A NEXT STEP

Part of Canada's Radioactive Waste Review

Draft Integrated Strategy for Radioactive Waste (ISRW)

-DRAFT FOR PUBLIC COMMENT-

DATE:

August 25, 2022 (REV 1)

Comments and Ideas Submission Process

Interested individuals and groups are invited to submit their comments and ideas about the recommendations captured in this document: Draft Integrated Strategy for Radioactive Waste (ISRW).

The process of submission is open to all Canadians and Indigenous peoples, and can be made as an individual or on behalf of an organization.

Submissions are accepted through the ISRW website (https://radwasteplanning.ca) as well as by email (info@radwasteplanning.ca) between August 25, 2022 and ~~October~~ November 24, 2022 (~~60~~ 90 day period).

Please note that information provided by external sources will be published in accordance with our Community guidelines and privacy policy.

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Executive Summary

In the fall of 2020, the Minister of Natural Resources Canada tasked the Nuclear Waste Management Organization (NWMO) with leading an engagement process with Canadians and Indigenous peoples to inform the development of an integrated long-term management strategy for all of Canada's radioactive waste, in particular low- and intermediate-level waste, as part of the government's radioactive waste management policy review. The NWMO was asked to lead this work because it has 20 years of recognized expertise in the engagement of Canadians and Indigenous peoples on plans for the safe long-term management of used nuclear fuel.

The intent of the Integrated Strategy for Radioactive Waste (ISRW) was to identify next steps to address gaps in Canada's current radioactive waste management strategy and to look further into the future (radwasteplanning.ca). The Integrated Strategy should build on the plan developed by NWMO for the long-term management of Canada's nuclear fuel waste. It should include:

- Taking stock and describing the current waste management situation in Canada in terms of current and future volumes, characteristics, locations, and ownership of the waste;
- Updating on current plans and progress in advancing long-term management and disposal solutions for Canada's wastes as well as identifying the gaps that must be addressed;
- Providing conceptual approaches for dealing with those wastes for which no long-term plan exists, including technical options for long-term management or disposal, and options for the number of long-term waste management facilities in Canada; and
- Making recommendations about the staging, integration, establishment, and operation of long-term waste management facilities.

This report presents this draft Strategy and solicits feedback on the recommendations that it contains. The comment period for this report will conclude on October 24, 2022, 60 days from the date of publication. Comments received will then be reviewed and considered to inform the final ISRW recommendations. The final report will only be submitted to the Minister of Natural Resources Canada following the publication of the revised *Policy for Radioactive Waste Management and Decommissioning*, which at the time of writing is expected in the last quarter of 2022, to ensure the final recommendations align with and support the policy.

Technical options and inventories

In 2020, the NWMO began its work by undertaking an international benchmarking study of the best practices used for radioactive waste management of low and intermediate-level radioactive waste. Based on this work, six (6) potential options for the long-term management of Canada's low- and intermediate-level waste were identified by the NWMO:

- Engineered Containment Mound
- Concrete Vault
- Shallow Rock Cavern
- Deep Geological Repository
- Deep Borehole
- Rolling Stewardship

Following the benchmarking study, the NWMO commissioned a preliminary technical assessment of the six potential options. A summary level of detail was gathered about the current and projected future inventories from the current Canadian waste owners to identify existing and future Canadian low- and intermediate-level waste that have no current long-term management plans totalling approximately 294,000 m^3 of low-level waste (LLW), 51,000 m^3 of intermediate-level waste (ILW) and less than 10 m^3 of high-level waste (HLW). The options were assessed from a technical perspective against the characteristics of the current and projected inventories of low- and intermediate-level waste.

Volume of radioactive waste with no long-term management plan

LLW: 294,000 m^3

ILW: 51,000 m^3

HLW: less than 10 m^3

The Engineered Containment Mound was determined to be the most suitable option for bulk low-level waste such as soils and demolished concrete, given the low concentrations of radionuclides and the large volume of waste. It could also potentially accommodate other low-level waste with further assessment. The Concrete Vault and Shallow Rock Cavern were considered the most suitable options for non-bulk low-level waste, given the increased containment and structural integrity offered (concrete barrier or rock mass) compared to the Engineered Containment Mound. These long-term management options may also be suitable for bulk low-level waste.

The Deep Geological Repository emerged as the most suitable option for all intermediate-level waste. Additionally, the co-disposal of non-bulk low-level waste was considered as an alternative. Deep Boreholes are considered an alternative long-term management option for small dimensional intermediate-level waste such as disused sealed sources and spent ion exchange resins.

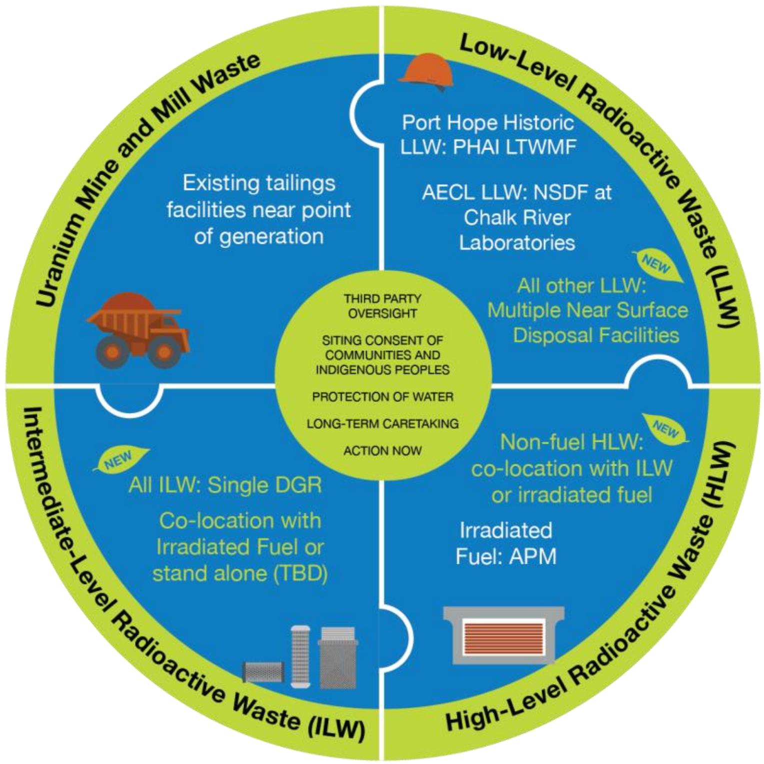
The Draft Integrated Strategy

With extensive input from waste producers and owners, government, Indigenous peoples, and interested Canadians, the NWMO focused on identifying gaps in current plans for the long-term management for radioactive waste and providing technical options to address these gaps. The resulting recommendations consider options for the number of long-term waste management facilities in Canada, as well as for the staging, integration, siting, establishment and operation of these facilities for all of the radioactive waste in Canada, regardless of how it was generated. This draft strategy represents a next step and is a result of what we have heard from Canadians and Indigenous people. It is not intended to replace other projects currently in progress but rather includes these plans.

Table 1: Draft Integrated Strategy for Radioactive Waste

Waste Type		Long-Term Plan	Responsibility for Implementation	Status
Uranium Mine and Mill Waste		Tailings Facilities near point of generation	Uranium Mining Companies	Existing Facilities
Low Level Waste (LLW)	Port Hope Historic low-level radioactive waste	Port Hope Area Initiative Long-Term Waste Management Facility (PHAI LTWMF)	Canadian Nuclear Laboratories (CNL)	Existing Facilities
	Low-level waste owned by Atomic Energy of Canada Limited (AECL)	Near Surface Disposal Facility (NSDF) at Chalk River Laboratories	Atomic Energy of Canada Limited	Ongoing project (under regulatory review)
	All other low-level waste –	Multiple near surface disposal facilities	Waste owners	New project recommended as part of ISRW
Intermediate Level Waste (ILW)		Single Deep Geological Repository (DGR) – colocation with irradiated fuel or stand alone to be determined	Nuclear Waste Management Organization (NWMO)	New project recommended as part of ISRW
High-Level Waste (HLW)	Irradiated Fuel	Adaptive Phased Management (APM) Deep Geological Repository (DGR)	Nuclear Waste Management Organization	Ongoing project (in site selection)

The Draft Strategy



The process that was followed, the work that was completed and the input received in developing this draft are outlined in this report.

Proposed Recommendations for the Implementation of the Strategy

The following recommendations consider the inputs obtained from international benchmarking, stock taking, technical and cost estimate assessments, and public and Indigenous engagement. These recommendations address the existing gaps in Canada's long-term management of radioactive waste. These recommendations when taken along with the existing ce projects in operation or undergoing regulatory assessments at the time of writing form a complete strategy to address all existing and future waste in Canada.

Recommendation 1: Low-level waste should be disposed of in multiple near-surface facilities with implementation resting with the waste owners

Disposal of low-level waste aligns with international best practices and was preferred by the majority of participants.

From a technical, financial and societal perspective, near-surface disposal is the best option to contain the waste until it no longer poses a hazard.

The Concrete Vault options is the recommended technical approaches to address all the low-level waste. The Engineered Containment Mound was the option most often preferred from a societal and financial perspective, but it is only suitable for 6% of the inventory based on preliminary technical assessments.

From a societal point of view, multiple facilities located in willing host communities were preferred given the large volumes of waste and transportation considerations. Centralization does garner significant support as well and, financially, economies of scale may favour centralization. Further detailed analysis, including the cost of transportation, is needed. The concept of regional facilities should be further explored.

DID YOU KNOW:

Low level radioactive waste (LLW) comes from operating reactors and from medical, academic, industrial, and other commercial uses of radioactive materials.

LLW contains material with radionuclide content above established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations), but generally has limited amounts of long-lived activity.

LLW requires isolation and containment for periods of up to a few hundred years. An engineered near surface disposal facility is typically appropriate for LLW.

Recommendation 2: Intermediate-level waste should be disposed of in a single deep geological repository with implementation by a single organization, the NWMO

Disposal of intermediate-level waste aligns with international best practices and was preferred by the majority of participants.

From a technical and societal point of view, disposal in a deep geological repository is the best option to isolate the waste from the environment. This approach would also be able to accommodate non-fuel high-level waste.

We heard from participants that having one central place in the country for intermediate level waste would be preferable to several regional facilities. From a societal perspective, co-location with irradiated fuel has the same level of support as a separate deep geological repository for intermediate-level waste. From a financial perspective, co-location is the most economical option.

We heard from participants support for the NWMO to be the organization to implement the solution for intermediate-level waste.

Recommendation 3: A third-party, independent of the implementing organizations, should oversee the implementation of the strategy

In the development of the ISRW, there was also considerable support expressed for independent oversight of the implementation of the strategy for radioactive waste, as well as for the greater ongoing involvement of interested parties throughout the lifecycle of the facilities. Waste owners would retain responsibility for funding, planning, development and operation of their radioactive waste disposal sites.

Natural Resources Canada should consider an appropriate oversight model that is independent of the implementing organizations. This oversight should consider how to incorporate the input or involvement of interested parties such as Indigenous peoples and civil society.

Recommendation 4: Consent of the local communities and Indigenous peoples in whose territory future facilities will be planned must be obtained in siting

This consideration was prioritized by the majority of contributors. It is also aligned with the objectives of Canada's draft Radioactive Waste Policy, in relation to the implementation of United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Recommendation 5: Design of facilities should prioritize the protection of water

While safety can be demonstrated from a technical standpoint regardless of location, it may be difficult to obtain societal support for facilities located in close proximity to major sources of drinking water. This was a priority for most participants who felt strongly that waste disposal sites should not be built near sources of drinking water as they felt these could contaminate it and affect their way of life.

While participants indicated that facilities should be located away from any major water sources, the reality of the Canadian landscape is that this would not be feasible. Protection of water is paramount, and therefore any disposal facilities must meet the highest standards of environmental and water protection

Recommendation 6: Long-term caretaking should be established for disposal facilities

There should be oversight of the waste and of the facilities for as long as future generations deem it to be necessary to ensure that the environment remains protected. This concept also includes the transfer of knowledge of the waste and where it is located with future generations and periodic review of the monitoring plans, to determine whether they continue to be adequate or necessary.

Recommendation 7: We need to take action now and not defer to future generations

There is a need for an integrated strategy, and the approach to the long-term management of low-level and intermediate-level waste should be determined with a sense of urgency rather than leaving this to future generations. This will require on-going commitment and support from government, with a structure that will be empowered to deliver on the implementation of the strategy regardless of changes in power.

Additional Recommendations Outside of the Scope of the ISRW

The ISRW did not consider options for additional waste processing, including volume reduction, beyond those planned and quantified by the waste owner. Subject to future study, the Integrated Strategy for Radioactive Waste may benefit from a holistic approach to waste processing upstream from disposal. Furthermore, an integrated approach may open avenues of waste processing resulting from economies of scale for waste processing options that have not yet been accessible for smaller waste owners.

Engagement

In 2021, the NWMO began engaging with Canadians and Indigenous peoples, conducting public opinion research, hosting a Summit to hear from diverse voices, listening to citizens in a series of engagement sessions in communities where waste is stored today, hosting Roundtable discussions, and Technical Workshops. In total, the NWMO engaged in over 70 activities offered in a variety of formats over a period of 18 months from January 2021 to June 2022, with a total of nearly 4000 participants. The following summarizes the key themes that emerged during this engagement.

Figure 1: ISRW Engagement Activities

Key Theme 1 – Safety is Paramount

The most prominent theme that emerged throughout the engagement was the importance of safety in every aspect of the development and implementation of the Integrated Strategy for Radioactive Waste. Participants prioritized safety over cost efficiency. As a key priority, safety should be considered through a long-term lens so that the strategy is able to respond to future risks and ensure safety in unpredictable and potentially unstable future conditions in the environment, government, and technology.

Key Theme 2 – The Time to Act is Now

There is a need for an integrated strategy, and the approach to the long-term management of low-level and intermediate-level waste should be determined. There was general agreement that it was the right thing to do to have and to implement a plan for all of Canada's radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations.

Key Theme 3 – Communication and Transparency

Participants were adamant that clear, fact-based, inclusive communication that provides context in a relevant, accessible and an unbiased way is essential. Transparency, including clear, open and ongoing communication about decisions and processes, is very important. Transparency about the waste and any potential risks associated with it is also needed, as is effective communication providing context when necessary. Some participants expressed the importance of having more visibility of waste inventories, as they exist today, and what could be expected in the future.

Key Theme 4 – Trust and Relationships with Indigenous Communities

Meaningful engagement and ongoing relationship building with Indigenous communities must be central to developing and implementing the plan. Listening to Indigenous peoples is important to restore trust, bridge relationships and affirm the importance of reconciliation. Ensuring that Indigenous Knowledge was incorporated along with western science was also identified as important to a strategy that would address the far future, as well as more immediate considerations. Participants wanted the strategy to reflect Indigenous communities' right to Free Prior and Informed Consent and to avoid exploitative practices with respect to Indigenous involvement.

Key Theme 5 – Education and Engagement

Full engagement is required to achieve real buy-in for a strategy that will work for people in Canada and the importance of youth engagement was emphasized. Education is vital to enable potentially impacted people and communities to be appropriately informed and needs to be further integrated into discussions to help Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste, and how safety is assured. Learning from science-based best practices internationally was also identified as an important pathway to ensuring both public safety and cost effectiveness, which are both important, now and in the long-term. Youth saw a need for an intergenerational education strategy to cultivate a sense of responsibility for the long-term strategy implementation among young people.

Key Theme 6 – Sustainability and the Environment

In addition to the safety of the community and its residents, minimizing the carbon footprint and protecting the environment, in particular water, over the long-term were important. Participants shared that we needed to be mindful of the climate emergency to ensure that every aspect of this strategy is sustainable, considers the risks posed by climate change, respects the environment, and protects water sources for all future generations. The goal of minimizing environmental impacts should be viewed through a lifecycle approach and include the construction of facilities and transportation of radioactive waste. Youth participants were acutely aware of the history of environmental racism especially towards Indigenous communities. They saw environmental justice as a key consideration when discussing how many facilities to build and where.

Key Theme 7 – Transportation

Transportation is a particularly important aspect of the long-term plan. People had many questions about the risks associated with transportation, and the consequences of transportation accidents on the safety of the radioactive waste being transported and generally preferred to minimize the transportation of radioactive waste, to reduce any associated risks. Other concerns around transportation included cost, potential increase of greenhouse gas emissions and potential environmental impacts from building new access roads. Participant views on the relative risks of transportation influenced their views on having one central repository for low-level waste and for intermediate-level waste or having multiple disposal facilities closer to where the waste is produced.

Key Theme 8 – Shared Responsibility Framework / Independence of Accountable Entity

There were varying perspectives regarding who should be responsible for the oversight of the strategy. There were differences of opinion about the role of industry, but there was general agreement that there should be a single entity with appropriate expertise that is independent from the implementers, subject to regulated safety and environmental oversight. The governance of such an entity was subject to different ideas, with some suggesting that the oversight governance should be comprised of industry, civil society organizations, and Indigenous peoples, and others focusing on ensuring the oversight remained independent and included the right expertise. There was broad support for the waste owners to pay for financing the strategy.

Key Theme 9 – Rolling Stewardship and Waste Disposal

A majority supported the idea of finding solutions to permanently dispose of the waste now, and not leaving the decision for future generations. Uncertainty about climate change, and whether changes to government or society in the long term could leave waste vulnerable under indefinite storage arrangements were some of the concerns that were cited. Participants wanted to see intermediate-level waste treated the same as high-level waste and disposed of in a deep geological repository. However, there were others that saw rolling stewardship as the preferred strategy, in particular for low-level waste, because of considerations such as potential future technology innovations, ensuring that the waste was not forgotten, and the ability to constantly monitor the waste to ensure that any environmental impacts could be identified and remediated before causing significant harm, especially to the water table.

Key Theme 10 – Co-location and Centralization

There was a range of responses from participants who felt minimizing the number of facilities could have advantages. Participants acknowledged the difficulty in finding willing and informed host communities, and obtaining the free, prior, and informed consent of Indigenous peoples made multiple sites more challenging. However, there were concerns about the impact of a single location on the transportation of waste. Some participants cautioned about the importance of ensuring appropriate technical arrangements for different waste types located in the same facility, while others noted the cost advantages of consolidating expertise and facilities in a single location.

The majority preferred using a centralized facility for intermediate level waste to enable greater control and oversight over the long lifespan of this waste, with potential cost and time savings. Centralizing intermediate-level waste was seen as preferable to limit potential risk exposure to one location instead of potentially endangering multiple ecological zones. The idea of co-location and centralization was more broadly supported for intermediate-level and high-level waste, than it was for low-level waste and intermediate-level waste. The volumes of low-level waste are greater, and participants generally felt that leaving it nearer to the sites where it was generated or stored, rather than transporting it vast distances, was preferable. Regardless of the option preferred, community willingness was identified as a pillar for any disposal facility.

Key Theme 11 – A Strategy by and for Canadians and Indigenous peoples

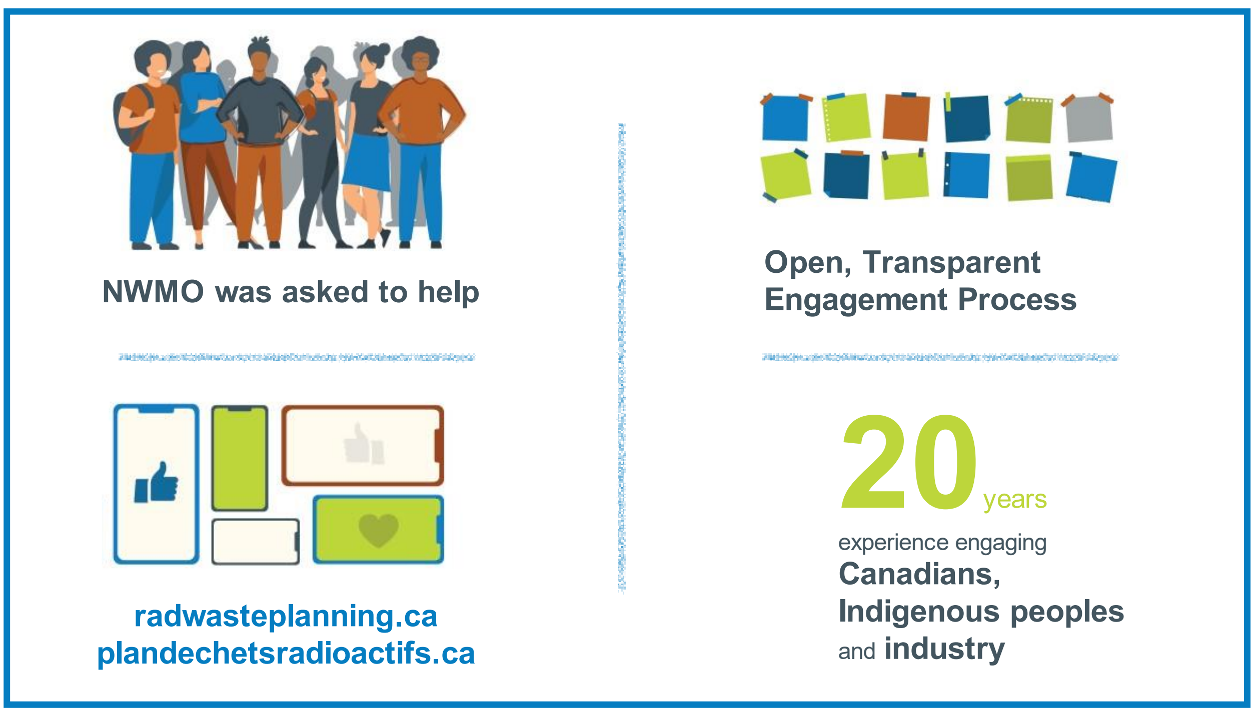
Overall, across sessions, it was clear participants want this to be a strategy created by and for Canadians and Indigenous peoples and that this is key to have buy-in. An inclusive strategy is a reflective strategy. In addition, the ISRW should consider the unique conditions and environment of Canada including the size of the country, the diversity of Canadians and the changing climate.

Chapter 1: The Strategic Plan

Introduction

Context: The [NWMO]() was asked by the federal government to engage Canadians and Indigenous peoples to develop an Integrated Strategy for Canada's Radioactive Waste (ISRW), recognizing that the decisions made today will impact future generations

In November 2020, the Nuclear Waste Management Organization (NWMO) was asked by the Minister of Natural Resources Canada (NRCan) to engage with Canadians and Indigenous peoples to help develop an Integrated Strategy for Radioactive Waste (ISRW) as part of the government's radioactive waste management policy review. The NWMO was asked to lead this work because it has 20 years of recognized expertise in the engagement of Canadians and Indigenous peoples on plans for the safe, long-term management of used nuclear fuel.

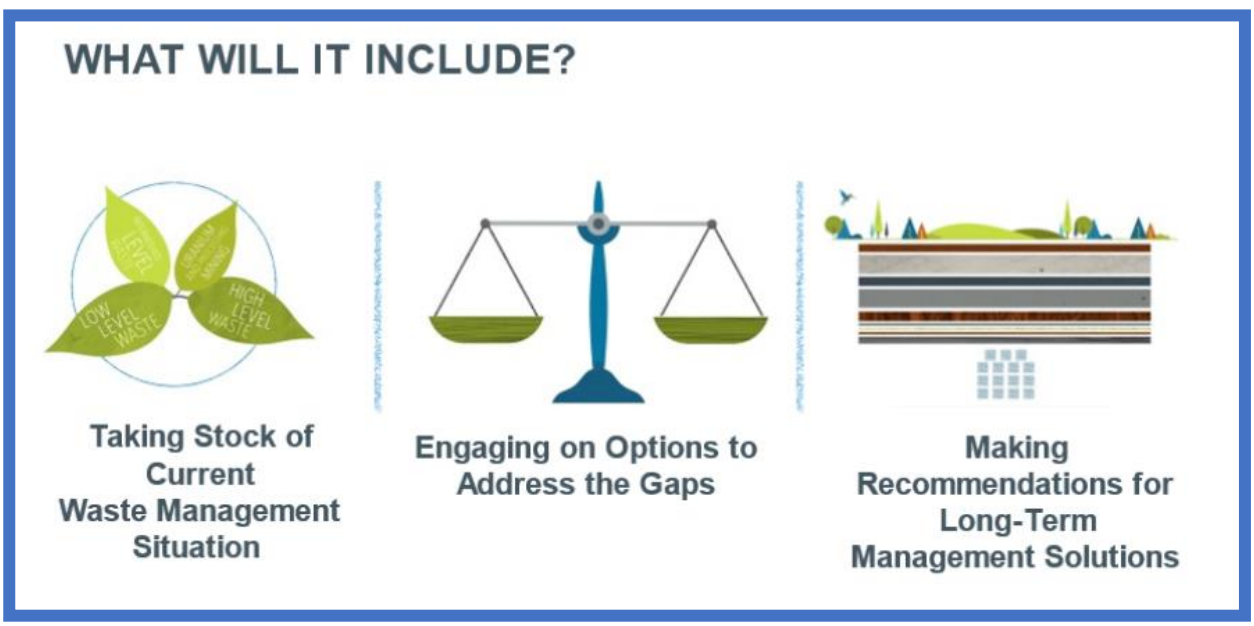


This strategy represents a next step – to identify and address gaps, and to look further into the future. Gaps exist in the long-term plans for low-level and intermediate-level waste, and Canada lacks an integrated strategy. Although all of Canada's radioactive waste is safely managed today, not all of Canada's radioactive waste has a long-term plan that will ensure the safety of people and the environment well into the future. An integrated strategy must be developed in a way that reflects citizen input, international scientific consensus and best practices from around the world to ensure that people and the environment are protected long into the future.

In collaboration with waste producers and owners, government, Indigenous peoples, civil society organizations, and interested Canadians, the NWMO has focused on:

Taking stock and describing the current waste management situation in Canada in terms of current and future volumes, characteristics, locations, and ownership of the waste;

- Updating on current plans and progress in advancing long-term management and disposal solutions for Canada's wastes as well as identifying the gaps that must be addressed;
- Providing conceptual approaches for dealing with those wastes for which no long-term plan exists, including technical options for long-term management or disposal, and options for the number of long-term waste management facilities in Canada; and
- Making recommendations about the staging, integration, establishment, and operation of long-term waste management facilities.



The NWMO is deeply committed to a transparent, inclusive engagement process and wants to emphasize that there were no pre-determined outcomes. The NWMO committed to reporting on the engagement process throughout and created a project hub to make information available to participants whenever they join the process – radwasteplanning.ca.

Context

'Radioactive waste' is any material (liquid, gaseous, or solid) that contains a radioactive nuclear substance for which no further use is foreseen. It comes mostly from nuclear power generators and other kinds of nuclear fission or technology, like research and medicine. Because it is hazardous to most forms of life and the environment, it requires careful management and is highly regulated by government agencies.

In Canada, radioactive waste is created from uranium mining and processing, nuclear medicine, nuclear fuel fabrication, nuclear reactor operations, research and development activities, radioisotope manufacture and use, and decommissioning activities.

Waste Classification

The CSA Group, industry, government, and the Canadian Nuclear Safety Commission categorize radioactive waste into four classes: low-level radioactive waste, intermediate-level radioactive waste, high-level radioactive waste, and uranium mines and mill waste. Each class of waste has its own type of storage and disposal methods.

Waste containing amounts of radioactive material too small to pose a hazard is not considered to be radioactive waste. As such, waste with radionuclide content below established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations) may be disposed of using conventional means, such as sending the waste to a local landfill.

Low-level radioactive waste comes from operating reactors and from medical, academic, industrial, and other commercial uses of radioactive materials. Low-level waste contains material with radionuclide content above established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations), but generally has limited amounts of long-lived activity. Low-level waste requires isolation and containment for periods of up to a few hundred years. An engineered near surface disposal facility is typically appropriate for low-level waste.

Intermediate-level radioactive waste is generated primarily from power plants, prototype and research reactors, test facilities, and radioisotope manufacturers and users, including some medical applications. intermediate-level waste generally contains long-lived radionuclides in concentrations that require isolation and containment for periods greater than several hundred years. Intermediate-level waste needs no provision, or only limited provision, for heat dissipation during its storage and disposal. Due to its long-lived radionuclides, intermediate-level waste generally requires a higher level of containment and isolation than can be provided in near surface repositories. Waste in this class may require disposal at greater intermediate depths of the order of tens of metres to a few hundred metres or more.

High-level radioactive waste is primarily used nuclear fuel and/or is waste that generates significant heat via radioactive decay. High-level waste is associated with penetrating radiation, thus shielding is required. High-level waste also contains significant quantities of long-lived radionuclides necessitating long-term isolation. Placement in deep, stable geological formations at depths of several hundred metres or more below the surface is the recommended for the long-term management of high-level waste.

Uranium mine and mill tailings are a specific type of radioactive waste generated during the mining and milling of uranium ore and the production of uranium concentrate. In addition to tailings, mining activities typically result in the production of large quantities of waste rock as workings are excavated to access the ore body. The wastes contain long-lived radioactivity that does not decrease significantly over extended time periods. In general, long-term management in near-surface facilities adjacent to mines and mills is the only practical option for these wastes, given the large volumes of waste generated in mining and milling operations.

Refer to Appendix A for the status of current plans and progress in advancing long-term management and disposal solutions for Canada's wastes.

Table 2: Radioactive Waste Classification in Canada

Uranium Mine & Mill Waste	Low Level Waste	Intermediate Level Waste	High Level Waste
Tailings and waste rock generated by the mining and milling of uranium ore	Mop heads, rags and paper towels Medical Isotopes	Filters, resins and used reactor components Medical / Industrial Sources	Primarily used nuclear fuel
No Heat Generated	No Heat Generated	No or Little Heat Generated	Significant Heat Generated
Long-lived radioactivity does not decrease significantly over extended time periods	Isolation and containment up to a few hundred years (less than 300 years)	Isolation and containment for periods greater than several hundred years	Isolation and containment Hundreds of thousands of years
Near Surface Repository	Near Surface Repository	Deep Geological Repository (DGR)	Deep Geological Repository (DGR)
Only practical option for these wastes, given the large volumes of waste generated	More radioactive than clearance levels & exemption quantities	Generally requires a higher level of containment and isolation than can be provided in near surface repositories	Significant quantities of long-lived radionuclides necessitating long-term isolation

Process for the development of the ISRW draft strategy and recommendations

In order to develop the strategy, the NWMO undertook a number of activities and assessments, including international benchmarking, technical assessments and engagement with the public, Indigenous peoples and various other stakeholders.

In 2020, the NWMO first began by commissioning an international benchmarking report on the long-term management of low- and intermediate-level waste. This report provided an overview of the technical options being implemented or pursued, from a survey of over 22 countries.

This was followed by a compilation of inventory data and the commissioning in 2021 of an assessment of the potential options from a technical point of view. Later in 2021, a complementary cost estimate report was commissioned to assess the relative costs of the potential technical options.

Results from these reports are discussed in Chapter 3.

Quantitative opinion data was collected through two surveys: a survey conducted with a panel of representative Canadians and a survey open to all. Our online surveys provided an opportunity for Canadians and Indigenous peoples to identify potential priorities, principles and considerations for developing a comprehensive strategy. It also provided us with valuable perspectives, opinions and feedback that will help ensure the best options are in place for the management of Canada's radioactive waste. Both surveys looked at the same set of issues, mostly using the same exact questions. The two surveys also provided essentially the same fact-based background information on the topic (e.g., levels of radioactive waste, current waste management practices, international practices).

In early 2021, the NWMO commissioned a deliberative survey of representative Canadians on the development of an integrated strategy for the long-term management of radioactive waste. The research was conducted during the last two weeks of January 2021. A random sample of 1,625 adult residents of Canada completed the survey online. Prior to gathering respondent input, the questionnaire provided fact-based background information on the issues (e.g., types of radioactive waste, current waste management practices, international practices).

A similar format was used for the second survey which was open from May to December 2021. One of the distinguishing features of this online survey is that it was open to all to allow anyone with an interest to contribute. A total 345 people participated in the Open Survey. Of note, the Open Survey included an informational video on transportation and another on the regulation of radioactive waste in Canada, whereas the initial survey did not.

Results from these surveys are discussed in Chapter 2.

From an engagement perspective, the NWMO engaged in a multitude of activities offered in a variety of formats over a period of 18 months from January 2021 to June 2022, with a total of nearly 4000 participants.

In January 2021, the NWMO launched a website for the ISRW, distinct and separate from the NWMO website. This website was the hub for all information related to the ISRW. Presentations and reports are posted there to maximize transparency. Registration for most engagement activities was also conducted through this website. Social media was leveraged for promotion of engagement activities, reaching approximately 1 million people.

Held from March 30 to April 1, 2021, the Canadian Radioactive Waste Summit was the kick-off of the engagement process to develop the ISRW. It was designed to provide a safe, shared space for multiple voices to be heard, connect participants in new and meaningful ways, and showcase diverse voices and perspectives on the important issues related to developing an integrated strategy for Canada's radioactive waste.

Invited speakers represented Indigenous peoples, civil society organizations, industry, municipal officials, youth and international perspectives. The three-day event was free of charge and open to anyone interested. It was not a technical event; rather it aimed to create the opportunity for participants, who may not be familiar with all the issues, to hear from a diversity of voices expressing different considerations and to be able to ask questions and participate in breakout sessions to explore these topics and share their ideas.

The remainder of the engagement activities can be divided into the following categories: Community Engagement Sessions open to all; Roundtables with industry, academics, civil society organizations and federal and provincial civil servants; Youth Engagement; Indigenous Engagement.

70+	13	27	16	15+
Engagement Activities	**Community Engagement Sessions**	**Roundtables**	**Youth Engagement Sessions**	**Indigenous Engagement Sessions**

In these engagements, participants were invited to take part in a discussion on three key topics that would help inform the development of an Integrated Strategy for Canada's Radioactive Waste:

- The first focused on identifying what is most important to get right when developing an Integrated Strategy for Canada's Radioactive Waste.
- The second focused on how we best deal with Canada's low- and intermediate-level waste over the long-term (considered separately).
- The third focused on who should be responsible for implementing the strategy.

These discussion topics helped identify key considerations that participants view as being necessary to include in a strategy.

In addition, the NWMO hosted six technical workshops for experts and laypersons: three on low-level waste and three on intermediate-level waste. During the sessions, participants were asked to comment on the report, and asked if the order of recommended options is prioritized in the way they felt it should. Participants were encouraged to focus on the technical options in isolation of other factors that will come into the final strategy recommendations.

The NWMO published a series of What We Heard reports to capture the input provided during the various engagement activities. See Appendix B, Matrix of Input from Engagement Activities, by Participant Grouping to see the contributions of various participant groups to the development of themes and ideas captured within the recommendations.

It should be noted that several civil society organizations declined to participate in the development of the ISRW. Civil society organizations that did participate made a valuable contribution to the dialogue and their comments are captured and reflected in this report.

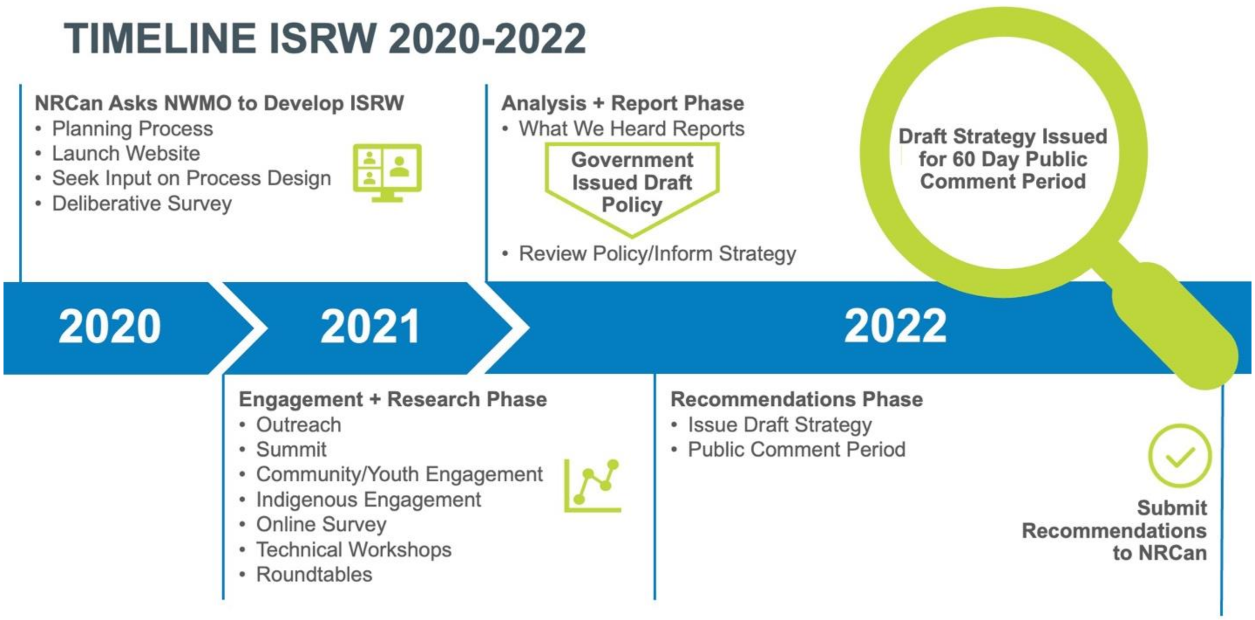
It is disappointing that some groups declined to participate, as we want to ensure all perspectives have an opportunity to be heard. We continued to reach out throughout the process and invited these groups to provide input on what steps we could take to address their concerns with participating, to ensure their perspective is considered. They chose not to engage with the NWMO.

The civil society organization Nuclear Waste Watch convened the Radioactive Waste Review Group in 2019 and in April 2022 released a document entitled "An Alternative Policy for Canada on Radioactive Waste Management and Decommissioning." The NWMO reviewed this document and considered the relevant inputs as part of the development of the strategy.

Timeline and Next Steps

The NWMO was tasked with leading the ISRW engagement in November 2020. It launched its engagement process in January 2021 with a Deliberative Survey. Public engagement concluded one year later; Indigenous engagement is set to conclude in the fall of 2022.

The comment period for this draft Strategy report will conclude on October 24, 2022, 60 days from the date of publication. Comments received will then be reviewed and considered to inform the final ISRW recommendations. The final report will only be submitted to the Minister of Natural Resources Canada following the publication of the revised *Policy for Radioactive Waste Management and Decommissioning*, which at the time of writing is expected in the last quarter of 2022, to ensure the final recommendations align with and support the policy.



Guiding Principles

The NWMO developed a set of principles that are comprised of what the organization had heard previously from Canadians and Indigenous peoples. These initial principles were included in public opinion research and refined by participants at the Canadian Radioactive Waste Summit, the first of the engagement events for the development of an Integrated Strategy for Radioactive Waste, held from 30 March to 1 April 2021. The principles that emerged were used as the basis for discussion in the Community Engagement Sessions. All the work undertaken by the NWMO was anchored on these principles.

The full text of the Guiding Principles is as follows:

- The strategy must have safety as the overarching principle guiding its development and implementation. Safety, including the protection of human health, must not be compromised by other considerations.
- The strategy must ensure the security of facilities, materials, infrastructure, and information.
- The strategy must ensure that the environment is protected, including the protection of the air, water, soil, wildlife, and habitat.
- The strategy must be developed and implemented to meet or exceed regulatory requirements for the protection of health, safety and the security of people and the environment.
- The strategy must be informed by the best available knowledge. This includes Indigenous Traditional Knowledge, science, social science, local knowledge, and international best practices. Ensuring that Traditional Knowledge and ways of life are interwoven throughout is important for a strong strategy. This includes knowledge about the land and environment. It also includes values and principles about developing and maintaining effective and meaningful relationships.
- The strategy must respect Indigenous rights and Treaties and consider that there may be unresolved claims between Indigenous peoples and the Crown.
- The strategy must be developed in a transparent manner that informs and engages the public, including youth and Indigenous peoples. It is important to proactively provide

easily understandable information to those most likely to be affected by implementation of the strategy. Questions and concerns must be heard, acknowledged, and addressed. Information used to develop the strategy will be readily available to the public.

- The strategy must be developed and implemented in a fiscally responsible way to ensure that the cost of the project does not become a burden to current electricity ratepayers, taxpayers, or future generations.

- Where possible, the strategy should make use of existing projects for the long-term management of Canada's nuclear waste.

Technical Options Considered in Our Study

From the international benchmarking report commissioned in 2020, the NWMO retained six potential options for further discussion and assessment, as defined in the following table.

Table 3: Summary of Technical Options Retained for Assessment

Engineered Containment Mound Engineered containment mounds are used in Canada for some low-level waste, specifically near Port Hope, Ontario, and there are similar facilities around the world.	• Suitable for low-level waste which will not reduce in volume or compact over time, contaminated soil or concrete. • Uses layers of natural materials in combination with synthetic materials. • May be constructed in several types of soil. • Similar to the design of a landfill for domestic waste. • In operation in Canada, France, Sweden, and the U.S.
Concrete Vault Concrete vaults are widely used around the world for the disposal of low-level radioactive waste. A concrete vault repository is easy to construct and operate. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed.	• Simple, modular design. • Expandable according to need. • Suitable for low-level waste in various packages, including waste that may become compacted over time, such as clothing and paper products. • May be constructed in several types of soil. • In operation in the Czech Republic, France, Japan, Slovakia, Spain, and the UK.
Shallow Rock Cavern Shallow rock caverns could potentially be suitable for the disposal of low-level waste. A series of rock caverns are excavated at a nominal depth of 50 to 100 meters below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels.	• Suitable for low-level waste, including waste that may reduce in volume or compact over time, such as paper products. • Requires suitable geology. • Makes use of natural barriers. • Buildings on the surface are relatively small. • In operation in Finland and Sweden.
Deep Geological Repository Recognized as one of the best-practice methods to dispose of waste that requires isolation for more than a few hundred years, such as intermediate-level waste or high-level waste.	• International best practice for intermediate- and high-level waste requiring isolation for more than a few hundred years. • Requires suitable geology. • Makes use of natural and engineered barriers. • In operation in Hungary and the U.S.
Deep Borehole This emerging technology could potentially be beneficial for smaller quantities of intermediate-level waste. The method would require drilling a series of narrow boreholes to a depth of about 500 to 1000 meters into which waste packages would be lowered, creating a stack deep underground.	• Relatively simple to construct and operate, compared to larger facilities. • May be suitable for small volumes of intermediate-level waste. • Requires suitable geology. • Makes use of natural barriers. • Limited in size. • In operation: none at the time of publication
Rolling Stewardship Rolling stewardship for the long-term storage of low and intermediate-level waste would involve multi-generational intervention. Although there are advocates of this approach for the long-term management of nuclear waste, rolling stewardship is not recognized internationally as a preferred method for the disposal of nuclear wastes.	• A way to manage waste indefinitely, not to dispose of it. Keeps options open for the future. • Assumes future technology will present a permanent disposal option. • Requires continuous monitoring, inspection, and renewal of waste packages and storage facilities for many years. • Requires work and investment by future generations. • Not recognized internationally as a method for the disposal of radioactive waste. • In operation in the Netherlands

Waste Inventory

Following the identification of the six technical options, the NWMO commissioned an assessment of these options in the context of Canada's radioactive waste inventory, titled Nuclear Waste Management Organization's Integrated Strategy for Radioactive Waste (ISRW) Initial Plan Development Characterization and Options Project Report (referred to as the Report on Technical Options).

The purpose of the Report on Technical Options was to evaluate Canada's low- and intermediate-level radioactive waste inventory at a summary level, to categorize and group the radioactive waste, and to identify suitable long-term management options for each radioactive waste category.

Irradiated fuel was not included in this study since it is being addressed through the NWMO's Adaptive Phased Management project, as mandated by the Nuclear Fuel Waste Act. Similarly, uranium mine and will waste was excluded from the assessment as it is already being managed in existing long-term management facilities. The six potential options retained for the long-term management of Canada's low- and intermediate-level radioactive waste based on international benchmarking were assessed against the remaining inventory of radioactive waste.

For the purposes of this initial plan, a summary level of detail was gathered about the current and projected future inventories from the current major Canadian waste owners. The Report on Technical Options identified existing and future Canadian low- and intermediate-level radioactive waste with no current long-term management plans and presented an integrated assessment for the long-term management of this waste. This includes waste from nuclear medicine, nuclear fuel fabrication, nuclear reactor operations, research and development activities, radioisotope manufacture and use, and decommissioning activities.

The waste was grouped into categories of similar nature for the purpose of long-term management. In general, the waste was grouped based on radiological classification (i.e., low-level and intermediate-level radioactive waste) and physical configuration (i.e., bulk material, packaging, size etc.).

The waste volumes under the ISRW scope include current and future Canadian low- and intermediate-level radioactive waste that has no current long-term management plans, totalling approximately 294,000 m3 of low-level waste and 51,000 m3 of intermediate-level waste. It should be noted that options for the remainder of the total inventory (high-level waste, uranium mines and mills waste, low-level waste under the responsibility of AECL) are not covered in this report because there are already facilities or plans in place to address them. Refer to Appendix A for the status of current plans and progress in advancing long-term management and disposal solutions for Canada's radioactive waste.

Table 4 summarizes the volumes of low-level (LLW) and intermediate-level radioactive waste (ILW) included in the ISRW inventory by waste owner.

Table 4: Volumes of low-level and intermediate-level radioactive waste included in the ISRW inventory by waste owner.

Waste Owner	LLW Volume (m^3)	ILW Volume (m^3)
Ontario Power Generation (OPG)	270,000	40,000
Hydro Québec	18,000	1,000
NB Power	2,270	780
Cameco	2,000	N/A
Other	1,740	1,000
AECL/CNL * (*CNL LLW planned for disposal in NSDF)	N/A	8,200

Source: Report on Technical Options

The Report on Technical Options found that 15% of the ISRW waste inventory is intermediate-level waste (ILW), and 85% is low-level waste (LLW). For reference, the current total radioactive inventory in Canada is presented in Figure 2 (below). A chart showing the proportions of radioactive waste without long-term plans as percentages of the total waste volume are presented in Figure 3 (below).

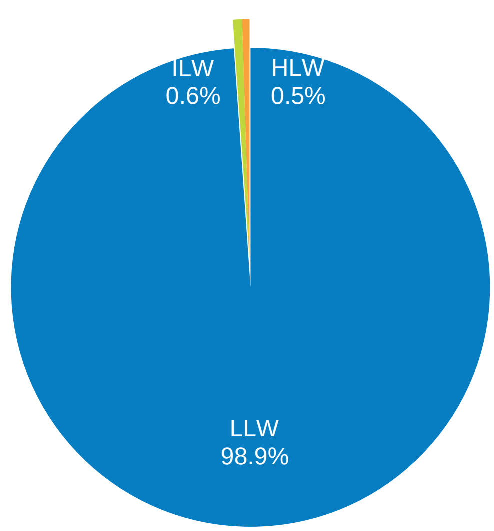


Figure 2: Total Canadian Radioactive Waste Inventory as of 2019.

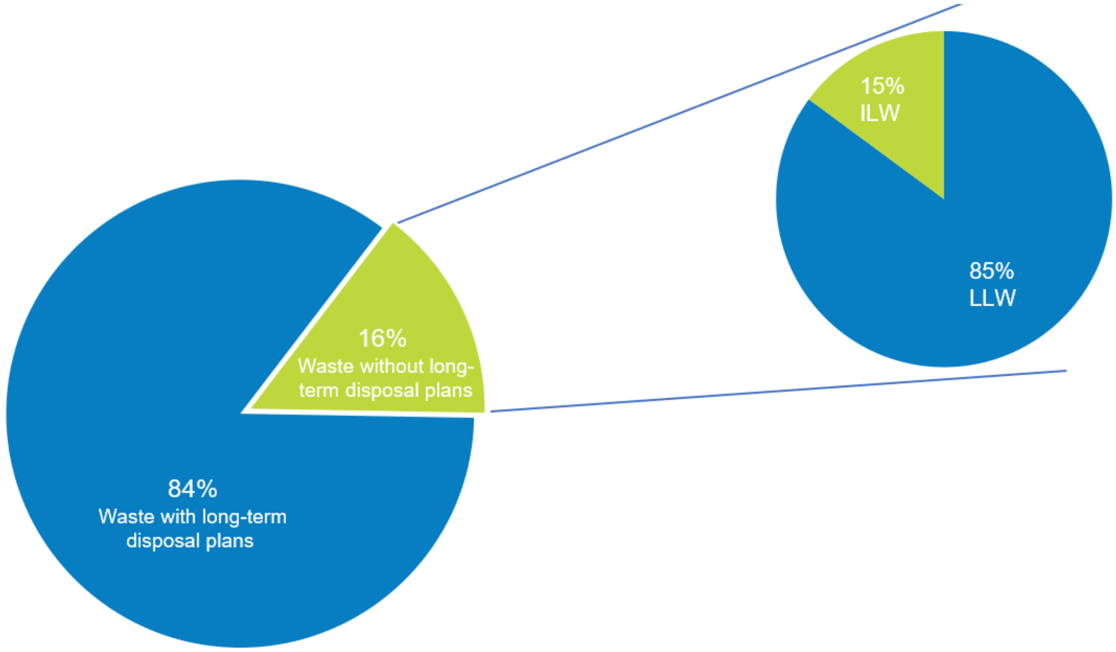


Figure 3: Status of plans for total waste inventory in Canada

For the purpose of the Report on Technical Options, a summary level of detail was provided by each waste owner and is different between waste owners. For instance, some owners reported only their current waste inventory while others reported their lifecycle waste volumes (i.e., including their projections of future waste generation). The Report on Technical Options made adjustments such that lifecycle waste volumes were estimated and used in the analysis for all waste owners.

Chapter 2: What We Heard

Context: In 2021, the NWMO began engaging with Canadians and Indigenous peoples, conducting public opinion research, hosting a Summit to hear from diverse voices, listening to citizens in a series of engagement sessions in communities where waste is stored today, hosting Roundtable discussions, and Technical Workshops.

ISRW Overall - Digital Promotion of Engagement Opportunities

The public engagement on the Integrated Strategy for Radioactive Waste was designed to provide safe shared spaces for multiple voices to be heard and to connect participants in new and meaningful ways. The engagement opportunities were free of charge and open to anyone interested.

As it was important to encourage wide participation, the NWMO used various outreach and promotional tools, including social media (owned and paid), emails, and community partner outreach to broaden its existing reach to relevant audiences in order to raise awareness, and stimulate registration and participation for activities such as the Canadian Radioactive Waste Summit, ISRW Survey and Community Engagement Sessions.

Paid Channels - Methodology, Parameters and Results

To encourage wide participation, the NWMO used paid promotion on the ISRW's social media channels and struck a balance between its project-specific channels (Facebook and Twitter) and the official languages (English/French).

Ads deployed on Facebook and Twitter advertising the Canadian Radioactive Waste Summit, a deliberative ISRW Survey and Community Engagement Sessions were shown and seen over 1.91 million times across Canada, reaching a total of 1,153,878 people with invitations for opportunities to participate.

Key Themes from Engagement

This section presents the commonly heard themes that arose over the course of the engagement activities across the country and is not a reflection of each of the individual comments that were made. The NWMO published a series of What We Heard reports to capture the input provided during the various engagement activities. Additional details about these activities can be found in Appendix B.

Key Theme 1 – Safety is Paramount

The most prominent theme that emerged throughout this engagement was the importance of safety in every aspect of the development and implementation of the Integrated Strategy for Radioactive Waste. We heard from participants that safety was important in every aspect of the nuclear waste strategy; protecting the environment was a key consideration across all sectors.

We heard that as a key priority, safety should be considered through a long-term lens. This is important so that the strategy is able to respond to future risks and ensure safety in unpredictable and potentially unstable future conditions in the environment, government, and technology. For the youth participants, this meant choosing solutions that offer the highest level of safety in terms of storage and isolation of waste; integrating climate and social change modeling as part of risk management; embedding flexibility and adaptability into the strategy; and using governance approaches that provide consistency and accountability. Participants prioritized safety over cost efficiency.

Safety was also the main theme in all discussions with Indigenous peoples. Conditions may change over the long-term and anticipate future risks including environmental disasters, climate change and social disruptions. Participants identified the need for embedding flexibility and adaptability into the strategy and building in checks and balances in case of failures and changes to the status quo.

Participants raised concerns about location, storage, containment, and transportation of the waste as key factors in the final decision. We heard from participants, that in the future when any waste disposal project is undertaken, the design would need to be suitable for the location, waste volumes and waste characteristics, and meet regulatory requirements.

Key Theme 2 – The Time to Act is Now

We heard that an integrated strategy was needed, and the approach to the long-term management of low-level and intermediate-level waste should be determined. We also heard that the current lack of a disposal facility for intermediate-level waste meant higher risk because the waste is being stored above ground in interim storage facilities, and that this should be addressed as a priority. There was general agreement that to have and to implement a plan for all of Canada’s radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations, is the right thing to do.

Key Theme 3 – Communication and Transparency

Transparency and communication were common themes among all participants. In general, participants in all engagement activities were adamant that clear, fact-based, transparent, inclusive communication that provides context is essential. We heard that we need to be completely transparent about the waste and any potential risks associated with it. Some participants expressed the importance of having more visibility of waste inventories, as they exist today, and what could be expected in the future.

Participants defined transparency in communication as providing all of the key information in a relevant, accessible and an unbiased way. Transparency also includes providing regular and frequent check-ins and updates to the impacted communities and stakeholders. Similar to the theme on education, participants underlined the importance of transparent information and communication for meaningful engagement and building trusting relationships.

Participants stated the waste producers need to clearly communicate the roles and responsibilities of the various stakeholders in the nuclear energy field. In addition, many participants expressed the importance of disclosure when hazardous goods are transported through their traditional territories and the sharing of industry emergency plans.

We heard that the ISRW needed to consider the social dimension and emphasize consensus building, transparency and informed consent. We heard that there seemed to be an abundance of technical discussions about waste, but not enough about the social or political aspects.

Key Theme 4 – Trust and Relationships with Indigenous Communities

There was support expressed by participants to ensure trust and relationships are built with Indigenous communities in developing the plan and implementing it. Ensuring that Indigenous Knowledge was considered along with western science was identified as important to a strategy that would address the far future, as well as more immediate considerations. Indigenous participants emphasized that this information must come from the knowledge holders and need to be engaged and included at all steps of project development, implementation and operation. It is not an instrument to be used by proponents to bypass the inclusion of the community or its input.

We heard that meaningful engagement and ongoing relationship building with Indigenous communities is a priority for young people. Participants wanted the strategy to include a requirement to observe Indigenous communities' right to Free Prior and Informed Consent and to be mindful of exploitative practices with respect to Indigenous involvement. They expressed that the strategy should be centering Indigenous perspectives, expertise and worldviews and contribute to Indigenous Sovereignty through building structures for Indigenous communities to take back control over the long-term stewardship of their land. This includes embedding Indigenous communities and leaders within the management and oversight of the strategy and supporting capacity building for Indigenous communities to take part in these processes.

Meaningful commitment to reconciliation with Indigenous communities was a key finding in the Indigenous engagement sessions. There is a need for broad, diverse and comprehensive partnerships especially with communities that may be directly impacted, as key to making good decisions. Accountable to legacy issues and being open to inclusion from Indigenous communities and collaboration is a must to ensure partnerships and reconciliation.

Treaty Rights and Title, including the Duty to Consult, Free and Prior Informed Consent were at the forefront of most Indigenous engagement sessions. Most participants specifically emphasized the importance of being included by way of meaningful engagement or consultation in development and implementation of any strategy or project relating to nuclear energy.

Key Theme 5 – Education and Engagement

Many participants across the sessions highlighted the importance of education through public engagement during the development of the strategy and expressed that education is vital for success.

We also heard that education needs to be further integrated into our discussions. Participants shared that they want to contribute to the strategy, but sometimes need more information. Some participants expressed that they did not have enough information to make adequate judgement as part of the discussion. This highlighted the need for further public education so that Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste. Some felt that it was difficult to consider the technical options without also looking at cost, environmental and safety factors including waste descriptions and makeup, and the application of the waste hierarchy (what happens before storage including other uses).

Participants recognized the importance of expertise but had a strong desire to learn more themselves to contribute to the strategy and noted that experts were required to educate and provide options. Education is vital to help Canadians and Indigenous peoples understand the unique challenges posed by radioactive waste, and how safety is assured. Participants also expressed that education was essential to address misinformation about radioactive waste.

Education was highlighted as a key factor when engaging Indigenous communities and people in the decision-making process. Participants recognized that their education on radioactive waste, options for disposal facilities, benchmarking in other countries, and Canada's use of nuclear energy was low. Some groups located in siting areas possessed a higher level of familiarity, but overall, different levels of knowledge may impact the choice of facilities.

We heard that participants wanted to learn more about all aspects of the strategy to make better informed decisions that could contribute toward the overall strategy. We heard that learning from science-based best practices internationally is an important pathway to ensuring both public safety and cost effectiveness, which are both important, now and in the long-term, and provides valuable data and expertise. However, participants, in particular youth, generally supported the idea of a made-in-Canada solution that would consider the unique conditions and environment of Canada including the size of the country, the diversity of Canadians and the changing climate.

We heard that relevant and accessible education about radioactive waste management is a requirement for creating meaningful engagement opportunities for all groups. Some participants noted that the public is not typically engaged until a solution is presented in their community. They expressed a desire to be engaged early in the development of any plans. We heard that engagement should continue to be an important aspect of this strategy, and any plans going forward.

Youth participants wanted to see broad engagement across diverse stakeholder groups and ongoing engagement and relationship building with impacted communities and Indigenous peoples. Participants felt that youth perspectives should be an integral part of any future planning and management strategy. They saw a need for an intergenerational education strategy to cultivate a sense of responsibility for the long-term strategy implementation among young people.

Key Theme 6 – Sustainability and the Environment

In addition to the safety of the community and its residents, we heard that minimizing the carbon footprint and protecting the environment, in particular water, over the long-term were important. Participants shared that we needed to be mindful of the climate emergency to ensure that every aspect of this strategy is sustainable, considers the risks posed by climate change, respects the environment, and protects water sources for all future generations.

We heard from youth that protection of land, water, and the environment needs to be a top priority. Participants expressed that waste disposal sites should not be built near water as they can contaminate it and affect their way of life. They also noted that the goal of minimizing environmental impacts should be viewed through a lifecycle approach and include the construction of facilities and transportation of radioactive waste.

Land protection and minimizing the impact on the land and the natural environment, including disruptions to wildlife and lands used for ceremonial and traditional purposes was a priority for Indigenous peoples. Participants expressed a preference for technical options that would have the least environmental impact. They felt that options which place waste underground or that can be restored or covered with vegetation appear to address this priority of environmental impact. Minimizing visual impacts was also highlighted as an important consideration especially from participants that have seen other types of industrial facilities near where they live.

Many Indigenous participants also identified protecting water sources and minimizing impacts on water sources as priorities. The recommendation that no facility or disposal site be located near water sources was a common theme.

We heard a broad and repeated consensus from participants that waste minimization should be further pursued. Industry and Civil Society Organizations both advocated for the importance of minimizing waste. Further, it was identified that there may be opportunities for Canada to invest in technologies to support waste minimization initiatives. Accurate waste characterization was also identified as important to ensure that waste is managed and disposed of in accordance with the hazard.

Youth participants were acutely aware of the history of environmental racism in Canada especially towards Indigenous communities. They saw environmental justice as a key consideration when discussing how many facilities to build and where. Participants wanted to ensure that the strategy does not disproportionately place the responsibilities and risks associated with radioactive waste management on some communities.

Key Theme 7 – Transportation

We heard from participants that transportation is a particularly important aspect of the long-term plan and that, when radioactive waste is transported, it must be done safely. We heard that people have many questions about the risks associated with transportation, and the consequences of transportation accidents on the safety of the radioactive waste being transported. We heard that people generally preferred to minimize the transportation of radioactive waste, to reduce any associated risks. Participant views on the relative risks of transportation influenced their views on having one central repository for low-level waste and for intermediate-level waste or having multiple disposal facilities closer to where the waste is produced.

While participants understood that transportation of radioactive waste is heavily regulated, they were concerned about the potential risks associated with transporting the waste over large distances and near built up areas. Participants wanted to ensure there are risk mitigation and incident response plans in place. Other concerns around transportation included cost, potential increase of greenhouse gas emissions and potential environmental impacts from building new access roads.

Transportation of hazardous waste through traditional territories with no consultation, engagement, or notification was an expressed concern of Indigenous Peoples. The safety of waste through sensitive areas with no communication or inclusion of an emergency management plan is of the utmost concern. The potential impact of transportation of waste on or through communities and traditional territories was a common theme in all Indigenous engagement sessions.

Key Theme 8 – Shared Responsibility Framework / Independence of Accountable Entity

There were varying perspectives regarding who should be responsible for the implementation of the ISRW. There were differences of opinion about the role of industry, but there was general agreement that there should be a single entity with appropriate expertise that is independent from government and industry, but subject to regulated safety and environmental oversight.

The governance of such an entity was subject to different ideas, with some suggesting that the organization's governance should be comprised of industry, civil society organizations, and Indigenous peoples, and others focusing on ensuring the organization remained independent and included the right expertise. Some saw this organization as a government body or government-led, while others wanted to see this organization being more independent. A shared perspective among these responses was that this organization should include multi-stakeholder representation with Indigenous communities playing a key, if not the lead role.

There was a mix of responses about the role of waste producers in strategy implementation. Some participants wanted to see waste producers playing a stronger role, with government oversight. Others felt that waste producers' role should be limited to fiscal responsibility and engagement in a multi-stakeholder process. There was broad support for the polluter pays approach for financing the strategy.

Indigenous participants noted the importance of collaboration among multiple stakeholders and highlighted the important roles to be played by the government, Indigenous communities, and industry in the responsibility of disposing radioactive waste and implementing the strategy.

Key Theme 9 – Rolling Stewardship and Waste Disposal

We heard differing views on rolling stewardship versus ultimate disposal of radioactive waste. Most participants supported the idea of finding solutions to permanently dispose of the waste now, not leaving the decision for future generations, and that intermediate-level waste should be disposed of in a deep geological repository. However, some individuals expressed a preference for rolling stewardship, where the waste remains above ground where it is today, so that monitoring of the waste would be assured over the long-term and the location of the waste would not be forgotten. Many participants, including youth, were open to either approach as long as safety was ensured.

A considerable number of participants included a caveat which stressed the need for perpetual monitoring, for as long as the waste is hazardous, regardless of the option chosen. These participants noted the importance of having assurance that someone was overseeing the waste and keeping waste owners accountable.

For those who saw rolling stewardship as the preferred strategy, some of the considerations included the possibility of future technology innovations, ensuring that the waste was not forgotten, and the ability to constantly monitor the waste to ensure that any environmental impacts could be identified and remediated before causing significant harm, especially to the water table. Some participants found rolling stewardship to be a good solution for low-level waste. They felt it provided better oversight and created the possibility of taking advantage of future technological advances for recycling or reusing this waste.

Some of the concerns cited by those who preferred disposal to rolling stewardship included uncertainty of impacts arising from climate change, and whether changes to government or society in the long term could leave waste vulnerable under indefinite storage arrangements. Other concerns were around deferring the responsibility of dealing with radioactive waste to future generations and the risks associated with forgetting about these facilities, facility failure or mismanagement.

We heard that industry preferred a broad, flexible framework allowing waste owners to consider all the strategies, methods, and acceptable technologies that can ensure safety.

Key Theme 10 – Co-location and Centralization

We heard a range of responses from participants who felt co-locating waste could have advantages. Participants acknowledged the difficulty in finding willing and informed host communities, and obtaining the free, prior, and informed consent of Indigenous peoples made multiple sites more challenging. However, there were concerns about the impact of a single location on the transportation of waste. Some participants cautioned about the importance of ensuring appropriate technical arrangements for different waste types located in the same facility, while others noted the cost advantages of consolidating expertise and facilities in a single location.

The idea of co-location and centralization was more broadly supported for intermediate-level and high-level waste, than it was for low-level waste and intermediate-level waste. The volumes of low-level waste are greater, and participants generally felt that leaving it nearer to the sites where it was generated or stored, rather than transporting it vast distances, was preferable.

We heard an overall openness from youth to co-location strategies for all types of waste. However, participants noted that they required more information about how different types of waste are managed and the implications around co-location.

Responses showed that most participants considered specialized and more decentralized facilities to be an appropriate strategy for low-level waste due to lower risks associated with this waste, leaving waste nearer to the sites where it was generated or stored, rather than transporting it vast distances. One recommendation that received broad support was to explore building several facilities around the country (multiple facilities but a limited number of them). Participants expressed a greater preference for using centralized facilities for intermediate level waste.

Participants indicated that the best option for intermediate-level waste is deep-disposal. Some of the participants expressed support for the longer-lived intermediate-level waste to be emplaced with the high-level waste.

The majority of participants believed that there were cost advantages to co-location including re-packaging, surveillance, and monitoring. Some participants identified potential concerns related to the characteristics of the waste, such as heat and gas generation that could impact the feasibility of co-locating intermediate- and high-level waste.

Some participants discussed co-locating low- and intermediate-level waste. However, most participants felt that when it comes to low-level waste, any disposal facility should be built separately from that for intermediate-level waste.

Key Theme 11 – A Strategy by and for Canadians and Indigenous Peoples

Overall, across sessions, it was clear participants want this to be a strategy created by and for the people and that this is key to have buy-in. It is important that various groups, such as Indigenous communities, technical and scientific experts, academics, host communities and surrounding municipalities, have their voices heard during the engagement process. An inclusive strategy is a reflective strategy.

Additionally, youth generally supported the idea of a made-in-Canada solution that would consider the unique conditions and environment of Canada including the size of the country, the diversity of Canadians and the changing climate.

What We Heard from Surveys

One of the ways we explored what is most important to people regarding the long-term management of Canada's radioactive waste was through our online survey. Our online survey provided an opportunity for Canadians and Indigenous peoples to identify potential priorities, principles and considerations for developing a comprehensive strategy. It also provided us with valuable perspectives, opinions and feedback that will help ensure the best options are in place for the management of Canada's radioactive waste.

One of the distinguishing features of this online survey is that it was open to all. Thus, throughout this report, we refer to it as the "Open Survey." This Open Survey complements the research that was conducted during the last two weeks of January 2021, in which a random sample of n=1,625 adult residents of Canada provided input online. A total 345 people participated in the Open Survey.

WHAT	First step in the NWMO's efforts to engage Canadians on the development of an integrated long-term strategy for managing Canada's radioactive waste
WHY	The research was designed to: • Begin to identify principles, priorities and considerations the public believes should guide the development of Canada's ISRW • Shape the design of subsequent engagement efforts
WHEN	January 18 - February 5, 2021
WHO	Random sample of n=1,625 adult residents of Canada
HOW	Self-administered online survey

Both surveys looked at the same set of issues, mostly using the same exact questions. The two surveys also provided essentially the same fact-based background information on the topic (e.g., levels of radioactive waste, current waste management practices, international practices). Of note is that the Open Survey included an informational video on transportation and another on the regulation of radioactive waste in Canada, whereas the initial survey did not.

Overall, the results of the two surveys are consistent. It also seems apparent that, overall, Open Survey respondents are more knowledgeable about the management of radioactive waste (18% are employed by the nuclear industry and 10% are public sector employees). The views of nuclear industry members are much more homogeneous and unequivocal, but their views are generally consistent with those of other Open Survey respondents.

Priorities

Priorities were examined by means of a paired trade-off exercise involving a total of 10 items (i.e., each was randomly “paired” against the other nine a roughly equal number of times). Obtaining the “active support” of non-Indigenous and Indigenous communities near facilities are top priorities, along with having “a separate not-for-profit organization” responsible for implementing Canada’s strategy. At the bottom are “minimizing transportation” and “minimizing costs to electricity ratepayers”.

In comparison, Representative Sample Survey respondents placed relatively higher priority locating waste disposal facilities away from the Great Lakes and population centers. They also placed more emphasis on reducing transportation.

Perceived Pros and Cons of Potential Approaches to Radioactive Waste Management

The survey shifted from examining principles, priorities, to gathering input on more tangible considerations (e.g., the use of one versus several disposal facilities). Consistent with the findings from the Representative Sample Survey, respondents express an overall preference for not leaving radioactive waste on the surface, especially intermediate-level waste. This approach is thought to be safer, as well as more responsible vis-a-vis future generations.

Views are relatively divided on the merits of having a single centralized facility, versus a decentralized approach based on multiple facilities. There is plurality support for decentralization when it comes to managing low-level waste, and for centralization with respect to intermediate-level waste. The key trade off is viewed as being between reducing the perceived risks associated with transportation against the design, construction, monitoring and accountability benefits that would come from having everyone focus on one facility. In the Representative Sample Survey, a decentralized approach was somewhat preferred for both levels of waste.

Consistent with other results from the survey, most respondents express a preference for the creation of a separate organization to implement Canada’s strategy, feeling this approach is more likely to protect the public interest (e.g., more government involvement, higher profile/more visible organization). Views on Strategy Implementation and the Regulatory Framework The survey included six attitudinal questions that examined people’s level of comfort/trust in the organizations involved in waste management and in regulations.

Over half of respondents (56%) say they have “complete confidence” in the regulations surrounding radioactive waste management, which is 10 percentage points higher than the Representative Sample Survey result.

Respondents are divided on whether radioactive waste owners can implement a “safe and secure” strategy for the long-term management of Canada’s low- and intermediate-level waste: 44% think they can, while 42% do not.

Consistent with the Representative Sample Survey results, Open Survey respondents are more comfortable with having the federal government lead the implementation of a strategy for the long-term management of low- and intermediate-level waste, than with waste owners in the lead (59% vs. 38%).

Similarly, most (61%) agreed that the long-term management of all radioactive waste in Canada should be the responsibility of a separate not-for-profit organization. In the Representative Sample Survey the corresponding number was 70%.

We also find that compared to those who participated in the Representative Sample Survey, Open Survey respondents are more likely to view low- and intermediate-level waste as less concerning. This is also echoed in their written comments.

Chapter 3: Assessment of the Technical Options

Context: In 2021, the NWMO commissioned an assessment of the options. The purpose of this study was to evaluate Canada's low- and intermediate-level radioactive waste inventory at a summary level, to categorize and group the radioactive waste, and to identify suitable long-term management options for each radioactive waste category

Technical Options

The six potential options retained for the long-term management of Canada's low- and intermediate-level radioactive waste based on international benchmarking were assessed. These six options are described below.

Engineered Containment Mound

Engineered containment mounds are a type of engineered near surface disposal facility that sees waste packages placed on a waterproof base and then covered over with thick layers of natural materials such as clay and soil. Layers of synthetic materials such as high-density polyethylene are also incorporated to prevent release of radiation to the environment. These facilities usually have wastewater collection and treatment systems as well. The engineered containment mound is generally suitable for low-level waste which will not reduce in volume or compact over time.

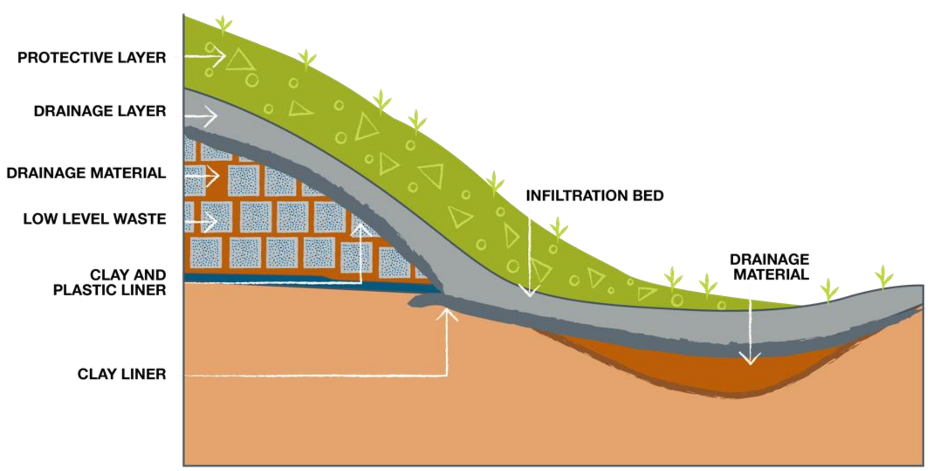


Figure 4: Engineered Containment Mound

Concrete Vault

Concrete vaults are a type of engineered near surface disposal facility widely used around the world for the disposal of low-level radioactive waste. Concrete vaults look like large concrete boxes and a repository would be made up of a series of these. Each one would have its own drainage system and an 'earthen cover system' engineered from multiple layers of soil and with grass or other plants growing on top. This disposal method can be used in a wide variety of soil conditions. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed

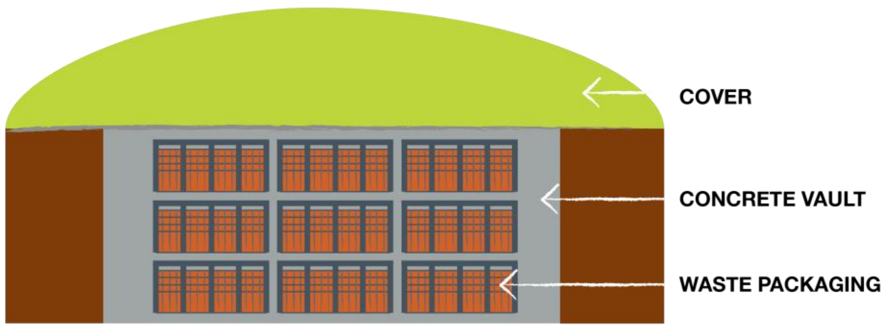


Figure 5: Concrete Vault

Shallow Rock Cavern

The shallow rock cavern is an engineered near surface disposal method sometimes used for the disposal of low-level waste, or low- and intermediate-level waste (low-level waste or low- and intermediate-level waste). A series of rock caverns are excavated at a nominal depth of 50 to 100 meters below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels.

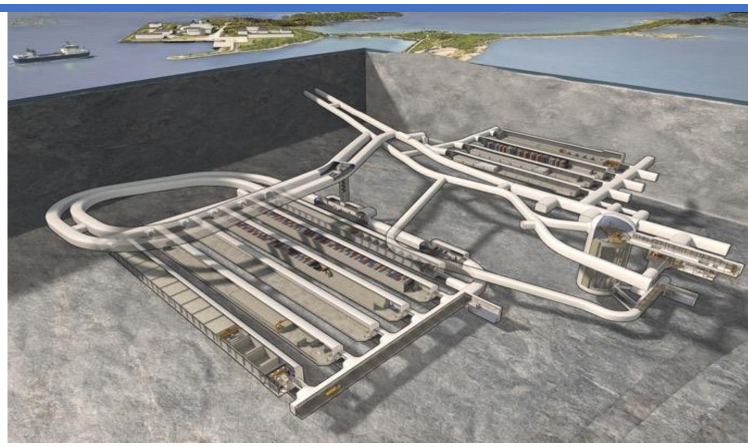


Figure 6: Shallow Rock Cavern (SFR Repository, Sweden) [SKB 2018]

Deep Geological Repository

A deep geological repository typically consists of a network of underground tunnels and placement rooms for radioactive waste constructed several hundred meters below the surface. Repositories are designed to use a system of multiple barriers: engineered barriers such as waste containers and natural barriers like the rock itself work together to contain the waste and isolate it from people and the environment.

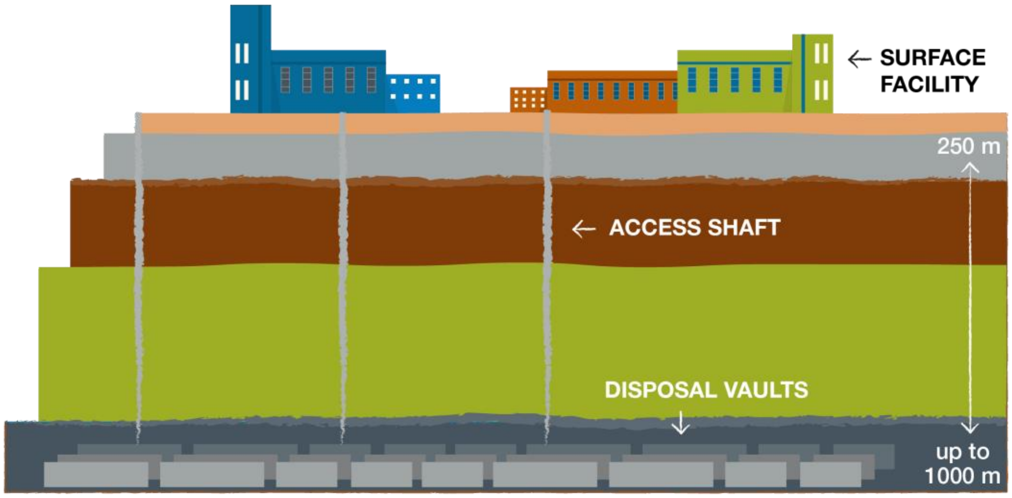


Figure 7: Deep Geological Repository

Deep Borehole

Deep borehole disposal is an emerging technology for waste that requires isolation for more than a few hundred years. It may be suitable for the disposal of small volumes of intermediate-level waste. The series of narrow boreholes are created to a depth of about 500 to 1000 metres into which waste packages would be lowered, creating a stack deep underground.

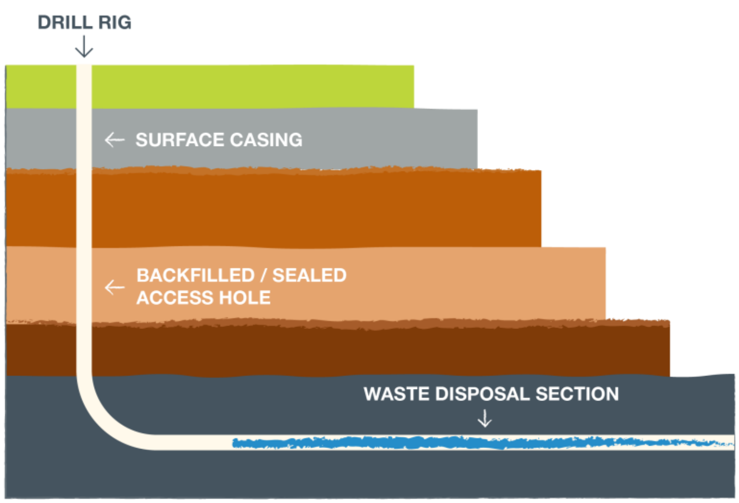


Figure 8: Deep Borehole Disposal

Rolling Stewardship

Rolling stewardship is an approach to managing radioactive materials for which there is no disposal solution in the near term. Under rolling stewardship, the radioactive waste is stored on the surface where human controls can safely contain, isolate, monitor, and secure it for many generations indefinitely i.e., roll the radioactive waste forward from generation to generation (a succession of stewards). This concept assumes that technology will eventually resolve the problem for the long-term management of the waste, potentially by finding methods to destroy or neutralizing it.

Technical Assessment of the Options

For the purposes of this initial plan, a summary level of detail was gathered about the current and projected future inventories from the current major Canadian waste owners. This study identified existing and future Canadian low- and intermediate-level radioactive waste with no current long-term management plans and presented an integrated assessment for the long-term management of this waste. The waste was grouped into categories of similar nature for the purpose of long-term management. In general, the waste was grouped based on radiological classification (i.e., low-level waste (LLW) and intermediate-level waste (ILW)) and physical configuration (i.e., bulk material, packaging, size etc.).

The study made the following assumptions in preparing each waste owner's radioactive waste inventory for analysis:

- All liquid waste is assumed to be solidified (e.g. via incineration, vitrification, grouting, solidification agent, as required).
- Unless quantified by the waste owner, additional decontamination and volume reduction practices were not assumed in this study.
- Projected operational waste is assumed to be packaged in the same physical configuration as an existing operational waste of the same source. For example, Ontario Power Generation's low level non-processible waste is currently stored in steel containers, so any future production of low level non-processible waste is assumed to be confined in steel containers as well.
- It is assumed that all long-term management options can accept nuclear waste with nonnuclear hazardous properties because non-nuclear hazardous waste facilities employ engineered containment measures similar to those present in near-surface nuclear waste disposal facilities, including waterproofing, leachate control, and monitoring. Additional design considerations may be required to address all non-nuclear hazards at the detailed design stage.
- Waste owner inventory volumes have been rounded, given the level of uncertainty present at this time. This is considered a reasonable simplification, given the level of detail required for this study.

The radioactive waste groups were assessed against each long-term management option based on technical feasibility and practicality. Each waste group was assigned one of four levels of applicability:

Y: The approach is applicable and recommended for the allocated waste group.

Y2: The approach may be applicable to the allocated waste group but would require further study.

Y3: The approach is conceptually feasible but, after considering technical, financial, and/or human risk factors, is considered impractical.

N: The approach is not suitable for the allocated waste group.

Table 5 illustrates the result of the assessment.

Table 5: Assessment of Options by Waste Type

Repository Type	LLW Bulk Material	LLW Other	ILW General	ILW Small
Engineered Containment Mound	Y Most suitable for large volumes of bulk LLW	Y2	N	N
Concrete Vault	Y2	Y Internationally accepted practice for LLW disposal	N	N
Shallow Rock Cavern	Y2	Y Internationally accepted practice for LLW disposal. Large objects may require segmentation or volume reduction	N	N
Deep Geological Repository	Y3	Y2	Y Internationally recognized best practices for ILW disposal. Large objects may require volume reduction.	Y Internationally recognized best practices for ILW disposal.
Deep Borehole	N	N	N	Y2
Rolling Stewardship	Y3	Y3	N	N

Matrix of Applicability	
Y	Applicable and Recommended for the allocated waste group
Y2	May be Applicable to the waste group but would require further study
Y3	Conceptually feasible but, after considering risk factors, is impractical
N	Not suitable for the allocated waste group

It was identified that all low-level waste might be disposed of at a near surface facility (i.e., Engineered Containment Mound, Concrete Vault, or Shallow Rock Cavern), whereas all intermediate-level waste must be disposed of in a Deep Geological Repository or a Deep Borehole. Typically, low-level waste can be disposed of in a higher level of containment (i.e., deep underground), but intermediate-level waste cannot move to a lower level of containment (i.e., near the surface). This is demonstrated by the Deep Geological Repository, which is technically feasible for the full low- and intermediate-level waste inventory.

The Engineered Containment Mound was determined to be the most suitable option for bulk low-level waste such as soils and demolished concrete, given the low concentrations of radionuclides and the large volume of waste. Additional low-level waste may be suitable for the Engineered Containment Mound, depending on the specific safety case of the disposal facility.

The Concrete Vault and Shallow Rock Cavern were considered the most suitable option for non-bulk low-level waste, given the increased containment and structural integrity offered (concrete barrier or rock mass) compared to the Engineered Containment Mound. These long-term management options may also be suitable for bulk low-level waste, noting that the containment and isolation offered by these options exceed what is required for bulk material. Additionally, the co-disposal of non-bulk low-level waste in a Deep Geological Repository was considered as an alternative.

The International Atomic Energy Agency (IAEA) states that intermediate level radioactive waste can be disposed of in different types of facility depending on its characteristics. While disposal could be by emplacement in a facility constructed in caverns, vaults or silos a few tens of metres below ground level, this option was not retained for intermediate-level waste in the ISRW inventory given its long-lived characteristics. From the international benchmarking undertaken, the Deep Geological Repository emerges as the preferred approach to intermediate-level waste long-term management and was therefore considered the most suitable option for all of the intermediate-level waste. The Organisation for Economic Co-operation and Development endorses the strong scientific consensus regarding the use of Deep Geological Repositories for the disposal of nuclear wastes has been developed after decades of scientific analyses, engineering tests, development and operation of underground research laboratories.

Deep Boreholes are considered an alternative long-term management option for small dimensional intermediate-level waste such as disused sealed sources and spent ion exchange resins. Deep Boreholes are best applied to a decentralized disposal approach (i.e., with multiple borehole locations across Canada) in order to reduce the need for radioactive waste transportation. Further investigation on the applicability of this option is required as the technology develops.

Rolling Stewardship is a potential near-term waste management solution but is not considered to be a practical solution for all low- or intermediate-level waste in the long-term given the uncertainties associated with costs, climate change and societal evolution.

Rolling Stewardship may be feasible for certain types of low-level waste that decays quickly allowing its free release or conventional disposal in several decades, but not for wastes that will remain radioactive for several hundred years or longer. Detailed characterization data would allow the half-life of the waste inventory to be assessed and potentially identify any shorter-lived low-level waste as Rolling Stewardship candidates. However, Rolling Stewardship is not in line with international best practices for the long-term management of radioactive waste. Additional cost considerations include the potential need to repackage waste as waste containers degrade for centuries, as well as the potential need for new, specialized long-term facilities.

Given the summary level of detail gathered for this initial plan, there is an opportunity to further engage each waste owner and investigate the characterization of the waste in future studies.

Technical workshops were held to discuss the results of the technical assessment. Separate workshops were held to address low- and intermediate-level waste. As well, separate workshops were offered to technical experts and laypersons, participants self-selected which option they preferred. During the workshops, participants were guided through a series of questions by an independent bilingual facilitator to obtain their views on the topic of ‘Does the order of recommendations for the storage of low- or intermediate-level waste stand?’

Focusing solely on the technical options for the long-term management of low- and intermediate-level waste, participants agreed with the order of recommended options as follows:

Ranked Order – Low Level Waste

1 **Engineered Containment Mound**

2 **Concrete Vault (tied for 2nd)**

3 **Shallow Rock Cavern (tied for 2nd)**

4 **Deep Geological Repository**

5 **Rolling Stewardship (not a disposal option)**

Ranked Order – Intermediate-Level Waste

1 **Deep Geological Repository**

2 **Deep Borehole (an option limited by the packaged size of the waste)**

Participants identified the importance of other decision factors such as safety, environment, transportation, and cost.

Analysis of Costs

To further support the analysis, the NWMO commissioned a cost estimate report of the six technical options. This cost estimate was prepared in conjunction with the technical assessment study. The purpose of this cost assessment was to provide indicative costs per unit volume of waste for the potential long-term management options.

The cost estimate was developed in accordance with the Association for the Advancement of Cost Engineering (AACE) cost estimating guidelines and recommended practices for a Class 5 cost estimate. A preliminary design basis and cost basis were established for each option based on publicly available information and input from subject matter experts in nuclear and non-nuclear industries. It is emphasized that this report was prepared for the relative cost comparison of different waste disposal options on a per-unit-volume basis and should not be used for the absolute cost estimate of the overall cost of individual options. Rolling Stewardship is presented as three sub-options (300, 500, and 1,000 years) for relative comparison with other options.

For each option, the lifecycle cost was determined through a bottom-up approach to cost estimating for each development phase (siting, regulatory approvals, design & construction, operation, decommissioning & closure, and monitoring). Common infrastructure and facilities were identified for each long-term management option (e.g., offices, utilities, security, etcetera) and were estimated on a general basis. Facilities-specific costs are also identified and estimated for each long-term management option. Costs that depend on facility size (i.e., total waste volume) were separated to identify variable costs. Fixed and variable costs were separately estimated to determine the economy of scale each facility type if the facility design inventory changes from the reference scenario.

The study assumes that new waste management facilities will be built. For all facility types except for the Deep Borehole, the cost estimate assumed the site development would occur in a new greenfield environment, in an unspecified general location with good access to infrastructure and trades personnel, and at a reasonable distance from developed urban areas. Since Deep Boreholes were assumed to be built on existing waste management sites with existing infrastructure, utilities, and support amenities, the site development costs are excluded from the Deep Borehole estimates.

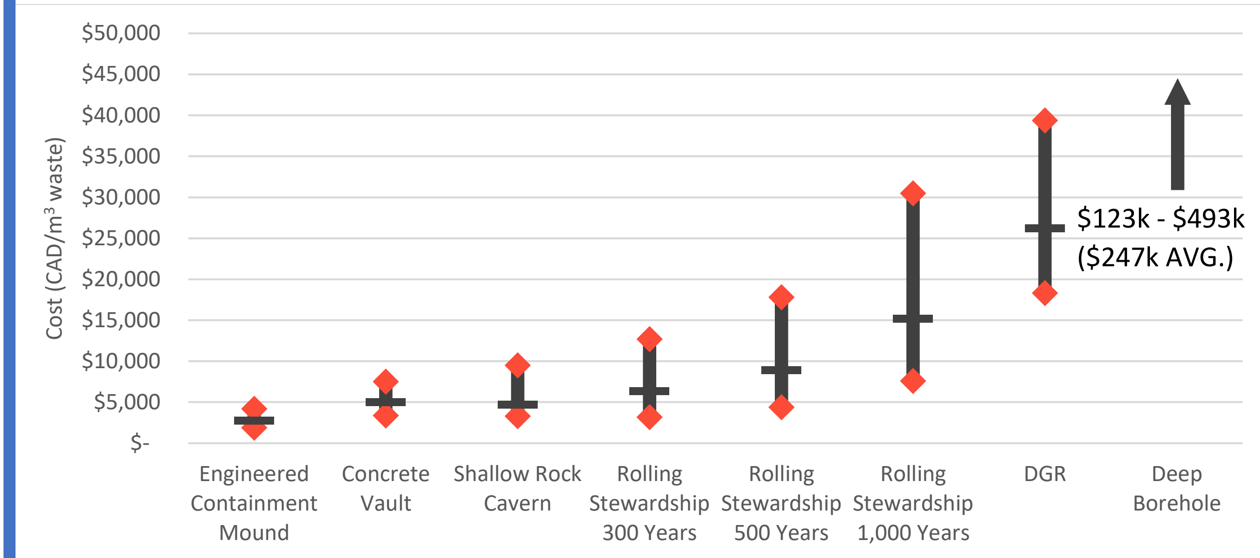


Figure 9: Cost Summary Graph of Each Long-Term Management Option, Including Accuracy Range

The waste volumes under the ISRW scope include current and future Canadian low- and intermediate-level waste that has no current long-term management plans, totalling approximately 294,000 m^3 of low-level waste and 51,000 m^3 of intermediate-level waste. The technical study showed that Rolling Stewardship, engineered containment mound, concrete vault, and shallow rock cavern are not suitable for the long-term management of intermediate-level waste. It is therefore assumed that the reference facilities for rolling stewardship, engineered containment mounds, concrete vaults and shallow-rock caverns are sized to host the low-level waste inventory, and the reference facilities for a deep geological repository (DGR) and deep boreholes are sized to host the intermediate-level waste inventory.

The cost estimate assumed the reference management scenarios and facility sizes for each option based on the recommendations made in the technical assessment report. It should be noted that the per-unit-volume cost of each long-term management facility benefits from economies of scale, and the results shown in this report can vary if the reference waste volume changes. The influence of economies of scale is shown, approximately, in Figure 10.

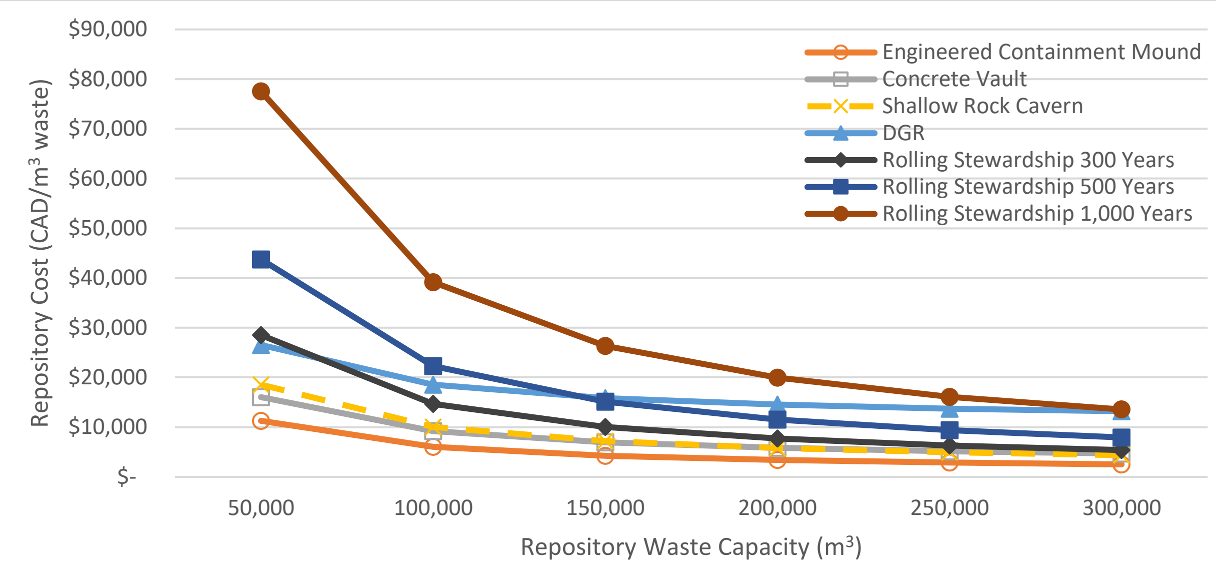


Figure 10: Indicative Effect of Changing Facility Size on Per-Unit-Cost (Accuracy Range and Deep Borehole Not Shown for Clarity)

As discussed previously, the four lowest cost options (Engineered Containment Mound, Concrete Vault, Shallow Rock Cavern, and 300-yr Rolling Stewardship) are only considered suitable for low-level waste. The Engineered Containment Mound was found to be the least expensive option, on average, but, as noted in the technical assessment, it may not be suitable for the entire low-level waste inventory. However, the accuracy ranges of all four options overlap, so further investigation and definition are recommended to confirm the most economical option as one of several option evaluation criteria.

For intermediate-level waste disposal, the Deep Borehole option was found to be approximately 10 times more expensive than the Deep Geological Repository (DGR) per unit volume of waste. Furthermore, the Deep Borehole option is only capable of disposing of part of the ISRW intermediate-level waste inventory. A Deep Geological Repository would be required to dispose of the remaining intermediate-level waste. Thus, the additional high cost of a Deep Borehole may not be suitable for intermediate-level waste under the ISRW scope.

Transportation costs and the implementation of a decentralized approach (i.e., multiple spread-out facilities) or a co-located approach (i.e., a single facility with one or more long-term management options) were not considered in this cost estimate. The cost associated with radioactive waste processing and/or conditioning is not considered as part of this estimate. However, a Deep Borehole repackaging plant is considered as part of this estimate since repackaging is necessary for the Deep Borehole to be feasible with the current ISRW waste inventory.

Chapter 4: ISRW Draft Strategy and Associated Recommendations

Context: In collaboration with waste producers and owners, government, Indigenous people, and interested Canadians, the NWMO focused on identifying gaps in current plans for the long-term management for radioactive waste and providing technical options to address these gaps. The resulting recommendations consider options for the number of long-term waste management facilities in Canada, as well as for the staging, integration, siting, establishment and operation of these facilities for all of the radioactive waste in Canada, regardless of how it was generated.

The Draft Strategy

This draft strategy represents a next step and builds on what we have heard from Canadians and Indigenous people. It is not intended to replace other projects currently in progress but rather includes these plans.

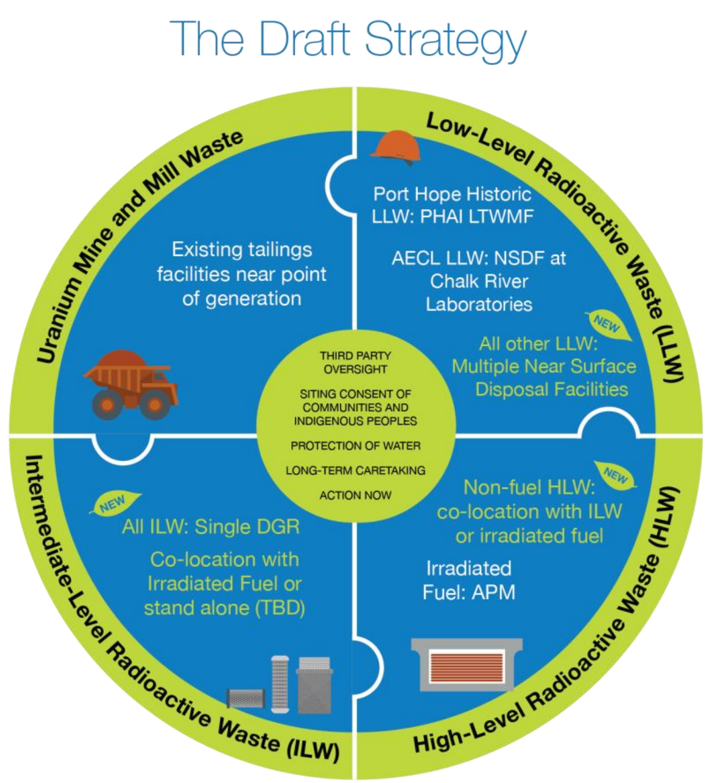


Table 6: Draft Integrated Strategy for Radioactive Waste

Waste Type		Long-Term Plan	Responsibility for Implementation	Status
Uranium Mine and Mill Waste		Tailings Facilities near point of generation	Uranium Mining Companies	Existing Facilities
Low Level Waste (LLW)	Port Hope Historic low-level radioactive waste	Port Hope Area Initiative Long-Term Waste Management Facility (PHAI LTWMF)	Canadian Nuclear Laboratories (CNL)	Existing Facilities
	Low-level waste owned by Atomic Energy of Canada Limited (AECL)	Near Surface Disposal Facility (NSDF) at Chalk River Laboratories	Atomic Energy of Canada Limited	Ongoing project (under regulatory review)
	All other low-level waste –	Multiple near surface disposal facilities	Waste owners	New project recommended as part of ISRW
Intermediate Level Waste (ILW)		Single Deep Geological Repository (DGR) – colocation with irradiated fuel or stand alone to be determined	Nuclear Waste Management Organization (NWMO)	New project recommended as part of ISRW
High-Level Waste (HLW)	Irradiated Fuel	Adaptive Phased Management (APM) Deep Geological Repository (DGR)	Nuclear Waste Management Organization	Ongoing project (in site selection)

Uranium Mine and Mill Waste

More than 200 million tonnes of uranium mill tailings have been generated in Canada since the mid-1950s. There are 25 tailings sites in Ontario, Saskatchewan and the Northwest Territories, 22 of which no longer receive waste material. The three remaining operational tailings management facilities are located near the point of waste generation in Saskatchewan. (Refer to Appendix A for more information on existing tailings management facilities).

At this time, there are no gaps, and no additional facilities are recommended as part of the ISRW.

Low-Level Waste

The long-term management of some of Canada's low-level waste is being addressed by existing facilities or projects undergoing regulatory reviews. Through the Port Hope Area Initiative, Canadian Nuclear Laboratories manage 1.7 million m^3 of historic low-level waste from in engineered above ground mounds. In addition to the Port Hope Area Initiative, CNL has submitted a licence application for the construction and operation of a Near Surface Disposal Facility (NSDF) at the Chalk River Laboratory site. The proposed disposal facility will be an engineered containment mound that will hold up to 1 million m^3 of low-level waste. (Refer to Appendix A for more information on the Port Hope Area Initiative and the Near Surface Disposal Facility projects)

To address the remainder of Canada's low-level waste, multiple near-surface disposal facilities are recommended as part of the ISRW.

Intermediate-Level Waste

Solutions are needed for all of Canada's intermediate-level waste. To address the long-term management of the intermediate-level waste, a single deep geological repository (DGR) is recommended as part of the ISRW.

High-Level Waste

High-level radioactive waste is primarily used nuclear fuel. The Nuclear Waste Management Organization is mandated under the *Nuclear Fuel Waste Act* to develop and implement a long-term solution for used nuclear fuel from Canada's reactors. Adaptive Phased Management (APM) is the name of Canada's plan for the long-term management of used nuclear fuel. It consists of the centralized containment and isolation of Canada's used fuel in a deep geological repository in an area with suitable geology and an informed and willing host.

However, there are also small amounts of non-fuel high-level radioactive waste in Canada. To address the non-fuel high-level waste, disposal in a deep geological repository (DGR) along with the intermediate-level waste is recommended as part of the ISRW.

Implementation of the Strategy

In addition to the technical options recommended to address the long-term management of the waste, the ISRW contains recommendations for its implementation. Overall, people have expressed a desire to see a third-party oversee the implementation of the Strategy with input from external parties such Indigenous peoples, regulators, experts, academics and civil society organizations. The willingness of the communities, including Indigenous communities, was highlighted as a priority for any new waste facilities to be developed as part of the Strategy, as was ensuring the protection of water. People also expressed support for long-term caretaking of the facilities for as long as future generations deem it to be necessary, while emphasizing the need for this generation to implement long-term solutions for the waste now rather than deferring to future generations. This aligns with the draft *Policy for Radioactive Waste Management and Decommissioning*'s objective to have key elements of Canada's radioactive waste disposal infrastructure in place and planning well under way for the remaining facilities necessary to accommodate all of Canada's current and future radioactive wastes by 2050.

The ISRW recommendations are discussed in greater detail below.

Proposed Recommendations for the Implementation of the Strategy

The following recommendations consider the inputs obtained from international benchmarking, stock taking, technical and cost estimate assessments, and all engagement activities. These recommendations when taken along with the existing disposal projects in operation or undergoing regulatory assessments at the time of writing form a complete strategy to address all existing and future waste in Canada.

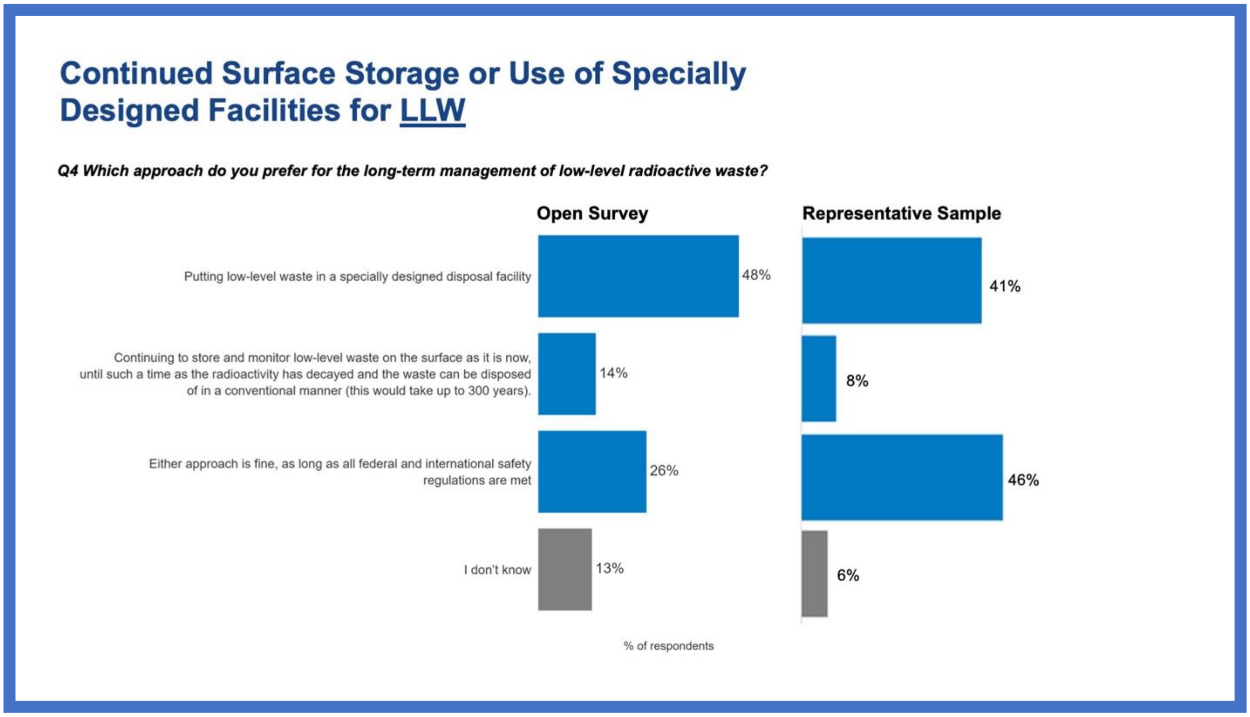
See Appendix B, Matrix of Input from Engagement Activities, by Participant Grouping to see the contributions of various participant groups to the development of themes and ideas captured within the recommendations.

Recommendation 1: Low-level waste should be disposed of in multiple near-surface facilities with implementation resting with the waste owners

Disposal of low-level waste aligns with international best practices and was preferred by the majority of participants, over rolling stewardship. From a technical, financial and societal point of view, near-surface disposal is the best option to contain the waste until it no longer poses a hazard. Near-surface disposal options were assessed as suitable for Canada’s low-level waste from a technical perspective. They are also the most affordable options from an economic perspective.

From the engagement, participants expressed that near surface disposal for low-level waste is an acceptable approach because low-level waste has lower risk and a shorter period in which it is hazardous. Some participants expressed that placing low-level waste deep underground was not commensurate with the lower level of risk, technical requirements, and international practice. They were also of the opinion that over engineering facilities would not be fiscally responsible and that it would be difficult to justify the cost of deep geological disposal for low-level waste. Some felt that there are lessons to be learned from the management of conventional waste, where Canada’s expertise in low hazard landfills is recognized. We also heard participants were comfortable with storing low-level waste both at surface level and at a shallow depth below surface level in purpose-built disposal facilities.

From a quantitative point of view, a strong plurality of respondents, 48% in the open survey and 41% in the representative sample, preferred that low-level waste be managed over the long-term using a specially designed disposal facility. In contrast, only 14% in the open survey (8% in the representative sample) opted for continued surface storage. 26% found either approach acceptable as long as all federal and international safety regulations are met, this number was however much higher in the representative sample at 46%.



The Concrete Vault and Shallow Rock Cavern emerged as suitable technical approaches to address all the low-level waste in the ISRW inventory. Either option is suitable from a technical perspective to accommodate all the low-level waste and would provide the greatest flexibility for future waste but the Shallow Rock Cavern option does require more specific site characteristics.

The Engineered Containment Mound was the option most often preferred from a societal and financial perspective; however, based on preliminary technical assessments and conservative assumptions, it was assessed to be suitable for only some of the ISRW inventory at this time. It could be suitable for a larger proportion of the low-level waste, contingent on more detailed analysis of the waste and its packaging. At this time, for the ISRW inventory, the Engineered Containment Mound could be considered in combination with one or both other two near-surface technical options.

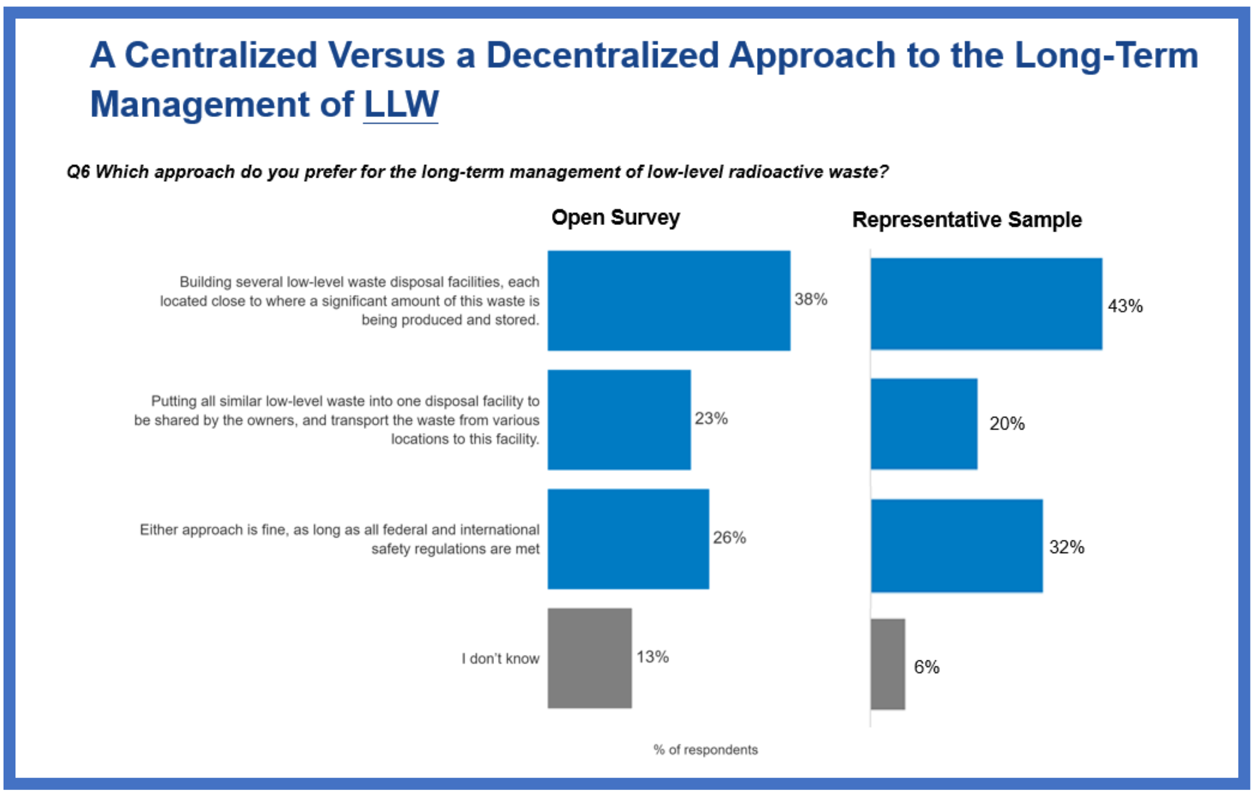
Multiple facilities were preferred from a societal point of view given the large volumes of waste and transportation considerations. Centralization does garner significant support as well and, financially, economies of scale may favour this approach. Further detailed analysis including the cost of transportation is needed.

The concept of regional facilities should be further explored to minimize the number of facilities and the distances that the waste would need to be transported. The regional concept may also play a pivotal role in ensuring that there are disposal facilities available to small waste generators. Regional facilities could be provincial, cover multiple provinces or multiple facilities within one province, depending on several factors such as volume of waste, transportation distances and cost. Further study is recommended.

When discussing centralization vs. decentralization of management and disposal facilities, many participants expressed a concern around ensuring equitable distribution of the responsibility and the risks from these facilities. They wanted to ensure that this burden is not placed on some communities over others and having several waste sites would contribute to social justice, with waste stored near to where it is produced. Some participants expressed that a single facility would increase transportation costs and risks and that having multiple facilities would be a fairer approach to host communities who would share the burden of hosting waste. Other participants identified the risk of an event occurring with only one single repository for all of Canada's radioactive waste. They expressed concern that if all the waste were in a single location, the impact of an event could be more significant and thus preferred multiple locations.

Others favoured multiple locations to avoid long distance transportation. We heard from some participants that because there was a significantly higher volume of low-level waste versus intermediate-level waste, there should be more facilities for low-level waste. Participants felt that the further the waste is transported, the greater the risk of transportation accidents. Some youth favoured the strategy of building multiple facilities across Canada to help reduce these risks. Additionally, participants noted that given Canada's size – the transportation of low-level waste from across the country would not be environmentally sustainable.

From a quantitative point of view, 38% in the open survey and 43% in the representative sample, opted for a decentralized approach to the long-term management of low-level waste, building several low-level waste disposal facilities, each close to where a significant amount of waste is being produced and stored. Centralization garnered 23% in the open survey (20% in the representative sample). 26% found either approach acceptable as long as all federal and international safety regulations are met, this number was slightly higher in the representative sample at 32%.



With regards to the implementation, responsibility for low-level waste should remain with the waste owners working collaboratively to ensure that there are disposal facilities for all low-level waste, regardless of ownership or quantity. Collaboration will be key in the implementation of the regional concept and in ensuring that there are disposal facilities available to small waste generators.

Through the engagement, we heard from several participants that the organizations producing waste today may be best positioned to take on a greater responsibility as part of the ISRW strategy implementation, because they would understand the type of waste they are producing. Some participants noted that they would be open to waste producers implementing the strategy under supervision and oversight from the government, with the waste owners responsible for their strategy and selecting the specific technology for the disposal of their waste considering the inventory, siting, geology, and waste characteristics. Having an oversight body in place to ensure that the waste is safely managed, solve problems, and enforce proper rules was seen as beneficial. However, participants also stated that, in the past, waste owners were only self-interested and not willing to take other waste regardless of proximity. We heard that key producers of small to modest volumes of waste are unlikely to have the capacity to implement the requisite waste facilities, so it is crucial that whoever implements the strategy must provide access to the small waste generators.

Some participants expressed the need for everyone to collaborate on the implementation of the strategy, but that it may not be ideal for a single entity to be responsible. They felt that shared responsibility is important and needs to be nationally aligned, with different companies coming together in a collaborative approach. Industry should retain responsibility for the implementation of the strategy with appropriate approvals and oversight by a trusted independent arms-length organization.

From a quantitative point of view, although we see a clear preference among Open Survey respondents (by a ratio of 5:1) and the Representative Sample Survey for creating an organization separate from the waste owners to implement the Canada’s strategy for the long-term management of low- and intermediate-level waste, the phrasing of the question did not allow respondents to provided different answers for different waste types. In fact, some people believe that different approaches could and should be used for low-level waste and intermediate-level waste, given that the latter requires containment for longer time periods. Thus, waste owners could continue to manage low-level waste, but a more collective approach could be used for intermediate-level waste (as it is for used nuclear fuel, which has a single implementer to advance Canada's plan).

WHAT DO YOU THINK?

Do you think of the concept of regional facilities for the disposal of low-level waste should be pursued? If so, do you think regional facilities should serve one or more provinces, multiple facilities in a defined geographic area or another grouping configuration such as Eastern, Central, and Western Canada?

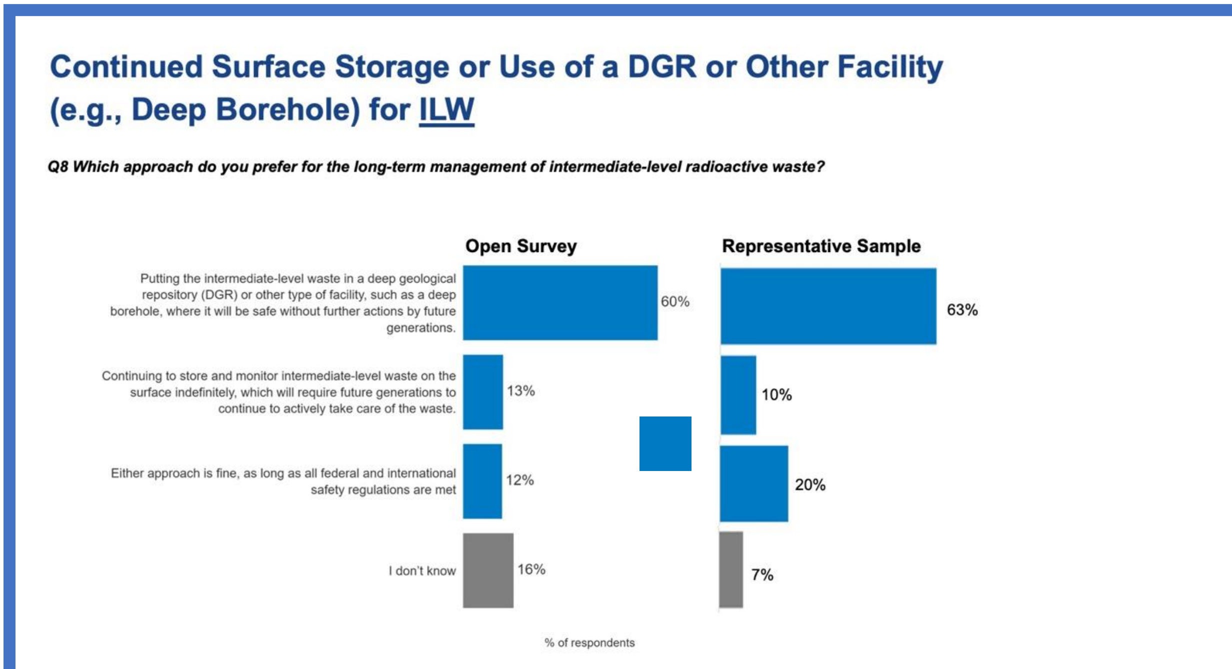
Some waste owners have only small quantities of low-level waste to manage. How do you think we can best ensure that all low-level waste has a long-term plan, while keeping costs and the number of facilities to a manageable number and maintaining the responsibility for implementation with the waste owners?

Recommendation 2: Intermediate-level waste should be disposed of in a single deep geological repository (DGR) with implementation by a single organization, the NWMO

Disposal of intermediate-level waste aligns with international best practices and was preferred over rolling stewardship by the majority of participants. From a technical and societal point of view, disposal of intermediate-level waste in a Deep Geological Repository (DGR) emerged as the best option to isolate the waste from the environment. This approach would also be able to accommodate non-fuel high-level waste.

Participants expressed a preference for technical options that would have the least environmental impact. They felt that options which place waste underground or that can be restored or covered with vegetation appear to address this priority of environmental impact. Minimizing visual impacts was also highlighted as an important consideration especially from participants that have seen other types of industrial facilities near where they live.

From a quantitative point of view, a majority of respondents, 60% in the open survey and 63% in the representative sample, preferred that intermediate-level waste be managed over the long-term using a specially designed disposal facility, deep underground. In contrast, only 13% in the open survey (10% in the representative sample) opted for continued surface storage. 12% in the open survey (20% in the representative sample) found either approach acceptable as long as all federal and international safety regulations are met.

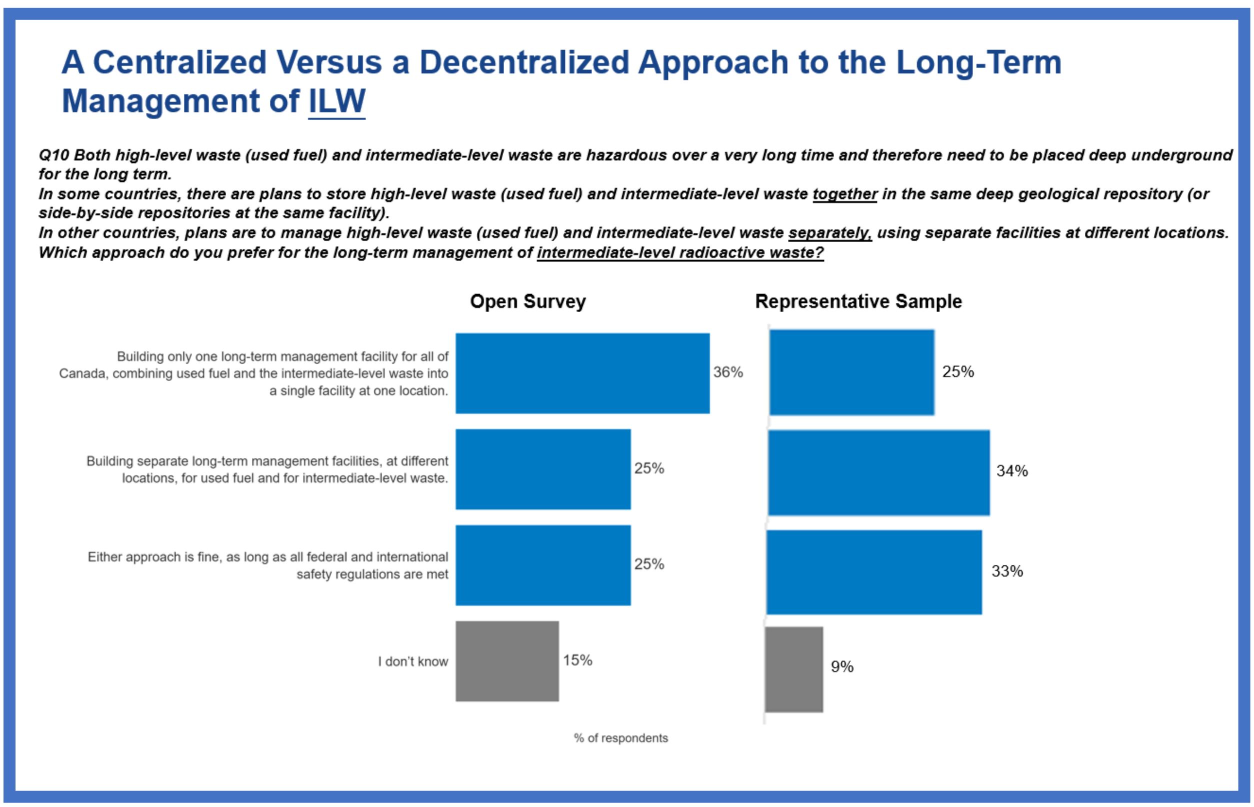


We heard that having one central place in the country for intermediate level waste would be preferable to several regional facilities. From a societal perspective, co-location with high-level waste in a technically suitable site with willing host communities has the same level of support as a separate Deep Geological Repository for intermediate-level waste. From a financial perspective, co-location with high-level waste is the most economical option.

From the engagement, some participants expressed it could be acceptable for some of the intermediate level waste to go into the same deep geological repository as high-level waste (co-location). Participants stated that co-location with high-level waste makes sense financially and is currently done in other parts of the world. We also heard that because of the low volume of intermediate-level waste in Canada (less than 1% of the total waste volume), it should be combined with high-level waste for permanent disposal rather than at a separate disposal facility.

Other participants expressed a preference for one community hosting a single site for low-level waste, and another community hosting a single site for intermediate-level waste. We also heard that a single distinct intermediate-level waste disposal facility could potentially be more socially acceptable than a combined facility, or multiple facilities for intermediate-level waste. Some participants felt having a separate deep-disposal site was the best option for high-level waste and intermediate-level waste. Some had questions about the technical viability of mixing intermediate level and high-level waste. In all instances, participants identified community consent as necessary.

From a quantitative perspective, a 36% plurality of respondents in the open survey preferred a centralized co-located option, which involves transporting intermediate-level waste to a single disposal facility that would also house both used nuclear fuel and intermediate-level waste. In contrast, 25% opted for a facility separate from used nuclear fuel for the long-term management. Almost one-quarter thought either approach is fine, as long as all federal and international safety regulations are met. This is one of the few instances where the results of the Open Survey differ from those of the Representative Sample Survey. In the latter, building distinct facilities at separate locations was the most popular (selected by 34%), while co-location of intermediate-level waste with used nuclear fueled was preferred by only 25% of the respondents. We also found a higher proportion of these respondents were ambivalent about the direction to take (33%).



Given that all intermediate-level waste would be disposed of in a single facility, a single, dedicated implementer would provide the greatest efficiency, as it is for used nuclear fuel. With its structure and its expertise in deep geological repositories, the NWMO is recommended as the implementer for intermediate-level waste. the waste owners would maintain the responsibility for funding the long-term management of intermediate-level waste, as outlined in the draft *Policy for Radioactive Waste Management and Decommissioning*.

Some participants expressed support for the NWMO to play this role, emphasizing the importance for joint responsibility between a federally mandated, arms-length body and waste owners, where waste owners fund the projects. They stated that this organization should take on Canadian best practices and international best practices that would not be impacted by elections or political process. We heard that a government regulated central body would alleviate public concerns. We also heard that to implement the strategy effectively, any organization needs to be independent of the regulator, independent of government and free from government interference, while following policy and regulations.

Participants were comfortable with an independent central agency, preferably not-for-profit, in charge of handling the waste, a single entity that has the community's trust and federal support with a board of directors comprising diverse stakeholder representation.

WHAT DO YOU THINK?

Given that co-location with used fuel garners the same level of support as a Deep Geological Repository in a separate location, what do you think should be considered in selecting an option, provided that there is consent from the potential host communities?

Recommendation 3: A third-party organization, independent of the implementing organizations, should oversee the implementation of the strategy

In alignment with the revised federal *Policy for Radioactive Waste Management and Decommissioning*, waste owners must retain responsibility for funding, planning, development and operation of their radioactive waste disposal sites. In the development of the ISRW, there was also considerable support expressed for independent oversight of the implementation of the strategy for radioactive waste, as well as for the greater ongoing involvement of interested parties throughout the lifecycle of the facilities.

Trust in the governance structure was important to public support and confidence. Decisions should include input from industry, Indigenous peoples and civil society organizations representation. It was noted that it is important to solicit input from experts and industry and just as important to dialogue with Indigenous communities when creating and implementing sites for storage over the long-term.

From an engagement perspective, the importance of collaboration among multiple stakeholders was underlined and the key roles to be played by the federal, provincial and municipal governments, Indigenous communities and the waste producers were highlighted. We also heard that provincial or the federal governments should play an active role and have a coordinated approach with those who currently manage the waste.

We heard that government, province, and utilities must ensure that all the parties are accountable to do their part, and together achieve a common goal. Some participants expressed that the current arrangement, where waste owners are individually responsible for waste management, perpetuates storage rather than a permanent disposal solution.

Finally, we heard that, before the ISRW is finalized, that the federal government and the provincial governments should agree on it. The involvement of a central agency was identified as important since key producers of small to modest volumes of waste are unlikely to have the capacity to implement the requisite waste facilities, so it is crucial that access to the small volume producers is ensured. This access is a key enabler to non-power nuclear uses and innovation in the areas of nuclear medicine, industrial applications, and research. A body with an oversight function could enforce or legislate a framework for fee-for-service disposal, ensure access for producers of small to modest volumes of waste.

WHAT DO YOU THINK?

What mechanisms do you think should be used for tracking the progress of the implementation of the Integrated Strategy?

Do you think an advisory committee would be helpful and if so, who do you think should be on it?

Recommendation 4: Consent of the local communities and Indigenous peoples in whose territory future facilities will be planned must be obtained in siting

This consideration was prioritized by the majority of contributors. It is also aligned with the objectives of Canada's draft *Policy for Radioactive Waste and Decommissioning*, in relation to the implementation of United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

This recommendation extends to the possible co-location of intermediate-level waste with used fuel (see Recommendation 2). This option would necessitate discussions with the core communities in the siting areas for the used fuel repository to understand their expectations around consent.

From an engagement perspective, it was imperative that Indigenous peoples be involved with the implementation of the strategy along with the other players in the industry and any projects being planned or operating. Indigenous communities in siting areas must have continuous involvement in all phases of any radioactive waste management project regardless of size. In addition, laws and regulatory processes developed and implemented by Indigenous peoples in areas where facilities will be planned should be respected and incorporated as part of the ISRW implementation.

WHAT DO YOU THINK?

How do you think can we best ensure the involvement of local Indigenous peoples in all phases of radioactive waste management projects?

Recommendation 5: Design of facilities should prioritize the protection of water

While the safety of the various technical options can be demonstrated from a technical standpoint for a variety of locations, it may be difficult to obtain societal support for facilities located in close proximity to major sources of drinking water. There were concerns about the perceived danger radioactive waste poses to humans and the risk when transporting and housing waste near waterways. Indigenous youth participants, in particular, underlined the importance of protecting water, including groundwater.

While participants indicated that facilities should be located away from any major water sources, the reality of the Canadian landscape is that this would not be feasible. Protection of water is paramount, and therefore any disposal facilities must meet the highest standards of environmental and water protection. Sources of potable water should be protected, and oceans should not be considered an option for any nuclear development, disposal or storage, now or in the future.

WHAT DO YOU THINK?

The safety of the various technical options can be demonstrated from a technical standpoint for a variety of locations, including near bodies of water. What information would be helpful to you to feel confident in the safety of the facilities?

Recommendation 6: Long-term caretaking should be established for disposal facilities

There should be oversight of the waste and of the facilities for as long as future generations deem it to be necessary to ensure that the environment remains protected. This concept also includes the transfer of knowledge of the waste and where it is located with future generations and ensuring that the waste is not forgotten. Roles should be created and included for future generations to ensure continuity and to monitor waste. These roles should include the periodic review of the monitoring plans, to determine whether they continue to be adequate or necessary.

Regardless of the option selected, most participants supported the implementation of environmental monitoring over the long term. They felt that stewardship and monitoring of the environment and of the waste from generation to generation is required. Since nuclear stations and existing waste facilities are located on Treaty territory, Indigenous communities should be leading conversations around land stewardship. These communities possess Indigenous Traditional Knowledge and should be at the forefront of any development that may disturb the land, threaten waters, and impact traditional uses. It should also be ensured economic benefits are shared with the local consenting communities.

WHAT DO YOU THINK?

What do you think would be the best mechanism to ensure oversight of the waste and of the facilities for as long as future generations deem it to be necessary?

Recommendation 7: We need to take action now and not defer to future generations

One of the objectives of the draft revised Policy for Radioactive Waste and Decommissioning is to have key elements of Canada's radioactive waste disposal infrastructure in place and planning well under way for the remaining facilities necessary to accommodate all of Canada's current and future radioactive wastes by 2050. In the development of the strategy, participants told us that there is a need for a strategy that is integrated, and that the approach to the long-term management of low-level and intermediate-level waste should be determined.

There was general agreement that the right thing to do was to have and to implement a plan for all of Canada's radioactive waste, and to do so with a sense of urgency rather than leaving this to future generations. This is consistent with the input received 20 years ago by the NWMO as part of the study on the long-term management of used fuel.

The implementation of the ISRW will require firm on-going commitment and support from government, with a structure that will be empowered to deliver on the objectives of the strategy regardless of changes in government.

WHAT DO YOU THINK?

How do you think that we can ensure that we deliver on the objectives of the strategy regardless of changes in government?

Additional Recommendations Outside of the Scope of the ISRW

The ISRW did not consider options for additional waste processing, including volume reduction, beyond those planned and quantified by the waste owner. Subject to future study, the Integrated Strategy for Radioactive Waste may benefit from a holistic approach to upstream waste processing. Furthermore, an integrated approach may open avenues of waste processing resulting from economies of scale for waste processing options that have not yet been accessible for smaller waste owners.

Appendix A

Status of Long-Term Waste Management Projects in Canada

Adaptive Phased Management

In 2002, the Government of Canada mandated the establishment of the NWMO through the Nuclear Fuel Waste Act. The NWMO is an independent, non-profit organization that is funded by the waste owners in Canada: Ontario Power Generation, New Brunswick Power, Hydro-Québec, and Atomic Energy of Canada Limited. The NWMO has been progressing the implementation of its long-term management strategy for used nuclear fuel from Canada's nuclear reactors; thus used nuclear fuel was excluded from the scope of the ISRW.

Currently, Canada's used nuclear fuel is stored at licensed, above-ground facilities. While this approach is safe, it is widely recognized as inappropriate over the long term. Canadians and Indigenous peoples have clearly expressed that they recognize the importance of taking action on a long-term solution today and not leaving it for future generations.

Canada's plan for used nuclear fuel, known as Adaptive Phased Management (APM), emerged through a three-year dialogue with specialists and the public. It is based on the values and objectives they identified. In 2007, the Government of Canada selected APM as the country's plan and directed the NWMO to implement it.

A significant milestone is now on the horizon for the NWMO, as it expects to select the site for the deep geological repository in 2024. Initially, 22 communities expressed interest in learning more about the project and exploring their potential to host it. Over the course of the past decade, the NWMO has narrowed down the potential siting areas to just two, both located in Ontario – the Wabigoon-Ignace area in the northwest and the SON-South Bruce area in the south.

APM includes a technical plan, as well as a phased and flexible implementation plan.

It is both a technical method (what we plan to build) and a management system (how we will work with people to get it done). The technological approach involves developing a deep geological repository in a suitable rock formation to safely contain and isolate used nuclear fuel. The management system involves phased and adaptive decision-making, supported by public engagement and continuous learning.

The project will only proceed in an area with informed and willing hosts. Together with the potential siting areas, we continue to explore the potential for partnership and look at how the project could enhance community well-being.

The work the NWMO is conducting today is laying the foundation for a transition to a new series of activities once a preferred site is selected. It will then initiate regulatory processes, construct a Centre of Expertise and begin to transition operations to the site.

The deep geological repository uses a multiple-barrier system designed to safely contain and isolate used nuclear fuel over the very long term. Constructed more than 500 metres below ground, the repository will consist of a network of placement rooms that will store the used nuclear fuel.

At the surface, there will be facilities where the used fuel is received, inspected and repackaged into purpose-built containers encased in a buffer box, before being transferred to the main shaft for underground placement. There will also be facilities for administration, quality, security, processing of sealing materials, and ongoing operation of the site.

The repository will include a centralized services area that will allow for underground ventilation through three shafts located within a single, secure area. The layout also includes multiple access tunnel arms that will let our technical specialists situate the placement rooms in areas with the most suitable rock. The buffer boxes will be arranged in the horizontal placement rooms, and any spaces left over will be backfilled with bentonite pellets.

To prepare for the regulatory decision-making process and construction, the NWMO has begun work on site-specific conceptual designs of the repository layout based on information from geoscience assessments and initial borehole drilling in the potential siting areas. This is an iterative process – as the NWMO develops additional site-specific information, we will continue to evolve the design of the repository. The proposed site in the Wabigoon-Ignace area would be located in crystalline rock, and in the SON-South Bruce area, it would be in sedimentary rock.

Rigorous safety standards govern the project. The NWMO has committed to meet or exceed all applicable federal and provincial regulatory requirements to protect the health, safety and security of people and the environment for generations to come.

A series of engineered and natural barriers will work together to safely contain and isolate used nuclear fuel within the repository. Each barrier will provide a unique and stand-alone level of protection, while serving as a backstop to the last barrier. If any of these barriers were to fail, another would be there to ensure any dangerous materials remain contained or isolated.

The first barrier is the fuel pellet. Fuel pellets are a very stable, solid ceramic, made from highly durable baked uranium dioxide powder. They are stored end-to-end in long tubes made of a strong, corrosion-resistant metal.

The second barrier is the fuel bundle, made from a very corrosion-resistant material called Zircaloy, which contains a number of these tubes.

The third barrier is a copper-coated steel container. These containers are engineered to resist corrosion and are strong enough to keep the used nuclear fuel completely contained until its radioactivity decreases to safe levels. They are designed to survive underneath 3,000 metres of snow, ice and meltwater, 800 metres of rock and dirt, groundwater, and surrounding clay pressure.

The fourth barrier is a buffer box made of highly compacted bentonite clay that encases each container. Bentonite clay is a natural material proven to be a powerful barrier to water flow. It is very stable, as observed in natural formations that are hundreds of millions of years old. It also naturally prevents microbial growth, which will help maintain the integrity of the container over a long time.

The fifth barrier is the rock itself, which will protect the repository from disruptive natural events, water flow and human intrusion.

Canadian Nuclear Laboratories's Near Surface Disposal Facility, Nuclear Power Demonstration and Whiteshell Reactor In-situ Disposal Projects, and Port Hope Area Initiative

The greatest volume of radioactive waste managed by Canadian Nuclear Laboratories (CNL) is low-level waste. CNL has been progressing the implementation of its long-term management strategy for low-level waste from operational, decommissioning and environmental remediation activities; thus the low-level waste CNL manages on behalf of AECL was excluded from the scope of the ISRW.

CNL has submitted a licence application for the construction and operation of a Near Surface Disposal Facility at the Chalk River Laboratory site. The proposed disposal facility will be an engineered containment mound that will hold up to 1 million m3 of low-level waste and further enable the environmental cleanup mission underway at AECL-owned sites.

In addition to the Near Surface Disposal Facility (NSDF), CNL has proposed the in-situ disposal of the Nuclear Power Demonstration (NPD) and Whiteshell Reactor (WR-1), which will complete the decommissioning of these two below-grade reactors and ensure long-term safety of the public and the environment. The validity of managing the low- and intermediate-level waste at these two reactors through this proposed approach is demonstrated through a robust safety case and complies with all applicable regulatory requirements.

Near Surface Disposal Facility

The Near Surface Disposal Facility (NSDF) is a key facility required to enable Canadian Nuclear Laboratories (CNL) to conduct environmental remediation of contaminated soils and materials that are already present at the Chalk River Laboratories (CRL) site to protect the environment, including the Ottawa River. The NSDF has been specially designed as a permanent solution to reduce environmental risk and isolate low-level radioactive waste, in accordance with international guidance and regulatory requirements.

The NSDF will only hold low level radioactive waste. This waste consists of building materials – mainly from the revitalization underway at Chalk River Laboratories – contaminated soils, and general items such as discarded mops, protective clothing and rags that have become marginally contaminated. Ninety percent of the waste proposed for the NSDF is already at CRL, five percent comes from hospitals and universities, and five per cent comes from other licensed sites.

The main feature of the proposed facility will be an engineered containment mound with natural and synthetic barriers which are designed to work together to isolate the waste materials from the environment for more than 550 years, hundreds of years after the radioactivity of the waste will have decayed to levels found naturally in the environment.

The NSDF will also feature a wastewater collection and treatment system that will remove radiological and chemical contaminants so that the treated effluent is safe to humans and the environment for discharge. Treated wastewater will be sampled prior to discharge to the environment to ensure that discharge targets are met.

CNL will expand its already extensive environmental monitoring of CRL, the sampling of air, water and groundwater, to include the NSDF. The Environmental Assessment for the NSDF project does not predict any signifi-cant impacts to humans or the environment, with the implementation of mitigation measures. Ongoing monitoring of the NSDF and surrounding environment will confi-rm these predictions and the effective use of the mitigation measures.

The proposed facility would be licensed under the *Nuclear Safety and Control Act*, and subject to the associated regulations and independent regulatory oversight from the Canadian Nuclear Safety Commission. A two-part public hearing on the Environmental Assessment and the application to authorize the construction of the NSDF took place in the first half of 2022. At the time of writing of this report, a decision is pending.

Nuclear Power Demonstration Facility

CNL is proposing to complete the closure of the Nuclear Power Demonstration (NPD) facility, ensuring the long-term safety of humans and the environment. The proposed approach is to demolish the above grade structure and place the debris into open areas in the below grade structure, then to fill the entire facility with grout to convert it into a permanent disposal facility. This technique is known as in-situ disposal as the waste remains in place, avoiding handling, shipping, and building another storage facility elsewhere. In situ disposal completes the decommissioning and contains and isolates the remaining empty systems and components below grade in bedrock.

Currently, this project is in the middle of a federal environmental assessment. The Canadian Nuclear Safety Commission has requested that CNL provide further revisions to information provided in the revised draft Environmental Impact Statement for the Nuclear Power Demonstration (NPD) Closure Project. CNL submitted the revised draft Environmental Impact Statement to the CNSC in December 2021 for a completeness check, which is a part of the ongoing federal environmental assessment for this in-situ disposal project.

CNL is closely examining the regulatory feedback and reassessing the Environmental Impact Statement submission. This feedback was specific to Indigenous content. CNL will continue to work with Indigenous communities and public stakeholders to ensure interests and concerns are reflected in the revised EIS and addressed by the project.

Once the completeness check has been achieved, the next step in the environmental assessment process is a technical review by Indigenous, federal and provincial representatives. More information on the milestones in the environmental assessment process can be found in Appendix A of the Administrative Protocol.

CNL is endeavouring to submit a final Environmental Impact Statement, incorporating all comments provided by the public, Indigenous communities, interest groups, and federal and provincial bodies since 2015, in late 2022.

Whiteshell Reactor 1

The decommissioning of Whiteshell Laboratories began in 2003, after the Canadian Nuclear Safety Commission approved an overall decommissioning framework and then issued a site decommissioning licence. Since that time, redundant buildings have been demolished, and new enabling facilities for waste handling have been constructed. The next major step in the plan is the decommissioning of the Whiteshell Reactor 1 (WR-1) itself, one of the largest and most complex facilities on the site.

CNL is proposing to decommission and leave the reactor in place at the Whiteshell site. All fuel and liquids have been removed, and what remains are the structural components of the reactor, such as the vessel and piping.

CNL's proposed approach – in-situ decommissioning – minimizes the risks to the health, safety and security of the public, workers and the environment. It avoids the necessity of transporting contaminated components and finding another location and facility for disposal.

The proposal for that project was sent to the Canadian Nuclear Safety Commission for approval in 2017. CNL has submitted the next revision of the WR-1 Project's Environmental Impact Statement to the Canadian Nuclear Safety Commission for regulatory review in 2020, after completing further work to address the comments on the draft Environmental Impact Statement, incorporating feedback from Indigenous Peoples, the public and federal and provincial regulators.

Port Hope Area Initiative

CNL has also made significant progress on the Port Hope Area Initiative (PHAI), which involves the cleanup of approximately 1.7 million m^3 of historic low-level waste from various sites in Port Hope and Port Granby. The historic low-level waste is being emplaced in engineered above ground mounds where the waste will be safely contained, with ongoing long-term monitoring and maintenance of the new facilities into the future.

The Port Hope Area Initiative represents the Government of Canada's commitment to the cleanup and safe, local, long-term management of historic low-level radioactive waste in two Southern Ontario municipalities – Port Hope and Clarington. The waste is the result of radium and uranium processing in Port Hope between 1933 and 1988 by the former Crown corporation Eldorado Nuclear Limited and its private-sector predecessors.

The Port Hope Area Initiative is based on community-recommended solutions for the cleanup and safe long-term management of approximately 1.7 million cubic metres of low-level waste. It is currently one of Canada's largest environmental remediation projects.

The Port Hope Area Initiative is being carried out as two projects – the Port Hope Project and the Port Granby Project. Each project has three phases: Phase 1 – planning/regulatory approval, Phase 2 – implementation and Phase 3 – long-term monitoring and maintenance. Both projects are currently in Phase 2.

Through its Historic Waste Program Management Office, Canadian Nuclear Laboratories is implementing the PHAI on behalf of Atomic Energy of Canada Limited, a federal Crown corporation. The HWP MO brings together a diverse and specialized staff from government, private industry and consulting backgrounds in fields such as engineering, environmental sciences, industrial safety, financial management, contract administration, communications and scheduling to implement the projects.

The Port Hope Long-Term Waste Management Facility is located in the Municipality of Port Hope. The facility provides safe, long-term storage for approximately 1.2 million cubic metres of historic low-level radioactive waste being cleaned up in the community as part of the Port Hope Project. The Port Granby long-term waste management facility is situated in Port Granby.

Each long-term waste management facility includes an engineered aboveground mound to isolate the historic low-level radioactive waste by securely encasing it on the top, bottom and sides with thick, multiple layers of natural and specially manufactured materials.

These layers form components of the cover and baseliner that, independently, are robust enough to prevent contaminants from entering the environment. Together, they function as multiple back-up safety systems.

The multi-component cover system will reduce surface water infiltration through the waste, provide protection of the mound from inadvertent intrusion into the waste, and reduce levels of gamma radiation on the surface of the mound to background levels.

Monitoring systems are installed within the mound and around the perimeter of the long-term waste management facility site.

Uranium Mines and Mills

(Adapted from Appendix 6 of Seventh Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management)

Waste owners are operating long-term management facilities for Canada's waste from uranium mines and mills waste; thus uranium mines and mills waste was excluded from the scope of the ISRW.

Key Lake

McArthur River ore is processed at the Key Lake mill. The McArthur River mine and Key Lake mill suspended production for an indeterminate period and have been in care-and-maintenance since January 2018. Uranium mills and operational tailings management facilities exist at Key Lake. Non-operational tailings management areas are located at Key Lake.

Tailings management

The purpose of tailings management at Key Lake is to isolate and store the waste residue from the milling process so that the public and the environment are protected from any future impact. Conceptually, this effort involves containing the solids and treating the water to achieve quality standards acceptable for release to the environment. The waste metal precipitates removed during water treatment are disposed of as solids in the tailings management facility.

From 1983 to 1996, waste from the Key Lake mill was deposited in an above-ground tailings management facility that covered an area 600 m by 600 m (36 hectares) and 15 m deep. The tailings management facility was constructed five metres above the groundwater table using engineered dikes for perimeter containment and a modified bentonite liner to seal the bottom and isolate the tailings from the surrounding soil infrastructure.

Since 1996, the mined-out Deilmann open pit has been used as the tailings management facility. Commissioned in January 1996, it is used to store tailings produced by milling a blend of McArthur River ore and special waste from McArthur River and Key Lake. The tailings management facility has a bottom drainage layer constructed on top of the basement rock at the bottom of the mined-out pit. Tailings are deposited on top of this drainage layer and water is continually pumped out to promote the solids consolidation of overlying tailings.

Tailings were initially deposited into the pit by sub-aerial deposition, with water extracted from the tailings mass through the bottom drain layer and the raise well pumping system. The facility later changed to sub-aqueous deposition by allowing the pit to partially flood.

Tailings are deposited under the water cover using a tremie pipe system which offers benefits in terms of the placement and attenuation of radon emissions. In this system, tailings are placed in the mined-out pit using a "natural surround" containment strategy. The residual water extracted from the tailings mass is collected for treatment. The consolidated tailings form a low-permeability mass relative to the higher-permeability area surrounding the tailings.

After decommissioning, groundwater will follow the path of least resistance (i.e., around the tailings rather than through them), which minimizes environmental impacts. At the end of 2019, the Deilmann tailings management facility contained 6.18 million tonnes of tailings.

Waste rock management

Waste rock management facilities include two special waste storage facilities and three waste rock storage areas. The waste rock disposal areas comprise primarily benign rock and therefore do not have containment or seepage collection systems. The special waste contains low (uneconomic) levels of uranium and other potential contaminants, so this material is contained in engineered facilities that consist of underliners and seepage collection systems. While operating, material from the special waste areas is reclaimed for blending with high-grade McArthur River ore for the Key Lake mill feed. All other waste rock areas are inactive.

To reduce the decommissioning liability associated with the Deilmann north waste rock pile, approximately 1.3 million m3 of nickel-rich waste rock were excavated and disposed of in the Gaertner pit in 1998. In addition, an additional 300,000 m3 was processed and used in the Deilmann tailings management facility west wall stabilization project in 2013. Similarly, in 2017, a total of 57,320 m3 of nickel-rich waste rock was removed from the Gaertner waste rock pile and placed on the south bench of the Deilmann tailings management facility.

Rabbit Lake

Rabbit Lake entered an indefinite period of care and maintenance, suspending mining and milling operations in mid-2016. Uranium mills and operational tailings management facilities exist at Rabbit Lake. Non-operational tailings management areas are also located at Rabbit Lake.

Tailings management

The Rabbit Lake above-ground tailings management facility is about 53 hectares in area and contains approximately 6.5 million tonnes of tailings which were deposited between 1975 and 1985. These tailings are all derived from the processing of the original Rabbit Lake ore deposit. The tailings within the above-ground tailings management facility are confined by earth-filled dams at the north and south ends, and by natural bedrock ridges along the east and west sides. The above-ground tailings management facility is currently undergoing long-term stabilization and progressive reclamation.

The original Rabbit Lake open-pit mine was converted to a tailings management facility in 1986 using pervious surround technology. Since its commissioning, the Rabbit Lake in-pit tailings management facility has been used as a tailings repository for ore from the Rabbit Lake, B-zone, D-zone, A-zone and Eagle Point mines (see figures 6.2 and 6.3). At the end of 2019, the Rabbit Lake in-pit tailings management facility contained 9.13 million tonnes (dry weight) of tailings.

The pervious surround, consisting of sand and crushed rock, is placed on the pit floor and walls before the tailings deposition. The pervious material allows the excess water contained in the tailings to drain to an internal seepage collection system, and it allows the water contained in the surrounding host rock to be collected, which maintains a hydraulic gradient toward the facility during operations. The collected water is treated prior to its release to the environment. Upon final decommissioning and return to normal hydrogeologic conditions, groundwater will flow preferentially through the pervious surround rather than through the low permeability tailings. Discharge of contaminants will be limited to diffusion across the tailings/pervious surround interface.

Waste rock management

The Rabbit Lake site contains a number of clean and mineralized stockpiles of waste rock produced in the course of mining the various local deposits since 1974. Some of the waste rock has been used for construction material. For example, waste rock was used to construct the road and pervious surround for the Rabbit Lake in-pit tailings management facility. Eagle Point special waste is stockpiled on a lined storage pad until it is returned underground as backfill. Some waste rock piles were used as backfill and cover material in their respective pits. One rock pile, consisting primarily of Rabbit Lake sediments, has been contoured and vegetated.

Current projections are that no waste rock will remain on the surface at Eagle Point after the mining and backfilling of mined-out stopes is complete. The A-zone (28,307 m3 of clean waste) and D-zone (200,000 m3 of primarily lake-bottom sediments) waste rock piles have been flattened, contoured and vegetated. The B-zone waste pile contains an estimated 5.6 million m3 of waste material stored on a pile covering an area of 25 hectares. The B-zone pile was contoured and reclaimed through the installation of an engineered cover followed by a one-metre till cover, complete with vegetation and drainage channels to promote controlled runoff. All the special waste from the A-zone (69,749 m3), B-zone (100,000 m3) and D-zone (131,000 m3) open-pit mines was returned to the pits and covered with layers of waste rock and/or clean till before the mined-out pits were allowed to flood.

There are approximately 6.89 million m3 of predominantly sandstone waste rock with some basement rock and overburden tills stored on the West 5 waste rock pile adjacent to the Rabbit Lake in-pit tailings management facility. Mineralized waste is stored on four piles (630,000 m3) adjacent to the Rabbit Lake mill. Runoff and seepage from these areas are collected in the Rabbit Lake in-pit tailings management facility.

McClean Lake

Uranium mills and operational tailings management facilities exist at McClean Lake.

Tailings management

McClean Lake is the only uranium mill constructed in North America in the last 20 years. The mill and tailings management facility feature state-of-the-art efforts for worker and environmental protection when processing high-grade uranium ore. Open-pit mining of the initial ore body (the John Everett Bates or JEB pit) began in 1995. After the ore was removed and stockpiled, the pit was developed as a tailings management facility (see figures 6.4 and 6.5). The design of the tailings management facility has been optimized for performance, both during operation and for the long term, by employing key features such as:

production of thickened tailings within the mill process (addition of lime, barium chloride and ferric sulphate) to remove potential environmental contaminants from the solution and yield geotechnically and geochemically stable tailings

transport of the tailings from the mill to the tailings management facility through a continuously monitored pipe-in-pipe containment system

final subaqueous tailings placement within the mined-out JEB pit for long-term, secure containment in a below-ground facility use of natural surround as the optimum approach for long-term groundwater diversion around the consolidated tailings plug

subaqueous tremie placement (from a floating barge) of the thickened tailings below a water cover in the pit; this method minimizes the segregation of fine and coarse material, prevents the freezing of the tailings and enhances radiation protection by using the water cover to attenuate radon emissions

a bottom filter drain feeding a dewatering drift and raise wells to allow collection and treatment of discharged pore water during tailings consolidation

recycling of pit water by floating barge and a pipe-in-pipe handling system

complete backfilling of the pit upon decommissioning with clean waste rock and a till cap

At the end of this reporting period (March 31, 2020), the JEB tailings management facility contained 2.244 million tonnes (dry weight) of tailings.

Waste rock management

Open-pit mining at McClean Lake has progressed from one pit to the next, and has included the JEB, Sue A, Sue B, Sue C and Sue E pits (see figures 6.6 and 6.7). Mining was completed at the Sue B open pit on November 26, 2008. Open-pit mining has not occurred at McClean Lake since the completion of Sue B.

The majority of the wastes removed from the JEB and Sue C open pits were overburden material or sandstone. The overburden and clean waste rock stockpiles are located near the pits. The pad for the waste rock stockpile has been constructed using overburden. Special waste from the Sue C and JEB pits was stockpiled during mining and was subsequently backhauled into the Sue C pit after the completion of mining.

Wastes (exclusive of the overburden) from the Sue A pit were deposited into the mined-out Sue C pit. This was a conservative approach, given the uncertainty about segregating special waste based on its arsenic content. Waste rock is segregated into clean and special waste based on acid-generating potential (using a simple laboratory test), radiological content (using the ore scanner) and a key non-radiological contaminant (arsenic, using an x-ray fluorescence scanner that was successfully tested during Sue A mining and subsequently implemented in the segregation procedures). Special waste from Sue E was also placed in the mined-out Sue C pit, while clean waste was placed in a separate Sue E waste rock stockpile.

Material removed from the Sue B pit was classified as special waste and placed in the mined-out Sue E pit below an elevation of 400 m above sea level. As of December 31, 2019, the total waste rock inventory at McClean Lake was 51.2 million tonnes of clean material (primarily waste rock) and 10.2 million tonnes of mineralized waste rock (special waste).

Cigar Lake

Tailings management

Cigar Lake does not have a mill and does not produce tailings. Cigar Lake ore is processed at the McClean Lake mill, and the resulting tailings are deposited in the JEB tailings management facility. Uranium mining was suspended at Cigar Lake in March 2020.

Waste rock management

There are four mine rock waste stockpiles (stockpile A clean rock, and A1 concrete and benign rock; B low-grade contaminated waste including wood, metal and rock, and C potentially reactive-acid waste rock) in operation at Cigar Lake. The current inventories are the result of mine development and operation at the site. The waste rock is classified as either clean or benign waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock (stockpiles B and C) are temporarily stored on engineered lined containment storage areas. Leachate from these areas is contained and collected for treatment in the mine water treatment plant. When possible, clean or benign waste rock is used as fill or construction material on-site. While some potentially acid-reactive waste rock may be used as backfill in the mine, the majority of this material is expected to be eventually transported to the McClean Lake mine site for disposal in a mined-out pit. At the end of 2019, stockpile B contained 2,373 m3 and stockpile C contained 378,541 m3. All potentially acid-generating mine rock (remaining stockpile C) is to be transported and disposed of at McClean Lake in a purpose-engineered in-pit repository. No mineralized mine rock, potentially acid generating rock or other contaminated or mineralized waste materials will remain on the surface after decommissioning is complete.

McArthur River

Tailings management

McArthur River does not have a mill and does not produce tailings. During operation, McArthur River ore is processed at the Key Lake mill. Production at the McArthur River mine and Key Lake mill was suspended for an indeterminate period of time; the mine and mill have been in care and maintenance since January 2018.

Waste rock management

The McArthur River operation generates waste rock from production mining, development mining and exploration drilling. The waste rock is classified as either clean waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock are temporarily stored on engineered lined containment storage pads. Leachate from these pads is contained and pumped to effluent treatment facilities. The segregated clean waste rock is disposed of on a pile that does not include the leachate containment and control systems.

The mineralized waste rock is shipped to the Key Lake operation and used as blend material for the ore feed to the Key Lake mill. The potentially acid-generating waste is crushed and screened, and the coarse material is used as aggregate for underground concrete backfilling operations. The clean waste is used for general road maintenance, both on-site and on the haul road between McArthur River and Key Lake.

Appendix B

Matrix of Input from Engagement Activities, by Participant Group

The tables in this Appendix display the contributions of various participant groups to the development of themes and ideas captured within the recommendations. Each table represents the main themes arising from the key focus areas of discussion held during various engagement sessions:

- Disposal versus Rolling Stewardship
- Colocation versus Centralization
- Responsibility for Implementation

Each table shows the various groups with whom we engaged along the top, and a summary of the main ideas generated from the discussion along the left side. A chevron indicates when a theme was identified by a group.

The themes along the left are arranged by relative frequency, with those themes higher in the table appearing more frequently than those lower in the table.

All of the summary statements from what we heard during our engagement sessions were grouped into like ideas while noting their participant group of origin. A subjective value for intensity of associated comments was assigned, as was a subjective value for the breadth of audience from which we heard the comment.

Disposal versus Rolling Stewardship

Category	Indigenous peoples	Community	CSO	Academia	Industry	Municipal	Government	Open	Youth
Disposal Preferred	»	»	»	»	»		»	»	»
Disposal – ILW + Colocation			»	»	»	»			»
Ongoing Monitoring + Stewardship	»	»	»		»			»	
Rolling Stewardship	»	»	»	»				»	»
Rolling Stewardship- LLW		»		»	»	»			»
Disposal- LLW				»	»				»
Rolling Stewardship- ILW		»		»				»	
Defence-in-depth			»						
Disposal- Evolution of Society Considerations				»			»		
Disposal- Technology Considerations + Flexibility					»				
No Preference									»
Other - Urgency			»		»				
Disposal- LLW (multiple technical options)		»							
Other- Retrievability			»						
Other- Waste Minimization		»							

Colocation versus Centralization

Category	Indigenous peoples	Community	CSO	Academia	Industry	Municipal	Government	Open	Youth
Multiple Facilities		»	»	»	»	»			»
Siting- Away from Water	»	»	»					»	»
ILW – Colocation with HLW	»	»	»	»	»		»	»	
LLW- Multiple Sites		»			»			»	»
LLW- Near Surface Disposal		»		»	»		»		
Multiple Sites- Near Point of Generation		»	»	»	»	»		»	
ILW- Single Site- Separate Location		»		»		»	»		
LLW- Colocation with ILW		»	»	»		»		»	
LLW- Multiple Sites- Near Point of Generation	»			»		»			
LLW- Single Site	»			»	»	»			
LLW- Multiple Sites- Regional	»			»					»
Multiple Sites- Regional					»		»	»	
Separate Facilities for LLW AND ILW		»		»	»				
Sitting Away from Population Centres	»						»		»
Colocation					»				
ILW- Fewer Sites								»	»
ILW- Multiple Technical Options					»				
Adaptability of Strategy				»					
Environmental			»						
ILW- DGR					»				
ILW- Near Surface			»						
LLW- Hazardous Waste Sites				»					
Processing- Stabilization and Solidification		»							

Responsibility for Implementation

Category	Indigenous peoples	Community	CSO	Academia	Industry	Municipal	Government	Open	Youth
Governanace - Diverse Representation	»	»	»	»				»	»
Multiple Organizations - Collaboration - Industry and Indigenous Peoples	»	»		»	»				
Single Organization - Independent	»	»	»			»		»	»
Single Organization - Arms Length Federal Agency	»	»		»	»		»	»	
Governance - Independence from Industry		»	»					»	»
Multiple Organizations - Industry Led		»		»	»		»		»
Financial Stewartship - Responsibility of Waste Owners		»			»		»		»
Other - Integration and Coordination of Implementation				»	»	»	»		
Single Organization - Goverment Led			»		»				»
Single Organization - NMWO or Equivalent	»				»				»
Financial Stewartship					»				
Financial Stewartship - Independent Funding							»		
Governance - CNSC or CNA Led						»			
Governance - Independent from Industry			»						
Governance - Indigenous Led									»
Governance - NWMO Model							»		
Multiple Organizations - Waste Type Specific				»					
Other - Process		»							
Other - Abolish CSA Role and Follow IAEA			»						
Single Organization - Service Provider				»					
Single Organization - HLW				»					
Single Organization - ILW				»					
Single Organization - GOCO				»					

Glossary of Terms

Bulk Material: Material that is granular in nature, such as soil, demolished concrete, or construction/demolition waste.

Concrete Vault: Concrete vaults are a type of engineered near surface disposal facility widely used around the world for the disposal of low-level radioactive waste (LOW-LEVEL WASTE). Concrete vaults look like large concrete boxes and a repository would be made up of a series of these. Each one would have its own drainage system and an 'earthen cover system' engineered from multiple layers of soil and with grass or other plants growing on top. This disposal method can be used in a wide variety of soil conditions. It is also modular in its design, which means that additional vaults can be added to increase its capacity as needed.

Deep Borehole: Deep borehole disposal is an emerging technology for waste that requires isolation for more than a few hundred years. It may be suitable for the disposal of small volumes of intermediate-level waste. The series of narrow boreholes are created to a depth of about 500 to 1000 metres into which waste packages would be lowered, creating a stack deep underground.

Deep Geological Repository (DGR): A deep geological repository typically consists of a network of underground tunnels and placement rooms for radioactive waste constructed several hundred meters below the surface. Repositories are designed to use a system of multiple barriers: engineered barriers such as waste containers and natural barriers like the rock itself work together to contain the waste and isolate it from people and the environment.

Disposal: The placement of radioactive waste without the intention of retrieval. Engineered Containment Mound (ECM): Engineered containment mounds are a type of engineered near surface disposal facility that sees waste packages placed on a waterproof base and then covered over with thick layers of natural materials such as clay and soil. Layers of synthetic materials such as high-density polyethylene are also incorporated to prevent release of radiation to the environment. These facilities usually have wastewater collection and treatment systems as well. ECM is suitable for low-level waste which will not reduce in volume or compact over time.

High-Level Waste (HLW): High-level radioactive waste is primarily used nuclear fuel and/or is waste that generates significant heat via radioactive decay. High-level waste is associated with penetrating radiation, thus shielding is required. High-level waste also contains significant quantities of long-lived radionuclides necessitating long-term isolation. Placement in deep, stable geological formations at depths of several hundred metres or more below the surface is recommended for the long-term management of high-level waste.

Intermediate-Level Waste (ILW): Intermediate-level radioactive waste is generated primarily from power plants, prototype and research reactors, test facilities, and radioisotope manufacturers and users. Intermediate-level waste generally contains long-lived radionuclides in concentrations that require isolation and containment for periods greater than several hundred years. Intermediate-level waste needs no provision, or only limited provision, for heat dissipation during its storage and disposal. Due to its long-lived radionuclides, intermediate-level waste generally requires a higher level of containment and isolation than can be provided in near surface repositories. Waste in this class may require disposal at greater intermediate depths of the order of tens of metres to a few hundred metres or more.

Long-Term Management: The long-term management of radioactive nuclear waste by means of storage or disposal.

Low-Level Waste (LLW): Low-level radioactive waste comes from operating reactors and from medical, academic, industrial, and other commercial uses of radioactive materials. Low-level waste contains material with radionuclide content above established clearance levels and exemption quantities (set out in the Nuclear Substances and Radiation Devices Regulations), but generally has limited amounts of long-lived activity. Low-level waste requires isolation and containment for periods of up to a few hundred years. An engineered near surface disposal facility is typically appropriate for low-level waste.

Radionuclide: A material with an unstable atomic nucleus that spontaneously decays or disintegrates, producing radiation. Nuclei are distinguished by their mass and atomic number.

Rolling Stewardship: Rolling stewardship is an approach to managing radioactive materials for which there is no disposal solution in the near term. Under rolling stewardship, the radioactive waste is stored on the surface where human controls can safely contain, isolate, monitor, and secure it for many generations indefinitely i.e., roll the radioactive waste forward from generation to generation (a succession of stewards). This concept assumes that technology will eventually resolve the problem for the long-term management of the waste, potentially by destroying or neutralizing it.

Shallow Rock Cavern: The shallow rock cavern is an engineered near surface disposal method sometimes used for the disposal of low-level waste, or low- and intermediate-level waste (low-level waste or low- and intermediate-level waste). A series of rock caverns are excavated at a nominal depth of 50 to 100 meters below the surface in low permeability rock. They are accessed from the surface by a small system of ramps and tunnels

Small Modular Reactors (SMR): Small modular reactors are advanced reactors that produce electricity of up to 300 MW(e) per module, which is less than current power generation reactors. Waste: In the context of this report, waste is assumed to be a radioactive waste unless specified otherwise (e.g., non-nuclear waste).

Waste Owner: The radioactive waste owner is the organization currently responsible for the radioactive waste.

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