoidable. Also, noting that the measurements were made 1 m above the surface, we question whether this is appropriate for estimating potential effects on small animals.

9m. Will Contaminants Currently Held in Sediment in Island Lake Eventually Release into Water?

The answer to this is clearly "Yes, some of it will". Island Lake was the primary receiving water body for treated effluent from the milling operation. The 2019 EP TID tells us *(ref 19, p.204/590)* "Over the intermediate term, the existing COPC inventory within the sediments of Island Lake are predicted to be a gradual source of contaminants to the surface water of Island Lake until the inventory is buried or otherwise depleted through desorption".

Orano reports *(ref 19, p.197/590)* that uranium in sediment at Island Lake currently exceeds the Lowest Effect Level but is predicted to drop below that level by year 2360. On p.132/590 it is reported that re-solubilization of a barium-radium co-precipitate is currently playing a role in radium-226 release from sediments, and that sediments may be a significant source of inorganic substances such as metal ions. Since the solubility of most metal ions is higher under aerobic than anaerobic conditions, most exchange occurs from the oxidised (presumably the upper) zone of sediments. So, a portion of the sediment-held material may be re-introduced into the water column; that which remains becomes buried by the continued deposition of fresh settling matter. Detailed modelling was used to simulate the transfer of COPC from sediment through the watershed and the uptake of COPC by biota from sediment. Modelling predicts that by the end of the modelling period (CY 7000), concentrations of *most* COPC at *most* modelled locations will have dropped below the applicable guidelines. However, future exceedances of sediment LEL values are predicted for As, Mo, Ni, U, Ra-226, Pb-210 and Po-210 at some locations. Ref 26, p.205/266 Table 2 presents a listing of comments and concerns raised by federal agencies with respect to the 2003 decommissioning plan, along with responses from the company (then known as Cogema). Environment Canada commented that "No contingency plan is offered for the possibility that contaminants release from sediment to water (*presumably referring to Island Lake sediment)*". Cogema's response was: 'The EIS predicts release, but at rates which do not result in water quality problems. The Fen will polish water quality if rates are higher than expected".

Comparing predicted future contaminant levels to sediment quality guidelines was used as a screening exercise to identify the need for further evaluation of the impact on aquatic receptors in the Ecological Risk Assessment *(ref 19, p.193/590)*. The results of this further work led to a conclusion that the impacts are minor and are acceptable. Orano believes that the intent of decommissioning, which includes the objectives of achieving DSWQG at select water bodies and the absence of unreasonable risk, has been achieved.

The question remains as to whether we should be reassured by this. We are not in a position to challenge the reliability of the modelling projections of the fate of the contaminants currently held in the lake sediment. We believe that it is legitimate to claim that there is insufficient certainty about the long-term ecological impacts of the contaminants in the sediments. We cannot guarantee that sediments will not at some point be disturbed, thus exposing previously buried contaminants to oxidation and release to the water column. We suggest it was a mistake to remove Island Lake from the Orano licence area last year, and we believe that it should be regarded indefinitely as a potentially hazardous site, with all that implies.

9n. Are the Contaminants Held in the Island Lake Fen Stable and Safe?

The Island lake fen, located downstream of Island Lake, has accumulated a contaminant load over the operational period. The sediments in the fen are acting as a sink for COPCs from upstream sources (*ref 19, p.204/590)*. (Studies carried out) indicate that the fen sediments have a high capacity for contaminant uptake and very little release of bound contaminants is expected even under extreme environmental conditions.

Studies have concluded that the Fen has continued to limit the transport of COPCs further downstream, and that the geochemical processes that concentrated uranium and other trace COPCs in the fen are the same processes that limit their mobility. Therefore, Orano concludes that COPCs are expected to be retained within the Fen for the long term.

If we accept this conclusion – and we acknowledge that it is most likely correct – concerns may still be raised about the permanent presence in this marshy area of serious levels of contaminants. The possibility of major changes in landforms in the distant future, while unlikely, cannot be ruled out. Changes in the physical environment could possibly result in changes in uranium chemistry, making uranium more mobile. Animal behaviour and occupancy could change as climate and human land use change, leading to physical disturbance of the area. However, there is little that could be done at this point to further reduce the likelihood of such unlikely developments. We must simply assume that a certain, low level of risk will remain indefinitely.

In the table of comments on the Decommissioning CSR (*ref 26, p. 205/266)* Canada's Department of Fisheries and Oceans (DFO) suggested that wetlands (presumably referring to the Fen) should be designated as a hazardous site. Cogema's response was that if the contaminants are permanently tied up, there is no long-term hazard. SES tends to agree with DFO on this point. Long-term precautionary measures should be considered.

9o. Is Country Food Safe?

The "base case" used in the human health assessment refers to impacts of consuming local wild food on an adult, a child and a toddler who visit the Cluff Lake site for 23 days a year and who hunt, fish and camp in the immediate area. (*EP TID 2019, ref 19, p.438/590)*. Areva (Orano's name at the time) used information about diet and the consumption of local wild plant and animal products from attendees at a 2005 workshop involving members of the Environmental Quality Committee and the Athabasca Chipewyan First Nation in assessing the health risk for people who may hunt, fish and gather (e.g. tea, berries) at the site.

The results of the human health assessment are interpreted to mean that there are no potential negative effects expected from the base case land use scenario. For exposure to radionuclides, the (most likely) highest predicted incremental dose (305 µSv/yr) would occur around CY 4000 for a toddler. This is slightly above the Health Canada dose constraint of 300 µSv/yr, and well within the range of variability of radiation from natural sources. Of this incremental dose, about 220 µSv/yr is from fish consumption and about 40 µSv/yr. from consumption of mallard. It is noted, however, that there is a wide range of highest predicted incremental doses. For the CY 4000, the 95th percentile figure is almost 1000 µSv/yr, appearing to mean that there is a small chance that the incremental dose would be that high. 1000 µSv/yr is over 3 times the Health Canada dose constraint but is the CNSC dose limit. The difference between the Health Canada and the CNSC dose constraints/dose limits is interesting (and unexplained).

It is also to be noted that these incremental dose figures represent the exposure on top of and beyond the natural sources of radiation. The natural sources in northern Saskatchewan will generally exceed the incremental dose resulting from the project. What the body reacts to is not just the incremental dose, but the sum of the natural plus the incremental dose. So, an incremental dose of 1000 µSv might mean an actual dose considerably higher. Perhaps the assumption is that people who have evolved in a particular region have a tolerance level specific to that region?

In the discussion of chronic exposure to non-radionuclide COPCs, the EP TID *(ref 19, p. 445/590*) indicates that, despite assuming diet for 6 months of the year to be from traditional food obtained at or near the Cluff Lake project, the traditional food contributions are generally small compared to the intakes associated with supermarket foods. For Cd, Co, Cu, Mo and Ni, the total intakes remain below the Toxicology Reference Value (TRV). Arsenic and Se show TRV exceedances at the mean but remain comparable to the general Canadian and high fish eater diets respectively. As and Se total intakes are dominated by the intake from supermarket foods. Uranium intake from the Cluff Lake project in the near-term contributes more to the total intakes than supermarket foods do. However, the total intakes remain below the TRV with the exception of the upper-bound intake for the toddler currently, and for the toddler and child in year 2400. "Considering that it is a conservative assessment, the results of the assessment do not indicate that changes to the health outcomes of people using the site and consuming country foods are expected".

For exposure to carcinogenic non-radionuclides, the *mean* incremental cancer risk is compared to the threshold cancer risk level of 1 per 100,000 and remains below this level. However, the upper-bound predicted cancer risk from arsenic is 1.8 per 100,000.
Overall, it is concluded that the project site is safe for traditional land use by adults, children and toddlers, both in the near-term and over the long-term, and that food from and near the site is safe to share with extended families.

SES would conclude that under present and estimated future conditions, and assuming that presently understood dietary practices are maintained, consumption of a limited amount of local foods and medicinal plants does not represent a hazard that we would consider unacceptable for ourselves.

9p. Will Future Environmental Changes, e.g. Rainfall, Fires etc. Cause Problems?

Section 120.4 of the 2019 Risk Assessment *(ref 19, p.485/590)* reports on potential effects of the environment on the decommissioned project. It identifies extreme weather, climate change, beaver activity, seismic events and wildfires as potential influences. Extreme weather events could include extreme precipitation and extreme drought.

<u>Precipitation</u>
Extreme precipitation has the potential to result in damage to the TMA cover. However, this will be minimized by the water re-routing features, the high boulder/rock/gravel content of the cover and the established vegetation. The diversion ditches were designed to convey the probable maximum flood (which was calculated on the basis of a probable maximum precipitation figure which is about 6 times the 1:500-year precipitation event as then defined).

In the case of a simultaneous failure of an upstream beaver dam and a probable maximum flood, any diversion ditch overtopping would be primarily away from the TMA; however,

there is a risk of over-topping towards the TMA if the beaver dam and pond became larger, resulting in "some limited potential for erosion or damage to the TMA cover".
Overall the risk level associated with extreme precipitation is rated as "low" (unlikely, and with negligible consequences) *(ref 19, p.487/590)*.

<u>Drought</u>
Negligible effects are also expected from potential long-term drought *(ref 19, p.488/590)*. However, we do question whether prolonged drought might result in cracking of the cover surface and what the implications of this might be.

<u>Fire</u>
The risk for the fen to release contaminants rapidly through burning was also studied *(ref 3, p.63/505 quoting Microbial Technologies 2006a)*. In the context of a changing climate, numerous models have been developed to better forecast the occurrence and size of fires in Canada. These models suggest, in the worst case, a small increase in the Fire Weather Index in north-western Saskatchewan. A moderate to severe fire would be required to mobilize metals retained within the fen; however, this is unlikely due to the high water table saturating the peat material, insufficient fuel (peat) to sustain a severe fire, and the extensive area of the fen precludes more than localized impacts from fires migrating from the adjacent forest. Based on these conditions, it is reasonable to expect fire events to be local and brief. The inventory of COPC retained in the fen is not expected to be mobilized to a significant degree and further resists fire impacts due to a high water table.

SES would observe that the water table level in the region seems to change with time and to be locally variable. To what extent is the present high water table in the Fen a reliable permanent feature?

<u>Climate change</u>
Noting that there is substantial inherent uncertainty about the data used, model projections for the area suggest a future mean far-term climate that will likely be warmer and wetter compared to current climate trends *(ref 19, p.488/590)*. Increased precipitation, predicted to be a ten % increase on average over the current normal, is assessed to increase net percolation at the TMA. *(It should have been noted that it is not just the total annual precipitation that needs to be considered, but also the distribution of that precipitation; more heavy downpours are projected.)* Higher temperatures may increase plankton growth and consequent additional removal of contaminants into sediment. However high flow associated with more extreme precipitation can mobilize sediment. Increased water temperatures may also affect chemical behaviour of contaminant materials. While the overall effect of climate change on most contaminant levels is predicted to be minor, the expected mean concentration of radium-226 in Snake Lake in a projected future climate is forecast to exceed guidelines. Despite this, Orano concludes that this will not lead to any material change in the conclusions of the earlier Environmental and Human Health Risk Assessments which did not take these changes into account *(ref 19, p.490/590)*.

<u>Beaver activity</u>
Beavers are expected to alter surface water flows over the post-decommissioning period *(ref 19, p.490/590)*. Their activity can influence the TMA site performance in 2 ways: 1) changing

flow rates by holding back water and influencing surface water chemistry concentrations (this would be a temporary (decades-long) disruption), and 2) potential failure of the beaver dam in the north diversion ditch that could potentially cause erosion. As noted above, a complete and instantaneous beaver dam failure occurring in conjunction with a Probable Maximum Flood could overwhelm the capacity of the North Diversion Ditch This is considered unlikely and the severity of impact is considered to be minor.

Seismic activity

Orano tells us (*ref 19, p.492/590)* that "Seismic activity is not a concern for the site due to the low probability of significant activity in the region". See Section 9g for discussion of stability of the main dam. SES questions whether the potential effect of oil and gas industry fracking on local seismic activity has been taken into account.

9q. Does the Institutional Control Program Have the Capacity to Take on Responsibility for Long-Term Monitoring and Maintenance? How Will Regulators Ensure that Land Use Restrictions Are Complied with over the Long Run?

Administrative responsibility for the Cluff Lake site is expected to be taken over by the Province of Saskatchewan following successful transfer into the province's Institutional Control Program (ICP). In consideration of future administrative controls, Orano recommends in its 2019 EP TID *(ref 19, p. 464/590)* that:

- The decommissioned mine footprint remains with unrestricted access for travel and on-going casual land use. Traditional resource user cabins and associated casual land use activities of hunting, trapping, fishing, camping and gathering berries and tea should remain unrestricted.
- Although the risk assessment presents low risk for full-time residency of Cluff Lake, as a prudent measure, it is recommended that full-time residency is restricted.

In addition, in the 2019 Hydrogeology and Groundwater TID, *(Ref 17, 323/335)* Orano recommends that

- The decommissioned mine footprint has industrial and commercial uses and disturbances restricted…The TMA should have no approved industrial or commercial uses or disturbances.
- There should be no draining or dredging of …Snake Lake.
- There should be no installation and use of wells to access groundwater for drinking.

These are conditions that will require constant monitoring and measures to ensure compliance.

We somewhat sceptically read in SNC's Cover Evaluation Report *(ref 18, App A, 89/111)* that *"Finally the site will be monitored and maintained for hundreds of years once it has been transferred into the provincial ICP…comprehensive policy planning behind the ICP provide the people of Saskatchewan with assurance that the site will continue to be monitored and the environment and public will be protected over the long term."*

SES has previously raised a concern about the ability of the ICP to guarantee that the required level of monitoring and maintenance will be carried out over "hundreds of years".

Orano's response *(ref 19 485/590)* is as follows: "there is some stakeholder concern regarding long-term political and economic uncertainties and the long-term resilience of regulatory systems that may affect the competent administration of the IC Program in hundreds of years. IC was created because government is inherently more stable than industry and in this way the IC program minimizes long-term risk. The Province of Saskatchewan has a stable government and Canada is a politically stable country. The Cluff Lake site has been designed such that no active maintenance is expected…The Cluff Lake property has a very low reliance on institutional controls for protection of people or the environment."

So Orano says that "the property has a very low reliance on institutional controls" despite the fact that they also recommend significant land use controls.

We read in the Saskatchewan Ministry of Energy and Resources 2009 publication "Institutional Control Program Post Closure Management of Decommissioned Mine/Mill Properties Located on Crown Land in Saskatchewan" *(ref 27)*.

"The land use restrictions are to be determined at the time an application is made to enter a site into the ICP and the Registry will retain the authority to enforce those restrictions. The surface responsibility will revert back to the management of the Saskatchewan Ministry of Environment or a delegated authority on surrender of the lease. The Ministry or delegated authority will have the responsibility of permitting permissible land use subject to the restrictions on record within the Registry.

Currently, the method implemented for land use restrictions is for the Ministry of Environment to issue a Miscellaneous Use Permit to the Registry."

It seems to be understood that significant land use restrictions will be required at the Cluff Lake site for the indefinite future. This would include ensuring that practices such as permanent residence, excavating in or around the TMA, construction activities, use of groundwater for drinking etc. do not take place. Compliance will apparently be the responsibility of the Ministry of Environment. This will require a level of frequent inspection and enforcement that goes well beyond a once-in-five-years monitoring visit and will need to be continued for hundreds of years or in perpetuity. We have not yet seen any strategy for ensuring that this will be maintained. SES assumes that indefinite compliance cannot be guaranteed, and that the likelihood of inappropriate land use eventually occurring is significant.

We agree that government is more stable than industry. It would indeed be very surprising if Orano were still to be in existence in a hundred years. This is not relevant to the fact that present regulatory systems are vulnerable and may not remain in place indefinitely. Politics and economics are full of surprises. In particular, Saskatchewan's future, as a non-renewable resource dependent economy, is unpredictable. We are not suggesting that it would be better to leave Orano permanently responsible for the site. While it would have been desirable for the site to be left in a condition that did not present potential future environmental hazards, this being impossible, SES would recommend that because of the greater resources of finance and expertise accessible to the federal government, regulatory resilience would be improved if strong federal oversight of the IC Program's responsibilities were retained indefinitely.

9r. How is the Cost of Long-Term Care and Maintenance Estimated?

While the site is still under Orano's licence, the company is obliged to provide a guarantee to the province of enough funds to cover remaining costs of decommissioning and costs for care and maintenance of the site in perpetuity. The most recent calculation of these costs, carried out by Orano and included in their 2019 licence renewal submission, has been approved by the Saskatchewan Ministry of Environment and the CNSC.

A figure of $3.5M was accepted, based on the assumption that decommissioning is complete. Monitoring of the site is to include geotechnical monitoring to ensure landforms are stable, and water quality monitoring to ensure continuous achievement of decommissioning objectives. Estimated costs of monitoring and maintenance are based on Orano's post-decommissioning site management experience.

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

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

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

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

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

The assumption seems to be that the money set aside as financial assurance will grow faster than the costs of monitoring and maintenance increase with inflation.

There are two factors that, at a minimum, cause anxiety for a non-economist in the discussion and calculation of the necessary financial guarantees.

First is the assumption that the average inflation rate for the past 10 years can be used to predict future inflation rates over the next 50, 75 or 1,000 years. Surely, we can assume that the price for travel, materials, wages etc. will increase over time with inflation, but to guess at what that increase might look like in the distant future is very challenging.

Secondly, the assumption of a constant (or average) 2% economic growth rate over a very extended period of time is hard to take seriously. This may look like a conservative figure compared to the past few years, but to assume that the economy will continue to expand *ad infinitum* at this rate surely appears unrealistic. Logic would seem to suggest that the value of our investment increases only to the extent that the interest or rate of return *exceeds* inflation. Is this not true? We suggest that there remains huge uncertainty about what sum needs to be put aside now to guarantee the ability to cover costs that will be incurred many decades and centuries into the future.

Although I am uncomfortable with the assumptions that have been made and am unconvinced that we will have a guarantee of future costs being covered, I am not in a position to offer more appropriate assumptions. I would only suggest that we have to recognise that the economic future is very uncertain, and that we should not try to give the impression that the existence of "financial guarantees" actually *guarantees* anything. We must admit that we are leaving behind unknown risks and uncertainties for future generations and that perhaps, despite present good will, the maintenance and monitoring and caring for unforeseen events may flounder because of inadequate resources.

SES would like to see the whole calculation of costs and its basis of assumptions reviewed by a couple of independent economists, with the results of such a review being made public before a decision to release the properties is made.

9s. Is it Appropriate to Assume that Present Land Use and Low Population Density Will Continue *ad infinitum*?

Evaluating the future safety of the TMA site, and indeed of the whole Cluff Lake site, for human occupancy is based on the requirement in the decommissioning objectives to return the land to a condition suitable for traditional land use. This implies an indefinite continuation of the present low population density, with short-term visits by a few people to the site for hunting, fishing and food-gathering. Projections of future land-use were based on surveys of current use by present residents of Uranium City and region. In this time of global climate change and large-scale human migration, it is not unreasonable to anticipate that northern

Saskatchewan will be seen as a desirable place to settle by people who have been driven from regions that have become much less hospitable to human life. While the EP TID does examine the potential health impact on a potential full-time resident at the site, it still does not take account of possibly much greater population density, nor of a different kind of economy that may develop in the region.

9t. How Much Responsibility Do We Have for Conditions in the Distant Future? - A Question of Values

The EP TID tells us (*ref 19, p.42/590)* that" Where legacy mines may experience peak COPC concentrations in the environment at the cessation of mining…the Cluff Lake Project will experience peak concentrations decades, centuries and millennia in the future (slow groundwater transport). The decommissioning strategy is to slow and minimize contaminant transport and in this way, the peak concentrations from the modern decommissioning of the Cluff Lake Project will be delayed and, most importantly, orders of magnitude lower than would have been experienced in the absence of decommissioning design and often resulting in surface water concentrations that remain below water quality objectives."
We appreciate the significant efforts that Orano has made to predict the long-term future impacts of contaminants generated by the Cluff Lake milling operation. The modelling that has been done to estimate the future condition of the TMA and the regions downstream extends several thousands of years into the future. While the modelling has attempted to take into account many potential changes in the physical and social environment during that time span, we have to recognise the difficulty of placing much assurance in predictions over such a long period. We suggest that the condition and locations of the various contaminants currently in the TMA, in Snake Lake, the Island Fen and the sediment of Island Lake thousands of years from now cannot be known with a strong degree of certainty. Nor can we assume that political, regulatory, economic and social conditions will remain stable for decades, let alone centuries and millennia into the future. Our best efforts to guarantee protection of human and other life forms into the distant future are just that – best efforts. So, we are bequeathing an unknown future to our distant descendants. How much that matters, and how much effort we should put into trying to reduce that uncertainty, is a matter of personal and societal values on which there is probably no consensus. The uncertainty about the movement of contaminants is just one among the many big unknowns about the future, most of which are largely beyond our control.

Indigenous cultures tend to feel responsible for the next seven generations. Most of us have difficulty feeling personal concern for any generation beyond those whom we have met – perhaps grandchildren or even great-grandchildren. But why should our responsibility end there? Maybe it's because three, or even seven generations is as far as we can realistically expect to have any influence. It still feels uncomfortable to be bequeathing environmental problems to those beyond that time frame.

9u. How Can Non-Scientific Concepts Be Incorporated into the Decision-Making?

Both the CNSC and Orano recognize the importance of including "traditional knowledge" in decision-making. This is relatively straightforward when it simply involves drawing on the observations of nature and the experience of people living close to the land. Interviewing traditional land-users and learning about their perceptions of ecological changes in the local environment provides a very valuable contribution to our understanding of the impacts of industrial development. While such information is often anecdotal, perhaps lacking scientific rigour, it is used effectively to identify issues that require attention.

What is more difficult is to incorporate "traditional values" which may differ from the values that generally guide economic and scientific decision-making.

Indigenousworks.ca identifies a number of ways in which traditional Aboriginal cultures differ from mainstream Western cultures. Aboriginal cultures, they say, place greater value on the future, on consensual decision-making, on mythical understanding, on community and communal ownership.

Similarly, www.ictinc.ca compares Indigenous (I) and Western (W) worldviews. For example:

a. Spiritually orientated society, system based on belief and spiritual world (I) vs. Scientific, skeptical, requiring proof as a basis of belief (W);
b. The land is sacred and usually given by a creator or supreme being (I). vs. The land and its resources should be available for development and extraction for the benefit of humans (W);
c. Time is non-linear, cyclical in nature (I) vs. Time is usually linearly structured (W);
d. Human beings are not the most important in the world (I) vs. Human beings are most important in the world (W).

These kinds of differences presumably affect the way in which people set priorities and weigh alternatives; how they consider how much cost and effort is justified in order to make minor reductions in risk.

"Values", according to Gratin et al *(ref 14),* "are related to the concept of beliefs. Beliefs are understandings about the state of the world that are typically considered *facts* to those who hold them, since individuals are usually unaware their understanding of the world is socially and culturally constructed. Values are a special set of beliefs about what is good and evil, right and wrong, beautiful and harmonious or not".

We would add that these beliefs are not necessarily based on science. We acknowledge that most of us who have been brought up in the so-called Western scientific tradition find it challenging to accept the legitimacy of values that are discordant with our own. Decision-making power tends to be concentrated in the hands of those who subscribe to a Western world view.

It is not our role say whose values should rule in this situation. Simply, we acknowledge the dilemma presented by differing values in our culturally diverse Canadian society, a dilemma that extends well beyond the issue of managing mine tailings.

9v. Can We Trust Orano and its Consultants Not to Bias Data and Its Interpretation? Is the Science Good?

This is another question we cannot answer with any certainty. There are various ways in which it might have been possible for Orano to arrive at faulty conclusions or to misrepresent the facts.

For example, in theory:

- Data could have been selectively presented, with omission of information that did not support the desired conclusion;
- Sampling may not have been carried out appropriately;
- Lab procedures could have been sloppy;
- Data could have been incorrectly interpreted;
- Consultants could have been over-anxious to please their client;
- Inappropriate assumptions may have been made in modelling.

We have no basis for suggesting that any of these occurred, nor can we rule out that possibility. If they had occurred, we would, for the most part, have had no way of knowing about it. We have no basis for questioning the technical competence of Orano staff or their contractors. They are highly qualified. They have been willing to answer our questions, to provide access to all documents that we asked for, and to explain items in those documents that we had trouble understanding. They took us to visit the site at their expense.

It is obviously in the interests of Orano to achieve closure and termination of their responsibility for the Cluff Lake site. We are also aware of the many problems experienced by the French parent company, which could be putting pressure on the Canadian unit to quickly conclude the Cluff Lake project that is currently costing money and generating no revenue.

Trust, where it exists, is based largely on personal relationships. My experience with those of Orano's senior environmental staff with whom I have interacted makes me tend to trust them as individuals and as scientists. I have no reason to think that they intend to deceive the public. Where we have differed is more on values and priorities rather than on science. SES would tend to go further than Orano is ready to on reducing uncertainty, and on re-balancing the "environmental benefit vs. economic cost" equation. I think it would help if the company were to publicly acknowledge that, due to lack of experience and to ignorance of the hydrogeology of the site several decades ago, the decision to place the tailings in an unprepared, low-lying area is regrettable, that it led to unanticipated leakage into the wider environment, and that it leaves behind a situation that can never be completely remediated. Something in the nature of an apology to the land and the water would help in establishing wider public trust.

There is also some public perception that the regulatory bodies are biased in favour of the industry rather than the interests of the public. The CNSC depends heavily on information provided by the proponent when it makes decisions. Major industries are generally much better equipped than are public interveners to lobby decision-makers. It is virtually unknown for approvals of environmental assessments or licensing requests to be denied, either by the

CNSC or by provincial regulators. Regulators' concerns are generally dealt with by negotiation with the proponent, by prescribing required action needed for approval. Governments at both the federal and the provincial level see the uranium industry as important to the economy, and it is not hard to believe that there may be political pressure on regulatory bodies to be accommodating of the industry's priorities. We do see indications that the present leadership at the CNSC is now open to exploring possible ways of redressing some of the power imbalance between proponents and concerned representatives of the general public. So far there has been insufficient action in this direction to remove the sense of distrust of the regulator experienced by some interveners.

10. HAVE THE DECOMMISSIONING OBJECTIVES BEEN ACHIEVED?

The 2019 EP TID (ref 19, p. 48/590) concludes:

"The mining of the Cluff Lake project has left a fingerprint on the landscape; the modern decommissioning of the Cluff Lake project has enabled that fingerprint to be substantially smaller in terms of magnitude and geographic extent than would have been experienced in the absence of decommissioning design that was guided by the goal of unrestricted access. While there are still elevated COPC concentrations in water and sediment in the Island Creek watershed, the system is recovering and will continue to do so in the future." …
"The results of the ERA/HHRA demonstrate that:

- The environmental effects of decommissioning are largely positive;
- The decommissioning effectively removed, minimized, or controlled potential contaminant sources;
- Potential adverse effects are moderate, localized, temporary, with recovery occurring over several generations;
- No downstream impacts; Effects of mining and decommissioning are not measurable at Sandy Lake;
- Confirmation of the continued safe use of the area for traditional land use, i.e. safe for hunting/harvesting, fishing, gathering etc.; and
- There is an absence of unreasonable risk both now and over the long term."

So, is this good enough? Orano appears to judge that the above conclusions confirm completeness of decommissioning. Because the objectives were defined in quite vague language, it would be difficult to claim that they have not been achieved. However, SES questions whether a site that is reported to be trending towards achieving water quality guidelines over several generations should be regarded as decommissioned. Perhaps we should regard it as "trending towards decommissioning". Maybe this is the best that can be hoped for.

11. THE NATURE OF SES' REMAINING CONCERNS

First it is important to reiterate that we are very impressed with the effort that the current generation of Orano staff have made to reduce uncertainty and to respond to many concerns raised by regulators, interveners and local residents.

For example, Section10 of ref 19 *(p.481/590)* responds to a number of "what-ifs". These include: What would happen if someone dredged Snake Lake? What if eco-terrorists deliberately contaminated surface water in order to cast doubt on the veracity of the IC Program? What if moose sunk into the muddy TMA cover, what if government collapsed, what if there were an earthquake?

After considering all their studies and calculations, Orano's conclusion *(p.493/590)* is that "The Cluff Lake project has been decommissioned appropriately to be able to endure potential effects of the environment and accidents and malfunctions without continued maintenance and minimum controls of land use after placement into IC. The potential risks for the decommissioned site are generally low, with the highest potential ranked as moderate."

Of course, whether "low to moderate risk", is acceptable is open to debate.

We have attempted to group the issues on which we feel legitimate questions about the effectiveness or completeness of the decommissioning can still be raised, according to the type of problem they represent. The issues seem to fall into the following six categories:

a) Ambiguity resulting from use of vague language; for example, the frequent use of terminology such as "reasonable", "acceptable", "minimize" in defining objectives and drawing conclusions. The vagueness of "ALARA, social and economic factors being taken into account" tends to make it almost meaningless. There is no guidance about how to define "reasonable", or what weight should be assigned to specific economic or social factors, which means that it can be interpreted however the proponent (or the regulator) chooses.
b) Assumptions used in drawing conclusions; for example, the assumption that the type of future human land use will remain basically unchanged; that monitoring, maintenance and compliance with land use restrictions can be assured in perpetuity; that future financial projections will reflect current rates of return and inflation;
c) Lack of consensus on values; for example, what level of risk or uncertainty is acceptable, to whom; how non-rational views should be accommodated; what degree of responsibility we have for distant future generations; what cost or effort is justified in order to marginally reduce risk or to satisfy local concerns;
d) Limitations of knowledge; for example, evolving understanding of safe levels of contaminants; ecological exposure levels for wild (as distinct from captive) animals;
e) Lack of faith that future regulatory regimes will be able to act reliably over the long-term future, given social, economic and political uncertainties.
f) Trust; the complexity of the issues makes it difficult for non-experts to responsibly critique the decommissioning studies, for example, has sampling and analytical work

been carried out accurately? Is the modelling reliable? Are conclusions drawn from the data unbiased?

12. CONCLUSIONS

How does SES react to these concerns?

1. We recognise that complete certainty is impossible.

   It is unfortunate that many years ago this company chose to use a rather leaky tailings disposal system which continues to allow contaminants to move into the wider environment. This may have resulted from limited knowledge at the time, reliance on very limited regulation, strong incentives to get the mines operative, and/or the assumption that dealing with any problems that might develop could be put off until the future. When society allows errors of this kind to go only partially remediated (because of cost and technical restrictions), it conveys a message to future potential developers that they will not be required to take full responsibility for contamination if it turns out to require a cost that they find unacceptable.

   Ideally, detailed plans for waste management and decommissioning would be agreed upon and necessary studies carried out before development of a mine is approved, rather than following the present practice of delaying the detailed studies required for decommissioning planning until after the operation is under way. We recognise that it is sometime necessary to adjust plans in the light of new information as a project proceeds, but it would have been helpful if all those hydrogeological studies that have been undertaken during the past two decades, and that have revealed the vulnerability of the tailings containment system, had been carried out before a decision was finalised about how to manage the tailings. Presumably, if the information now available had been on the table at the time those decisions were being made, a different decision would have been made.

   When challenged, individual Orano staff have acknowledged that if they were just developing the Cluff mine operation now, they would handle tailings disposal differently. This site, they tell me, marked a transition point between the old, largely unregulated mines of the 1960s and the much better-planned and regulated ones of the present day. Some of the older mine developments, such as Gunnar and Beaverlodge, were operated by companies that no longer exist, which makes it easier for those now responsible for remediating them to acknowledge that past practices were unacceptable in the light of present understanding. This is not the case with Cluff Lake, where the same company (albeit under a series of name changes) has been responsible for the development, operation and final decommissioning of the site. A public recognition by both the company and the regulators that decisions made in the past are regrettable in the light of present knowledge, could help in gaining public acceptance of the inevitability of uncertainty about future risks. Rather than focussing on trying to reassure concerned citizens, it would be helpful to hear acknowledgement that poor decisions were made 40 years ago as a result of lack of knowledge, lack of regulation, and corporate/political economic priorities.

2. Over the years we see a succession of changes in the body of data about the site and its interpretation. Updating of "safe" levels of contaminants, new understanding of site hydrogeology, and refinement of modelling etc., while obviously desirable, leave the impression that even conclusions drawn from today's data could potentially change at any time.

3. The vagueness of "ALARA, social and economic factors being taken into account" tends to make this expression almost meaningless. There is no guidance about how to define "reasonable", or what weight should be assigned to specific economic or social factors, which means that it can be interpreted however the proponent (or the regulator or the critic) chooses.

4. The issue of trust is a huge one. There is absolutely no possibility that a concerned member of the public can adequately absorb and evaluate the many thousands of pages of technically complex studies and reports that form the basis of any assurance that the method and degree of decommissioning is adequate. We cannot, for example, either confirm or deny that the modelling is competently designed and carried out, that water sampling and analysis were done accurately, that potential impacts of contaminants on various species have been adequately assessed, that contractors who have carried out studies for Orano have not been biased by a need to please by presenting only selective conclusions. The sheer quantity and complexity of information, while encouraging in many ways, also means that it cannot realistically be competently evaluated as a whole, particularly by members of the general public who lack resources, background, skills and time. As citizens our alternative is to trust that the proponent, their contractors and the regulators are unbiased, scrupulously honest, technically skilled and guided by values that we respect. Attempts to present a simplified version of the risk assessment and the many studies on which this assessment is based will inevitably include a large dose of "Trust me, I know it's complicated, but we're sure it's all OK".

   Because of the complexity of the technical issues involved in estimating the "safeness" of the TMA, most members of the public have little choice but to rely on gut feelings or on inadequately informed understanding in order to make judgements about the acceptability of the level of decommissioning. Because of the importance of public confidence, we need to ask – how much is it worth spending to assuage fears that are not recognized by the company or the regulator as rationally justified fears? An intuitive feeling that a thicker cover on the tailings would more reliably retain the contaminants is hard to dismiss by assurances that "the modelling, which is too complicated for you to understand, proves that the present cover depth is ideal".

5. Incorporating traditional knowledge is relatively easy when it means simply recognizing observations by local residents of changes in plant and animal life or other ecological features. It is much more difficult when it means accepting the significance of myth and legend, and the psychic relationship with the land experienced by its

long-time occupants. Which of us has the right to define how different kinds of "knowledge" should be valued? (And I say this as one who overwhelmingly values the scientific method and rationality).

6. Accepting that decommissioning is adequate is necessarily accompanied by a belief that government regulatory systems will be able to carry out necessary control, monitoring and maintenance tasks over an indefinite future. SES is concerned that the possibility of unpredictable, big changes in the economic, social and political environments means that we cannot rely on our present systems of governance and responsibility being in place hundreds of years from now. This is a concern that regulators seem to have been consistently unwilling to discuss. One senior CNSC staffer told me "you don't need to worry, CNSC will always be here". Reliance on building restrictions, on fishing advisories, on regular detailed inspection and groundwater monitoring to detect unexpected changes, all require a well-funded, appropriately staffed administration with excellent information access and retrieval that will be stable over very long time periods of time i.e. several hundreds of years. This certainly cannot be assured.

<u>And so…</u>
It is in the context of these issues and uncertainties that we, as concerned citizens, have approached the mass of technical information and interpretation generously provided by Orano. We can ask questions about how certain activities were carried out, how specific data were interpreted, what assumptions were made in forecasting the future movement of contaminants or the risk to specific wildlife. But an objective judgement about whether the decommissioning is technically satisfactory or adequate, to be very meaningful, would take far more resources and specialised expertise than the current project provides. Even if that were possible, it would still leave some of us unsatisfied, with issues of acceptable levels of uncertainty and prioritizing of values left unresolved.
We have approached the task of perusing Orano's many studies and reports with the aim of finding responses to the main concerns that we have heard raised about the long-term safety of the tailings site. We have been able to pursue questions with helpful Orano staff. However, the unusual opportunity to do this in greater detail and depth than has been available previously certainly does not preclude the likelihood that we have missed important relevant pieces of information and explanation. We are left with neither the ability to assure concerned citizens that we find the tailings management adequate, nor to condemn the company as in any way irresponsible in its approach to decommissioning. We see that Orano has made enormous efforts to identify potential risks and to respond to concerns. Whether this effort is sufficient is a question that cannot be answered objectively.

From the perspective of this reviewer,

- Regrettable, irreversible decisions about tailings disposal were made in the past.
- Orano has made a huge and commendable effort to remediate the damage resulting from those decisions.
- Despite this effort, a degree of environmental and human health risk will remain into the indefinite future, a future that is impossible to predict with certainty.
- We cannot be certain that governance structures to appropriately manage those risks will remain effective indefinitely.

- SES cannot confidently recommend further specific technical actions that Orano should now undertake in order to reduce risk. It is tempting to suggest removing the till cover and the tailings, lining the whole depression with an impermeable liner before replacing the tailings, then covering the tailings with another impermeable layer before replacing and revegetating the till cover. But because this process would likely result in greater exposure to contaminants during the operations than would be prevented by it, we will not present that as a recommendation. However, it would be interesting to see an analysis of the expected results of such a procedure. We would like to see this explored before a decision is made to transfer the site to institutional control.
- A formal ceremony of apology by Orano to the land and the water impacted by the tailings could help to bring a sense of closure to the decommissioning process.

13. EVALUATION OF PROCESS, ACKNOWLEDGEMENTS

This represents the first time that SES has engaged in an agreement with a uranium mining company. It was approached with some trepidation and great care on both sides, recognising the differences in goals, priorities and values between SES and Orano. We believe both organisations are to be congratulated for their willingness to venture into this new and perhaps risky experience. SES has a long-standing policy of favouring phase-out of the uranium industry in Saskatchewan. We recognised that there was a risk of our well-earned reputation as a reliable critic of the industry being tarnished by this collaboration. Orano understood this and was as anxious as we were to see the project designed in such a way that SES would remain completely free to criticize the industry and that our name would not be used in any way that could damage our reputation.

From SES's point of view, the opportunity to delve fairly deeply into the work that Orano has done in its efforts to achieve a satisfactory level of remediation of the TMA has helped us to understand the problems the company has confronted. We have become aware of their earnest attempts to respond to concerns raised by the public. Our work has enabled us to clarify the reasons behind our unease with the condition of the TMA and the downstream impacted waters. While it may seem disappointing that we have failed to produce the kind of clear technical evaluation that was perhaps hoped for, we feel that valuable insight has been achieved. The issues we have identified are relevant not only for the Cluff Lake site and not only for the uranium mining industry, and we hope that they may lead to a more broadly based discussion.

As the author of this study, I am grateful to the board of directors of SES for approving the undertaking of this unconventional venture. I am grateful to Orano for providing the funding which allowed SES to spend the necessary time and resources to carry out the work. And finally, I am grateful to the Orano staff people, especially Diane Martens and Dale Huffman, who were very generous with their time and help in bringing this project to fruition.

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15. LIST OF ACRONYMS AND ABBREVIATIONS

ALARA As Low as Reasonably Achievable
Bq/g Becquerel per gram
CCME Canadian Council of Ministers of Environment
CNSC Canadian Nuclear Safety Commission
COPC Contaminant of Particular Concern
CSQG Canadian Sediment Quality Guidelines
CSR Comprehensive Study Report
DSWQO Decommissioning Surface Water Quality Objectives
ERA Environmental Risk Assessment
HHRA Human Health Risk Assessment

ICP Institutional Control Program
LLRD Long-Lived Radioactive Dust
Pb Lead
pCi/g Picocuries/gram
Po Polonium
Ra Radium
RnP Radon Progeny
SES Saskatchewan Environmental Society
SI Screening Index
SSWQO Saskatchewan Surface Water Quality Objectives
Th Thorium
TMA Tailings Management Area
TRV Toxicity Reference Value

16. AUTHOR NOTES

Ann Coxworth is a volunteer researcher and board member with the Saskatchewan Environmental Society. With a master's degree in nuclear chemistry from the University of California, Berkeley, she has worked in research and adult education in the United States, England and Canada.