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Written Submission from MiningWatch Canada

In the matter of

Denison Mines Corporation

Licence Application to Prepare Site and Construct for Denison Mines' Wheeler River Mine and Mill Project

Commission Public Hearing

December 2025

Mémoire de MiningWatch Canada

À l'égard de

Denison Mines Corporation

Demande de permis pour la préparation de l'emplacement et la construction du projet de mine et d'usine de concentration d'uranium Wheeler River de Denison Mines

Audience publique de la Commission

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A Review of Key Environmental Considerations Related to Denison Mines’ Wheeler River Uranium Project

MiningWatch Canada
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Introduction

Denison Mines’ Wheeler River Project would constitute the first-ever use in Canada of *in situ* leaching (ISL), or *in situ* recovery (ISR), to extract uranium from an ore body, and the first attempt anywhere to use “freeze wall” technology to limit contaminant spread from an ISL mine. Our review has identified important gaps and shortcomings in the Environmental Impact Statement and the CNSC Staff Submission recommending licencing of the project related to the proposed ISL/freeze wall process and related issues. Given the magnitude of the uncertainties surrounding this application of both freeze walls and *in situ* leaching, the failure-ridden history of both technologies, and the potential extent and significance of the impacts of short and long-term failures, this proposal cannot responsibly be approved for licencing.

Background

The Canadian Nuclear Safety Commission is the federal authority responsible for an environmental assessment (EA) of the Project under the *Canadian Environmental Assessment Act, 2012.* A CNSC staff EA report recommends “that the Commission conclude that the Project is not likely to cause significant adverse environmental effects.”[1]

Uranium mining in Canada currently employs conventional mining methods, which involve removing mineralized rock (ore) from the ground, breaking it up, and treating it to remove the uranium. Canada lacks experience with ISL and its environmental impacts. This makes it important that the EA report be thorough and credible, giving due attention to international experience with ISL/ISR.

The International Atomic Energy Agency (IAEA) describes ISL as follows:

> In situ leach (ISL) mining is defined as, the extraction of uranium from the host sandstone by chemical solutions and the recovery of uranium at the surface. ISL extraction is conducted by injecting a suitable leach solution into the ore zone below the water table; oxidizing, complexing, and mobilizing the uranium; recovering the pregnant solutions through production wells; and, finally, pumping the uranium bearing solution to

[1] CNSC Staff Submission CMD 25-H9 Vol.1, Denison Mines Corp. Licence Application to Prepare Site and Construct the Wheeler River Project

> the surface for further processing. Acid leach technology employs an acid based leaching system. Dilute sulfuric acid is normally used.[2]

The World Nuclear Association reports that the share of ISL worldwide rose from 16% in 2000 to 56% in 2022. Nearly all uranium mining in Kazakhstan, which surpassed Canada as the world's leading uranium producer in 2009, is done using ISL with acid leach technology, as proposed for the Wheeler River Project.[3]

It is generally recognized that ISL/ISR results in significant groundwater contamination, with potential to adversely impact surface water bodies.

Groundwater and surface water contamination

Canada has no experience with ISL/ISR, or guidance on its application. Australia has used this technology and has developed a *Best Practices Guide.* Several points are relevant to the Wheeler River Project, including the following:

> An ISR mining proposal should be based on a full understanding of the hydrological/ hydrogeological/hydrogeochemical features, the current and potential uses and values of groundwaters and natural radioactivity in the project area and environs.
>
> Mining should not compromise groundwater in the mineralised aquifer to the extent that it cannot be remediated to meet the agreed post-mining use at mine completion… Other aquifers present in or around the mine lease should not be affected by ISR mining.[4]

CNSC staff reviewed the hydrological and hydrogeological characterization of the site provided by Denison Mines and accepted "that the provided information is sufficient at this time… for the site preparation and construction phase."[5]

A thorough and credible EA process requires a full understanding of the hydrological/hydrogeological/ hydrogeochemical features of the project area. It is not the construction phase, but the operating, decommissioning, and post-closure phases of the Wheeler River Project that have the greatest potential to cause significant adverse environmental effects.

Denison does recognize that ISL mining will unavoidably contaminate groundwater:

> For the Project, as with other ISR projects, it is anticipated that there will be a certain degree of outward migration (horizontal and vertical) of the oxidizing solution beyond the boundary of the wells/production area… Outward migration of fluids from the active mining area is a result of normal hydrodynamic behaviour…"[6]

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[2] International Atomic Energy Agency, 2001, "Manual of Acid in Site Leach Uranium Mining Technology," IAEA-TECDOC-1239. https://www-pub.iaea.org/MTCD/Publications/PDF/te_1239_prn.pdf. Consulted October 23, 2025.
[3] "In-Situ Leach Mining of Uranium," World Nuclear Association, updated May 16, 2025. https://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/in-situ-leach-mining-of-uranium. Consulted October 23, 2025.
[4] "Australia's in situ recovery uranium mining best practice guide: groundwaters, residues and radiation protection," Commonwealth of Australia, 2010. https://d28rz98at9flks.cloudfront.net/70503/70503.pdf
[5] CNSC Staff Submission, p. 39 of 631
[6] Wheeler River Project, Final Environmental Impact Statement, Section 7 – Geology and Groundwater, October 2024, Denison Mines Corp., p. 7-70

Of particular importance is avoidance of contamination of surface water bodies. The IAEA characterizes "suitable deposits for underground leaching" as having "no hydraulic connection of the ore bearing formation to other underground aquifers or surface water sources."[7]

The EA report, regarding *Characterization of baseline hydrogeology*, says the following:

> Water level elevations between the Phoenix deposit and Hd Lake consistently show an upward hydraulic gradient from the Lower Sandstone Aquifer (including the ore zone) toward Whitefish Lake, flowing through the Desilicified Zone in the Intermediate Sandstone Aquitard… It is interpreted that the high-conductivity Desilicified Zone represents a preferential pathway for water to discharge into Whitefish Lake.
>
> The modeling results suggest Whitefish Lake is the primary potential receiving surface water body for discharging groundwater along with COPCs originating from the mining area, while the potential for groundwater to discharge to other surface water bodies is significantly lower.[8]

Previous ISL mining projects have been located largely in dry environments. The Wheeler River Project would attempt to use this technology in a portion of the Canadian Shield with many lakes and complex hydrology. This potential for discharge of COPCs ("constituents" or "contaminants" of potential concern) into surface water bodies is high. This warrants careful consideration.

The EA Report, regarding *Effect of the Project on Groundwater*, lists the following COPCs with potential to cause adverse effects: sulphate, chloride, iron, aluminum, arsenic, cadmium, copper, chromium, lead, molybdenum, nickel, selenium, vanadium, zinc, and four radionuclides (radium-226, thorium-230, lead-210, and polonium-210).[9]

Acidification of groundwater and surface waters is a major concern for ISL mining. Various "lixiviants" (liquids used to dissolve and extract minerals from the solid materials in an ore body) can be used for ISL.[10] Denison Mines proposes to use an "acidic solution composed of sulfuric acid and hydrogen peroxide."[11]

Additional details such as the range of concentrations of sulphuric acid in the lixiviant are not provided.

The EA report suggests that pumping out the sulphuric acid and the resultant uranium-enriched groundwater solution would prevent contaminants from migrating away from the mining zone. It says that a "freeze wall" would provide an extra layer of protection. The freeze wall would be continuously maintained during the mining operation:

> At the Project site, the low-permeability basement rock beneath the uranium deposit acts as a natural aquitard; however, the overlying sandstone is permeable. Hydrogeological studies and models indicate that mining solution containment can be effectively managed by maintaining an inward hydraulic gradient, achieved by recovering more solution than is injected. Denison proposed a freeze wall to provide an added layer of containment to

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[7] IAEA, "Manual of Acid in Site Leach Uranium Mining Technology," p. 59
[8] CNSC Staff Submission, p. 212 of 631
[9] *Ibid.* p. 217 of 631
[10] "Uranium Leaching Lixiviants," 911Metallurgist. https://www.911metallurgist.com/blog/uranium-leaching-lixiviants/. Consulted October 23, 2025.
[11] CNSC Staff Submission, p. 187 of 631

> prevent migration of the mining solution into the surrounding groundwater. Mining solution will be confined within the freeze wall during operation."[12]

This paragraph provides only a limited understanding of the ISL process. Injection wells release sulphuric acid, creating a mineral-rich solution in a local zone. From this zone of high concentration, dissolved particles diffuse outward into areas of lower concentration. The movement of particles from areas of high to low concentration through the process of diffusion unavoidably increases the volume of groundwater affected by ISL mining.

An inward hydraulic gradient can limit outward diffusion of sulphate and other dissolved ions, but cannot fully contain them. If native groundwater has low ionic strength, diffusion will take place more quickly. Hydrogeological studies alone cannot account for this, which likely explains why Australia's Best Practices Guide calls for a full understanding of hydrogeochemical features of the site.[13] This appears to be lacking in the EA report.

The environmental effects of a particular ISL project depend upon groundwater chemistry, as well as hydrology. The IAEA notes that sulphuric acid "dissolves into solution more or less all elements present in the rock in concentrations exceeding the maximum admissible concentrations for public drinking water supply systems." It refers to the zone of contaminated groundwater as the '"halo":

> The sulphuric acid leaching process is observed to create different sized zones or areas of contamination for various species. This is especially true for species which have pH dependant solubilities. The pH nature varies from neutral or weakly alkaline values at the halo boundary up to 1-2 in its centre. The internal or smallest halo where the pH is less than 2.5 is distinguished by elevated concentrations of Fe, Al, and U…The sulphate ion is delivered in excess by sulphuric acid solutions. Sulphate ion (rarely NO_3^-) travels for the longest distances in the aqueous halo.[14]

The IAEA goes on to describe "two clearly discernible periods for the migration of contaminating components in the aquifer under ISL conditions:"

(1) The period of proper leaching, when the halo propagation is limited by hydrodynamic balance of the wellfield. In this case groundwater contamination takes place within a relatively small zone of hydraulic influence near leaching wells and does not move along the stratum (away from the wellfield).
(2) When the uranium recovery is finished and the artificial hydrologic cone of depression well is abandoned, the hydrologic control returns to the natural flow of groundwater. This could cause contamination to move away from the ISL site for fairly long distances.[15]

The IAEA says the contaminated pathway can range up to kilometres, adding that " a contamination halo progressing through unmineralized, unleached rock does not decrease in size (as was previously hoped) but actually spreads out, chiefly due to hydraulic dispersion and gravitation differentiation of the fluid."[16]

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[12] CNSC Staff Submission, p. 214 of 631
[13] "Australia's in situ recovery uranium mining best practice guide," p. 7
[14] IAEA, "Manual of Acid in Site Leach Uranium Mining Technology," p. 224
[15] *Ibid.* p. 228
[16] *Ibid.* p. 228

Literally hundreds of peer reviewed studies have modelled and/or monitored the movement of dissolved minerals in ISL mining projects, and resultant groundwater contamination.

Here is one example:

> Acid leaching has a significant influence on groundwater. The highest content elements in the groundwater of the acid-leaching mining area are usually SO_4^{2-}, ∑Fe, Ca^{2+}, Mg^{2+}, and U. Other heavy metals will also be leached into the groundwater. Although the concentration is relatively low, it still far exceeds the groundwater quality standard, posing a potential threat to the groundwater environment. The low pH of groundwater is another problem.
>
> For example, in an acid-leaching area of a mixed mine in Ili (Table 3), the pH of groundwater was 1.51–1.87, with an average of 1.73. The ∑Fe pollution was the most serious, exceeding the background value by more than 2400 times; the content of SO_4^{2-} ranged from 11,900 to 18,000 mg/L, with an average of 15,200 mg/L, which was 120 times more than the background value. The content of U (11231 μg/L) was approximately 114 times that before mining (98 μg/L). Other elements, such as Ca, Mn, Ni, Zn, Pb, As, and Cd, all exceeded the background value by dozens or even hundreds of times.[17]

Another example is the study by Wang et al. (2022), which found that "the uranium ore leaching area was much larger than the acidification area," and "the pollution plume of uranium and acid water was larger than that of the leaching area."[18]

The freeze wall

As noted above, Denison Mines proposes to use freeze wall technology as "an added layer of protection." Could a freeze wall contain the mining solution and avoid the spread of contaminated groundwater? How long would it need to be in place?

Section 4.2.1.2 of the EA report, *Containment methods for mining solution,* explains that the freeze wall would involve "circulating a low-temperature brine through cased drill holes to freeze the surrounding groundwater," and goes on to characterize the freeze wall as an "impermeable barrier."[19]

However, it is highly unlikely that the proposed freeze wall would represent a permanent impermeable barrier, for the reasons that follow.

With freeze wall technology, a refrigeration plant chills a brine solution, usually a calcium chloride solution, to a low temperature (e.g., between -25 and -35 C). The chilled brine is pumped through a network of pipes installed in boreholes. The brine in the pipes absorbs heat from the surrounding rock and groundwater, freezing the water and forming a wall that hardens the rock and acts as a barrier to groundwater movement. The warmed brine then returns to the refrigeration plant to be chilled again, completing the closed-loop cycle.

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[17] Zheng, F. et al., 2023, "Geo-environmental models of in-situ leaching sandstone-type uranium deposits in North China: A review and perspective," *Water*, *15*(6), p. 1244.
[18] Wang, B., et al., 2022, "Ion migration in in-situ leaching (ISL) of uranium: Field trial and reactive transport modelling," *Journal of Hydrology*, *615*, p. 128634.
[19] CNSC Staff Submission, p. 186 of 631

Existing uranium mines in Canada use artificial ground freezing for a variety of reasons. These include stabilizing weak rock formations during drilling operations, preventing the ingress of water into the mine, and limiting worker radon gas exposures. These measures can be suspended and resumed, within limits.

This would not be the case for the proposed use of a freeze wall in the Wheeler River Project. It would need to be in place continuously, with no failures.

Power consumption is a major consideration in the use of artificial ground freezing. During the summer months in northern Saskatchewan, lightning strikes frequently shut down the provincial power distribution network. As explained by Newman et al. (2011):

> All mines have backup diesel power generation capability, but the freeze plants are not intentionally operated on this back-up power during outages. The ground freezing is closely monitored via a network of temperature sensors that indicate the extents of the frozen ground and the temperature gradients across the freeze zones. Knowledge of the ground conditions at all times provides confidence to leave the freeze plants off during power outages which saves costs and greatly reduces the carbon footprint should diesel power be used to run the multi-megawatt freeze plant motors.[20]

In the case of the Wheeler River Project, the energy costs of continually pumping brine and running the refrigeration plant create an incentive to limit the number of boreholes and pipes in the freeze wall. This involves a trade-off: the freeze wall barrier should retain enough of the uranium-bearing solution to maintain an economically attractive recovery rate, while still allowing an "acceptable" rate of leakage.

Leakage through the freeze wall and contaminant spread would only be determined through monitoring activities that would occur after the start of acid ISL mining operations. Only monitoring the quality of groundwater outside the mining zone would determine whether the freeze wall represented a fully "impermeable" barrier.

Furthermore, the cost difference between inexpensive hydroelectric power and diesel back-up power would create a strong incentive to shut down the refrigeration plant and pumps during prolonged power outages.

In section 8.1 of the EA report, *Effects of accidents and malfunctions,* Table 8.1 says that the severity of consequence would be "major" for "loss of freeze capacity" or "failure of freeze wall." It says that "if this occurs, the mining fluids could migrate into the local groundwater environment and cause contamination of groundwater." The EA report rates both scenarios as" highly unlikely" and the overall risk as "moderate."[21]

The basis for this rating is questionable. In this situation, the severity and especially the irreversibility of potential consequences overcomes any probability greater than zero. The overall risk therefore should be considered as major. It is also worth recalling the catastrophic freeze wall failures at the nearby Cigar Lake and McArthur River uranium mines; although they are more or less conventional underground

[20] Newman, Greg et al., 2011, "Artificial ground freezing: an environmental best practice at Cameco's uranium mining operations in Northern Saskatchewan, Canada." *Rüde, Freund# Wolkersdorfer (Eds)*. p. 116. https://imwa.info/docs/imwa_2011/IMWA2011_Newman_253.pdf. Consulted October 23, 2025.

[21] CNSC Staff Submission, p. 238 of 631

mines, those disasters signal the difficulty of acquiring adequate hydrogeological knowledge to ensure that these systems operate safely, as intended.

No mitigation measures are identified to deal with a prolonged loss of power. The EA report calls the use of standby diesel generators a "worst-case scenario"[22] but provides no information regarding the worst-case circumstances that would require their use. It should be noted that prolonged power outages would affect not only the refrigeration plant and brine circulation pumps, but also the production well pumps that pump out the acid solution.

In Section 6.2.2.4, *Monitoring and Follow-up*, the EA report states that "During operation, the groundwater monitoring network will monitor conditions within and around the freeze wall, focusing on groundwater quality changes and potential excursions due to freezing capacity loss."[23]

A significant risk is that "excursions" would not be sporadic and rare incidents owing to freezing capacity loss, but would be ongoing, as a result of the economic imperative of minimizing energy costs. If so, COPCs and sulphuric acid would migrate considerable distances away from the mining zone during the operating phase of the Project.

But as explained by the IAEA, and confirmed by numerous studies, it is after the operating phase that contaminants can migrate from the ISL site for long distances. Avoiding this would require maintaining the freeze wall during groundwater remediation activities during the decommissioning phase, discussed in the next section.

A freeze wall has never been used to limit groundwater contamination from an ISL uranium mine. In general, the use of freeze wall technology to restrict water movement in or out of a contaminated zone has been limited, and has yielded mixed results.

Canada lacks operating experience with freeze wall technology. The federal government has allocated $4.4 billion (to date) to freeze 237,000 tonnes of arsenic trioxide dust at the former Giant Gold Mine in Yellowknife, NWT, but the actual freezing process has not begun, and critics have expressed concern about the amount of capital being allocated to a non-permanent solution.[24]

The best-known application of this technology, preventing groundwater from accumulating within the crippled Fukushima No. 1 nuclear power plant, has been plagued by technical flaws, ballooning costs, and unconfirmed effectiveness.[25]

A Canadian government website lists a number of "Limitations and Undesirable Effects of the Technology," several of which are relevant to the Wheeler River Project:

- Risk of the leak of refrigerant fluid in the environment is possible.
- Complex hydrogeological conditions and the presence of underground infrastructures could limit the integrity of the barrier.
- High energy consumption.

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[22] *Ibid*., p. 196 of 631
[23] *Ibid*., p. 223 of 631
[24] Tomesco, Frédéric, "Canada advances plan to freeze Giant mine's toxic waste," The Northern Miner, July 1, 2025. https://www.mining.com/canada-advances-plan-to-freeze-giant-mines-toxic-waste/. Consulted October 23, 2025.
[25] Fujinami, Yu, "Efficacy unclear of problem-hit ice-soil wall at Fukushima plant," The Asahi Shimbun, May 12, 2022. https://www.asahi.com/ajw/articles/14605126#. Consulted October 23, 2025.

- In cases where the contaminant plume is highly mobile, or the site is remote, additional measures must be implemented to ensure that an adequate and uninterrupted power supply is available.[26]

Denison's EIS and the CNSC's EA report would have been reasonably expected to include a discussion of these limitations.

Decommissioning and groundwater remediation

Australia's Best Practices Guide says:

> A rehabilitation security bond or other form of financial assurance should be lodged and reviewed regularly to reflect the full third party costs of clean up of the site at any stage this may become necessary. At mine completion, the site should be fit for agreed post-closure land uses and governments should not be left with any liabilities.[27]

Section 5.2 of CMD 25-H9-Vol.1, *Financial Guarantees*, refers to a guarantee "sufficient for the prepare site and construction activities;" section 5.4, *Nuclear Liability Insurance,* says there is "no requirement for nuclear liability insurance for uranium mines or mills."[28]

As noted earlier, it is not the construction phase, but the operating, decommissioning, and post-closure phases of the Wheeler River Project that have the greatest potential to cause significant adverse environmental effects. It is in the public interest that sufficient money be set aside prior to construction approval to address the clean-up costs associated with all these phases. This is also required by the *Uranium Mines and Mills Regulations.* Section 3 says that an application for a licence in respect of a uranium mine or mill shall contain… "the proposed plan for the decommissioning of the mine or mill."

Denison Mines Corporation has requested that the entire contents of its Preliminary Decommissioning Cost Estimate and Financial Guarantee be withheld from the public. The CNSC has accepted this request, stating that "Denison's proposed public summary presents an accurate summary of the document in question."[29]

However, this proposed public summary does not appear to be available. The Environmental Impact Statement Main Document for the Wheeler River Project does not describe the proposed decommissioning technology, stating only that "Groundwater will be remediated during Decommissioning to acceptable standards."[30]

The CNSC EA report provides limited additional information:

> The process of groundwater remediation involves injection and circulation of water (with or without addition of chemical reagents to accelerate groundwater quality recovery)

[26] Public Services and Procurement Canada, "Fact Sheet: Frozen Walls." https://gost.tpsgc-pwgsc.gc.ca/tfs.aspx?ID=2&lang=eng#infoMenu11. Consulted October 23, 2025.
[27] "Australia's in situ recovery uranium mining best practice guide," p. 6
[28] CNSC Staff Submission, pp. 91-92 of 631
[29] CNSC Staff's Review of Denison's Request for Confidentiality in Relation to CNSC Staff CMD 25-H9 Reference Documents. https://api.cnsc-ccsn.gc.ca/dms/digital-medias/CMD25-H9.pdf/object. Consulted October 23, 2025.
[30] Denison Mines, Wheeler River Project, Final Environmental Impact Statement, Geology and Groundwater, October 2024, p. 7-64

> through the mining area until it can be demonstrated that recovered groundwater has stabilized and meets groundwater quality decommissioning objectives.
>
> The freeze wall will remain until groundwater quality meets these targets, after which thawing will occur.
>
> Following remediation of the mining area and thawing of the freeze wall during decommissioning, dissolved COPCs from the mined-out zone may migrate downstream with natural groundwater flow and potentially discharge into nearby surface water bodies, such as Whitefish Lake.[31]

The "chemical reagents" that might accelerate recovery are not identified.

In terms of the "potential" discharge into Whitefish Lake, the EA report presents Figures 6.17 and 6.18 as evidence "that COPC concentrations and mass loadings from mining activities at Whitefish Lake are expected to show modest variations from background levels."

These modelled results should be considered as speculative. No empirical evidence is presented to support them.

As noted above, extensive groundwater contamination is well documented in the history of ISL mining. Remediation of acid ISL mining has proven challenging:

> ISL mines in the former Soviet Union generally used acid reagents and were operated without due consideration given to environmental protection. At many former mine sites, the extent of groundwater contamination is significant because of high salinity, heavy metal, and radionuclide concentrations compared with pre-mining and changes in the hydrogeological regime caused by mining… Programmes of restoration are now being undertaken but are proving technically difficult and hampered by a lack of adequate financial resources.[32]

ISL mining remediation in the U.S. has also proven challenging:

> To date, no remediation of an ISR operation in the United States has successfully returned the aquifer to baseline conditions. Often at the end of monitoring, contaminants continue to increase by reoxidation and resolubilization of species reduced during remediation; slow contaminant movement from low to high permeability zones; and slow desorption of contaminants adsorbed to various mineral phases.[33]

Early ISL mining in the US used alkaline solutions. This was, in part, because alkaline mine sites are considered to be easier to restore than acid sites, and in part because with acid leaching, "the problems and magnitude of groundwater contamination… coming to light in the 1990s, can only be described as

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[31] CNSC Staff Submission, p. 217 of 631

[32] Mudd, Gavin M., 2001. "Critical review of acid in situ leach uranium mining: 2. Soviet Block and Asia," *Environmental geology*, *41*(3), pp.404-416.

[33] Otton, J.K. and Hall, S., 2009. "In-situ recovery uranium mining in the United States: Overview of production and remediation issues," In: International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues, International Atomic Energy Agency, URAM-2009. https://www-pub.iaea.org/MTCD/Meetings/PDFplus/2009/cn175/cn175_BookOfAbstracts.pdf. Consulted October 23, 2025.

extreme."[34] Compared to alkaline leaching, acid leaching tends to mobilize more heavy metals, such as lead, cadmium, and arsenic.[35]

The Alternative Means section of the EA report says Denison Mines compared an alkaline solution composed of sodium bicarbonate and hydrogen peroxide to the chosen acid solution. The alkaline solution was rejected as "technically and economically unfeasible" based on core sample results.[36] However, the Final Environmental Impact Statement released by Denison Mines provides no information about these laboratory tests.

The first U.S. acid ISL trial to be described in detail was at Nine Mile Lake (NML) in Wyoming. This site was considered to be ideal for testing acid leaching because of favourable properties of the ore body. Core sample testing in the laboratory indicated that use of acid leaching was feasible, and would provide savings in chemical costs. But in the actual trial, the laboratory test results proved to be a poor indicator of field performance:

> The column leaching tests performed on NML core samples suggested significantly lower reagent consumption than that required in the field. The restoration of the laboratory columns indicated that about 13 pore volumes would be required to restore water quality, whereas in the field it was closer to 20 and still experienced deterioration after treatment efforts… because of greater reagent consumption and the difficulty and expense of restoration, acid leaching was no more cost effective than alkaline leaching.[37]

A CNSC staff review of Section 2.2.1.4 of the EIS for the Wheeler River Project, *Wellfield for In Situ Recovery Mining,* yielded Information Requirement IR-06 concerning Denison's "feasibility field test." While this test supposedly demonstrated the feasibility of remediation, it appears that the required information was never provided or included in the EIS, and Denison's response to the requirement was not accepted:

> Context: This Section of the EIS indicates that a tracer test was completed in 2021 and a feasibility field test was initiated in 2022. No information from these tests is included in the EIS and no reporting timelines are provided. Information
>
> Requirement: Please provide a summary of the results of field tests (i.e., tracer tests, wellfield leach tests, and remediation trials) in the EIS, or provide a technical supporting document with this information, and ensure the documentation is appropriately referenced in the EIS.
>
> Rationale: Guidance from the IAEA… and best practices highlighted by regulatory regimes in other countries such as the United States… and Australia… indicates that single and multi-well trial (feasibility) testing for mining and remediation techniques should be carried out before a licence for full-scale operations can be granted. This is part of the requirement for Proponents to demonstrate to government authorities that all

[34] Mudd, G.M., 2001. "Critical review of acid in situ leach uranium mining: 1. USA and Australia," *Environmental Geology*, *41*(3), pp.390-403. https://golomt.org/wp-content/uploads/2012/08/isl-mining-usa-and-australia.pdf. Consulted October 23, 2025.
[35] Zheng, F. et al., 2023. "Geo-environmental models of in-situ leaching"
[36] CNSC Staff Submission, p. 187 of 631
[37] Mudd, G., 2001 "Critical review of acid in situ leach uranium mining: 1. USA and Australia"

potential risks have been considered during the life of operation and post-remediation of the mine.[38]

In summary, poor results of past attempts to remediate acid ISL mines, lack of information on results of Denison's laboratory tests and field tests, and the lack of a publicly available decommissioning plan, make it difficult to reach a conclusion that the Wheeler River Project is not likely to cause significant adverse environmental effects.

Regional hydrology and landforms

Figure 1. Surface water bodies near the Wheeler River Project site

The Wheeler River Project represents a first-ever attempt to use acid ISL technology in a portion of the Canadian Shield with complex hydrology and extensive surface water bodies. Figure 1 shows that lakes occupy a high proportion of the landscape around the proposed mine site.

Contaminated groundwater would primarily enter Whitefish Lake, flow into McGowan Lake, and into Russell Lake, a widening of the Wheeler River. The Wheeler River, in turn, enters the Geikie River. It flows into Wollaston Lake. Wollaston Lake is a bifurcated lake that drains in two directions: west to Lake Athabasca and the Mackenzie Basin via the Fond du Lac River; and east to Reindeer Lake and the Churchill Basin via the Cochrane River.

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[38] Information Requirement (IR) Response Table – Denison's Response to December 2023 FIRT Comments, February 2024. https://ceaa-acee.gc.ca/050/documents/p80178/155680E.pdf. Consulted October 23, 2025.

The EA report says that Indigenous Nations and communities are concerned about contamination of water both below and above ground. It explicitly notes "worry about the future water quality for Whitefish Lake, Russell Lake, Wheeler River, Geikie River, and Wollaston Lake."[39]

The English River First Nation expanded on these concerns, stating that "Given the toxic nature of these mining fluids and the complex flow pathways of ground and surface water in the vicinity, any escape would significantly impact the regional ecosystem and downstream water bodies."[40]

First Nations' concerns about significant adverse environmental impacts on surface water bodies are justified. Power outages could compromise maintenance of the freeze wall during operational and decommissioning phases of the Project. Past experience with acid ISL mining suggests poor prospects for groundwater remediation. Faults in the Athabasca Basin sandstone provide preferential pathways for groundwater migration to surface water bodies. Hydrologic studies show upward groundwater migration to Whitefish Lake.

It should be noted that First Nations and Métis knowledge of these water systems, including groundwater communication, is profound, having been gathered and validated over many generations, far beyond the limited scope of the industry's baseline data and analysis in the region.

Alternative means

Section 19(1) of CEAA 2012 requires that an EA "take into account… alternative means of carrying out the designated project that are technically and economically feasible **and the environmental effects of any such alternative means**" [emphasis added].

The Impact Assessment Agency of Canada provides guidance on *Addressing "Purpose of" and "Alternative Means" under the Canadian Environmental Assessment Act, 2012.* It says "The information regarding the purpose of the designated project should be sufficient to provide context for public and technical comment periods during the project EA, and ultimately to allow the decision maker to understand the purpose of the designated project."[41]

Because the EA report limits the scope of the Wheeler River Project to "an ISR uranium mine," it does not take into account the environmental effects of the alternative means considered by Denison Mines. Section 4.1, *Indigenous consultation and engagement*, says "As part of the initial project planning (outside of the CEAA 2012 process), Denison undertook an analysis of alternatives to the project as a first step to determine the appropriate facility type (open pit vs. in-situ recovery) required for this project."[42]

Section 4.2.1 of the EA report presents Denison's assessment of alternative means to carry out the Project, but omits Denison's consideration of an open pit mine. It merely states that Denison "selected the ISR mining method based on technical, socio-economic, and environmental considerations.[43]

A description of these technical, socio-economic, and environmental considerations, and of Denison's analysis of alternatives to the Project, should have been included in the EA report. This would have

[39] CNSC Staff Submission, p. 228 of 631
[40] *Ibid.*, p. 250 of 631
[41] https://www.canada.ca/en/impact-assessment-agency/services/policy-guidance/addressing-purpose-alternative-means-under-canadian-environmental-assessment-act-2012.html. Consulted October 23, 2025.
[42] *Ibid.*, p. 185 of 631
[43] *Ibid.*, p. 186 of 631

provided context for the public during the EA, and would have helped inform the Commission's decision as to whether the Wheeler River Project is likely to cause significant adverse environmental effects.

ISL/ISR mining for uranium is a novel method in a Canadian context. All current uranium mining in Canada is by conventional mining, whether open pit or below ground. The CNSC's EA report should have addressed the question, "Why ISL rather than conventional mining in this context?" It should have taken into account the environmental effects of each.

The Alternative Means assessment should also have compared the environmental effects of acid ISL to the Surface Access Borehole Resource Extraction (SABRE) mining method. A Denison press release describes SABRE as

> a non-entry, surface-based mining technique that uses a high-pressure water jet at the bottom of a drill hole to excavate an ore cavity. The cuttings from the excavation process are then air lifted to surface, separated, and stockpiled. SABRE is unique in that the mining method can be selective and scalable, which has the potential to provide superior flexibility when compared to conventional mining methods and is thus ideally suited to ever changing uranium market conditions.[44]

The SABRE method might have potential to cause fewer adverse environmental impacts on groundwater than the acid ISL method.

Other environmental considerations

While it might be expected that ISL would reduce radon exposure for workers compared to conventional mining, this does not take into account the drill holes that would be bored in the rock to inject the acid solution and the freezing solution. These drill holes would be pathways for radon migration to the surface. As well, the drill hole wastes would have significant quantities of naturally occurring radioactive materials and would need to be managed to limit radiation exposures.

To use the terminology found in the CNSC Staff Submission, drill holes and drilling wastes would release "Long-Lived Radioactive Dust" (LLRD), radon gas (RnG), and radon progeny (RnP) for millennia after cessation of mining.[45] This would affect Denison employees at the mine, and future generations living and working in the area.

Note that the draft "Licence Conditions Handbook" for the Project would authorize "disposal of contaminated drilling wastes, including off-site,"[46] but the EA report provides no details on this matter, and does not recommend mitigation measures that would limit long-term exposures to ionizing radiation. This deficiency should be addressed.

Uranium ores can contain the sulphide mineral pyrite, which can oxidize into sulphuric acid. Acidic drainage can be a major environmental problem with uranium tailings.[47] If pyrite is present in the ore

[44] "Orano Canada and Denison Announce SABRE 1st Production at McClean Lake," July 17, 2025. https://denisonmines.com/news/orano-canada-and-denison-announce-sabre-1st-produc-122825/. Consulted October 23, 2025.
[45] CNSC Staff Submission, p. 39 of 631
[46] *Ibid.*, p. 572 of 631
[47] Kneen, Jamie, 2005, "Elliot Lake uranium mines," Mining Watch Canada, https://miningwatch.ca/blog/2005/9/13/elliot-lake-uranium-mines. Consulted October 23, 2025.

body at the Wheeler River site, this would compound the groundwater and surface water acidification caused by use of the sulphuric acid lixiviant.

Pyrite is abundant at the nearby McArthur River Uranium Mine.[48] Acidification from oxidative weathering of pyrite is not discussed in the EA report. Information is needed on pyrite in the Wheeler River ore body, its potential contribution to acidification following the cessation of mining operations, and ways to mitigate potential adverse environmental effects.

An on-site mill or "processing plant" is part of the Wheeler River Project. The processing plant would extract uranium from the solution brought to the surface, and convert it into triuranium oxide (U_3O_8) uranium concentrate, also known as yellowcake.[49]

Section 6.1.2.3, *Mitigation Measures for air quality and acoustic (noise),* contains limited information, and some misinformation, about management of processing plant waste.

For example, it states that air emissions from the mill "will be reduced" by

- directing processing plant exhaust from drying and packaging areas through a stack prior to release outside of the building; and
- designing the stack height based on results of air dispersion modelling to be an appropriate height for optimal dispersion.[50]

Dispersion of radioactive particulates from milling operations into the atmospheric environment does not "reduce" air emissions. Emissions reduction requires installation of stack filters. These should be required as a mitigation measure.

Conclusion

The information and analysis provided in the Environmental Impact Statement and the CNSC Staff Submission recommending licencing of Denison Mines' proposed Wheeler River Project, and specifically the use of *in situ* leaching in conjunction with "freeze wall" technology to limit contaminant spread, do not present an adequate understanding of the hydrological/hydrogeological/ hydrogeochemical features of the project area and do not adequately address the potential for groundwater and surface water contamination, especially in the post-operation phase. The potential scope and irreversibility of such contamination render even low probabilities of failure severe enough in outcome to make them an unacceptable risk for downstream communities and ecosystems. Poor results of past attempts to remediate acid ISL mines, lack of information on results of Denison's laboratory tests and field tests, and the lack of a publicly available decommissioning plan, make it difficult to reach a conclusion that the Wheeler River Project is not likely to cause significant adverse environmental effects.

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[48] Emberley, Justin et al., 2014, "Petrography and chemistry of pyrite from the McArthur River uranium deposit, Saskatchewan." Natural Resources Canada, https://publications.gc.ca/collections/collection_2015/rncan-nrcan/M183-2-7626-eng.pdf. Consulted October 23, 2025.

[49] CNSC Staff Submission, p. 12 of 631

[50] *Ibid.*, pp. 198-199 of 631