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Inventory of **RADIOACTIVE WASTE** in **CANADA** 2019

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OPG: page 34
OPG: page 38
Cameco Corp.: page 47
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CONTENTS

1.0 INVENTORY OF RADIOACTIVE WASTE IN CANADA OVERVIEW 1

1.1 Radioactive Waste Definitions and Categories 3

1.1.1 Processes That Generate Radioactive Waste in Canada 3

1.1.2 Radioactive Waste Minimization 6

1.1.3 Disused Radioactive Sealed Sources 6

1.2 Key Federal Organizations for Oversight, Regulation and Management of Radioactive Waste in Canada 6

1.2.1 Atomic Energy of Canada Limited 8

1.2.2 Regulation of Radioactive Waste in Canada 8

1.2.3 Key Policy and Legislation Governing Radioactive Waste in Canada 9

1.3 Waste Resulting from Ongoing Operations 10

1.4 Waste Produced through Decommissioning Activities 10

1.5 Radioactive Waste Projections 13

1.6 Long-Term Waste Management Facilities 13

2.0 HIGH-LEVEL RADIOACTIVE WASTE (HLW) 15

2.1 HLW Definition 15

2.2 HLW Locations 16

2.3 HLW Inventory 16

2.4 HLW Projections 18

3.0 INTERMEDIATE-LEVEL RADIOACTIVE WASTE (ILW) 21

3.1 ILW Definition 21

3.2 Non-Fuel Waste Locations 21

3.3 ILW Inventory 21

3.3.1 ILW Resulting from Ongoing Operations 22

3.3.2 ILW Produced through Decommissioning Activities 25

3.4 ILW Projections 25

4.0 LOW-LEVEL RADIOACTIVE WASTE (LLW) 29

4.1 LLW Definition 29

4.2 LLW Inventory 29

4.2.1 Historic Waste 30

4.2.2 LLW Resulting from Ongoing Operations 31

4.2.3 LLW Produced through Decommissioning Activities 35

4.3 LLW Projections 35

5.0 DECOMMISSIONING SCHEDULE AND ASSOCIATED L&ILW GENERATION 37

6.0 LONG-TERM MANAGEMENT 39

6.1 Proposed Long-Term Radioactive Waste Management Projects 39

6.1.1 NWMO's Proposed Deep Geological Repository 39

6.1.2 CNL's Proposed Near-Surface Disposal Facility (NSDF) 39

6.1.3 Long-Term Management Facilities for Historic Waste 39

6.1.4 In-Situ Decommissioning of the WR-1 and NPD Reactors 39

6.2 Waste Emplacement Projections into Long-Term Waste Management Facilities 40

7.0 URANIUM MINING AND MILLING WASTE 41

7.1 Uranium Mining and Milling Waste Definition 41

7.2 Uranium Mining and Milling Waste Locations 42

7.3 Uranium Mining and Milling Waste Inventory 43

7.3.1 Decommissioning Waste (Uranium Mining and Milling Waste) 44

7.4 Uranium Mining and Milling Waste Projections 44

ANNEX 1 – Detailed Radioactive Waste Inventory and Projection Tables 45

TABLES

Table 1. Summary of Radioactive Waste Inventory in Canada 1
Table 2. Reactor Start of Operation and Shutdown Date 11
Table 3. Future Waste Volumes (Projections to 2022, 2030, 2050 and 2100) 13
Table 4. HLW Inventory – 2019 16
Table 5. HLW Projections – 2022, 2030, 2050, 2100 19
Table 6. ILW Inventory Summary – 2019 22
Table 7. ILW Inventory from Operations and Decommissioning – 2019 22
Table 8. ILW Projections – 2022, 2030, 2050, 2100 25
Table 9. LLW Inventory Summary – 2019 29
Table 10. LLW Inventory – 2019 32
Table 11. LLW Projections – 2022, 2030, 2050, 2100 35
Table 12. Long-Term Management Site Projections to 2100 40
Table 13. Uranium Mine and Mill Tailings Accumulation Rate and Inventory - 2019 43
Table 14. Waste Rock Inventory - 2019 44
Table A.1 High-Level Radioactive Waste Inventory (by owner) - 2019 45
Table A.2 High-Level Radioactive Waste Projections (by owner) – 2022, 2030, 2050, 2100 48
Table A.3 Non-Fuel High-Level Radioactive Waste Inventory – 2019 51
Table A.4 Non-Fuel High-Level Radioactive Waste Projections (by owner), 2022, 2030, 2050, 2100 51
Table A.5 Intermediate-Level Waste Inventory from Operations (by owner) – 2019 51
Table A.6 Intermediate-Level Waste Inventory from Decommissioning (by owner) – 2019 52
Table A.7 Intermediate-Level Waste Projections from Operations (by owner) – 2022, 2030, 2050, 2100 53
Table A.8 Intermediate-Level Waste Projections from Decommissioning (by owner) – 2022, 2030, 2050, 2100 54
Table A.9 Historic & Deloro Low-Level Radioactive Waste Inventory – 2019 54
Table A.10 Low-Level Waste Inventory from Operations (by owner) – 2019 57
Table A.11 Low-Level Waste Inventory from Decommissioning (by owner) – 2019 58
Table A.12 Low-Level Waste Projections from Operations (by owner) – 2022, 2030, 2050, 2100 59
Table A.13 Low-Level Waste Projections from Decommissioning (by owner) – 2022, 2030, 2050, 2100 59
Table A.14 Uranium Mine and Mill Tailing Accumulation Rate and Inventory (by owner) – 2019 60
Table A.15 Uranium Waste Rock Inventory (by owner) – 2019 62

FIGURES

Figure 1. Processes that Generate Radioactive Waste 4

Figure 2. Federal responsibilities for managing radioactive waste 7

Figure 3. Processes that Generate High-Level Radioactive Waste 15

Figure 4. HLW – Inventory 2016 (m^3) - 2019 17

Figure 5. HLW Projections - 2050 18

Figure 6. HLW Projections - 2100 18

Figure 7. ILW Inventory - 2019 22

Figure 8. ILW Inventory From Operations - 2019 25

Figure 9. ILW Projections - 2050 27

Figure 10. ILW Projections - 2100 27

Figure 11. LLW Inventory - 2019 29

Figure 12. LLW Inventory from Operations - 2019 32

Figure 13. LLW Inventory from Decommissioning - 2019 32

Figure 14. LLW Inventory Projections - 2050 36

Figure 15. LLW Inventory Projections - 2100 36

Figure 16. Annual Volume of Radioactive Waste from decommissioning of Existing Nuclear Facilities to 2100 37

Figure 17. How Uranium Mining and Milling Waste is Generated 42

Figure 18. Uranium Mine Tailings Inventory - 2019 43

Figure 19. HLW Inventory by Producer - 2019 46

Figure 20. ILW Inventory by Producer - 2019 52

Figure 21. LLW Inventory by Producer - 2019 58

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1.0 INVENTORY OF RADIOACTIVE WASTE IN CANADA OVERVIEW

The information in this document provides an overview of the production, accumulation and projections of radioactive waste in Canada as of December 31, 2019. Information and data on Canada's radioactive waste inventory are compiled from reporting provided by the waste owners concerning their waste management facilities.

In the preparation of this document, information and some excerpts were used from the 7th Canadian National Report for the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*.

This edition of the Inventory of Radioactive Waste is available on Natural Resources Canada's website at https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/uranium-nuclear/17-0467%20Canada%20Radioactive%20Waste%20Report_access_e.pdf; older editions are available upon request.

The following table presents a summary of the inventory of radioactive waste in Canada as of December 31, 2019, and of the amount of waste generated in 2019.

Table 1. Summary of Radioactive Waste Inventory in Canada

Waste Category	Waste Inventory to the end of 2019	Waste Generated in 2019
High-Level Radioactive Waste	12,718 m^3 (0.5%)	365 m^3
Intermediate-Level Radioactive Waste	15,681 m^3 (0.6%)	182 m^3
Low-Level Radioactive Waste	2,524,670 m^3 (98.9%)	8,951 m^3
TOTAL CUBIC METRES	2,553,069 m^3 (100%)	9,498 m^3
Uranium Mill Tailings	218 million tonnes	0.75 million tonnes
Uranium Waste Rock	167 million tonnes	N/A*
TOTAL TONNES	385 million tonnes	0.75 million tonnes

*N/A The status of the waste rock piles is inherently dynamic due to fluctuations in uranium prices, which determine the ratio of ore to waste rock. As a result, the annual generation rate can be deceptive, and total inventory of waste rock is used to provide a more representative value.

As presented in the inventory summary, most of Canada's radioactive waste (98.9%) is low-level radioactive waste, and almost three quarters is in the form of contaminated soil, which is the result of historic and legacy practices. This is in keeping with the global trend whereby, for most countries, larger volumes of lower-hazard radioactive waste exist in comparison to the much smaller volumes of intermediate- or high-level radioactive waste as work practices seek to minimize the production of radioactive waste and limit the contamination of equipment, materials and land. As the level of waste radioactivity increases, so does the associated level of hazard, resulting in a need for greater design efforts for handling, interim storage and long-term management to ensure the protection of workers, the public and the environment. For example, low-level radioactive waste generally requires minimal isolation and shielding, whereas intermediate- and high-level radioactive waste requires greater shielding for handling, interim storage and long-term isolation.

Note that, due to rounding throughout this report, the numbers presented may not add up precisely to the totals provided, and percentages may not precisely reflect the absolute figures.

1.1 Radioactive Waste Definitions and Categories

Under CNSC Regulatory Document 2.11.1 Volume 1, radioactive waste in Canada is defined as any material (liquid, gaseous or solid) that contains a radioactive nuclear substance for which no further use is foreseen. The Government of Canada is committed to the ongoing management of radioactive waste, by relevant responsible parties, in a safe and environmentally responsible manner.

There are four broad categories of radioactive waste in Canada as per CSA Standard N292.019:

The CSA Standard N292.019 was compiled by government and industry stakeholders to provide technical requirements for sound waste management practices, and it came into force in March 2019. The radioactive waste classification system is organized according to the degree of containment and isolation required to ensure safety in the short and long term. It also considers the hazard potential of the different types of radioactive waste. A precise boundary between LLW and ILW cannot be provided, as limits on the acceptable level of activity concentration will differ between individual radionuclides or groups of radionuclides, and will be dependent on short- and long-term safety management considerations. For example, a contact dose rate of two millisieverts per hour (mSv/h) has been used in some cases to distinguish between LLW and ILW. Sections 2.0, 3.0, 4.0 and 7.0 provide a detailed summary and inventory for each of the four main categories of radioactive waste.

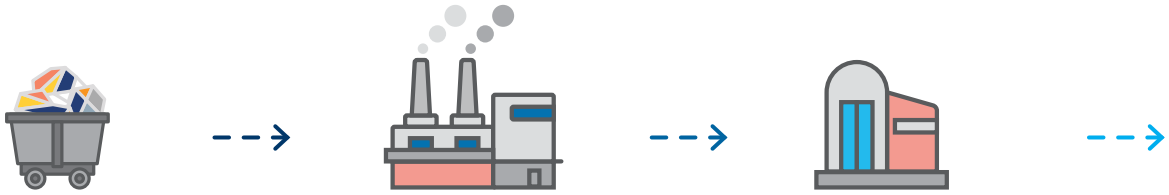
1.1.1 Processes That Generate Radioactive Waste in Canada

Radioactive waste is a by-product of Canada's use of nuclear technology. Radioactive waste is generated during various stages of the nuclear fuel cycle, including uranium mining, refining and conversion, nuclear fuel fabrication, nuclear power and research reactor operations, and eventual decommissioning of nuclear facilities.

Radioactive waste is also generated by other activities and facilities such as:

- Medical activities – radioactive materials are used for a number of purposes in the medical industry, including hospital and laboratory diagnostic procedures and treatment of illnesses, and equipment sterilization;
- Industrial activities – the industrial sector uses radioactive materials for non-destructive testing of materials and components;
- Research activities – academic and industrial research using radioactive materials can produce a small amount of radioactive waste.

Figure 1. Processes that Generate Radioactive Waste



Uranium ore mining and processing

Milling (processing) of *uranium ore* produces *uranium concentrate*.

Refining

During refining, the ore concentrate from uranium milling operations is upgraded to *uranium trioxide*.

Conversion

The uranium trioxide is then converted to *ceramic grade uranium dioxide* for fabrication into fuel for CANDU reactors or converted into uranium hexafluoride for foreign light water reactors.

Uranium mining and milling waste

Waste rock (mineralized) mill tailings

Mine decommissioning
Mine shut down

Waste rock and uranium tailings exist at operating uranium mine and mill sites. Because of the large volumes and low activity levels, tailings and waste rocks are decommissioned in place.

Historic LLW (1930s–1970s)
Waste from handling, transporting, processing and use

Low-level

Incinerable waste
Scrap lumber, pallets, rags, paper, cardboard, rubber and plastic

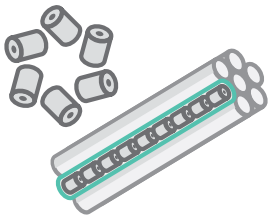
Non-incinerable waste
Air filters, fibreglass, PVC ductwork, floor sweepings, sandblast sand, insulation, sample bottles, scrap metal anodes

Other waste
Recyclable scrap metal, radioactive drain waste

Historic LLW (1930s–1970s)
Waste from handling, transporting, processing and use

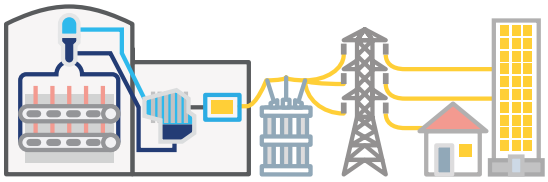
Low-level

Other waste
Rags, paper, gloves, oil and oil sludges, equipment and construction materials, filters and dust collectors



Fuel fabrication and fuel bundle production

During fuel fabrication, uranium dioxide is formed into pellets. *Fuel pellets* are used in the manufacture of *fuel bundles* for reactors.



Nuclear reactor

Fuel bundles are loaded into power reactors for the production of *electricity* or into research reactors for *research and development* and the production of radioisotopes.

About 15% of the uranium mined in Canada is used for domestic nuclear electricity production.

Low and intermediate

Incinerable waste
Paper, plastic, rubber, cotton, wood, organic liquids

Compactible waste
Paper, plastic PVC suits, rubber, fibreglass, metal pieces, empty drums

Non-processable waste
Filters, light bulbs, cable, used equipment, metals construction debris, absorbents (sand vermiculite, sweeping compound), ion exchange resins, reactor core components, retube waste

Processable liquids
Radioactive drain waste, chemical cleaning solutions

Low and intermediate

Nuclear reactor decommissioning

1 PHASE

Incinerable waste
Paper, plastic, rubber, cotton, wood

Compactible waste
Paper, plastic PVC suits, rubber, fibreglass, metal pieces

Non-processable waste
Filters, used equipment, ion exchange resins, absorbents (sand, vermiculite, sweeping compound)

Processable liquids
Radioactive drain waste, Decontamination solutions

2 PHASE

Small quantity of L&ILW

3 PHASE

Waste
Same as Phase 1
+ Active systems (e.g. fuel channel components, calandria, reactor and shield tanks, piping, boilers)

+ Active structures (e.g. biological shield, fuel bay)

High-level

(Nuclear fuel waste) interim storage

Wet

Dry

1.1.2 Radioactive Waste Minimization

As disposal facilities are not yet available in Canada for radioactive wastes and, in alignment with CSA Group Standards N292.0 and N294, emphasis is placed on minimization, volume reduction, conditioning and interim or long-term storage of wastes. It may be possible for waste to be reduced in volume prior to storage through reclamation of existing storage space, through further compaction or segregation, or both.

Uranium processing facilities can reduce their waste through incineration and recovery or re-use of uranium-bearing metals.

In the case of nuclear power plants, prior to storage, the volume of the radioactive waste may be reduced by incineration, compaction, liquid evaporation, shredding or metal melt. In addition, Canada's nuclear power plants contain facilities for decontaminating parts and tools, laundering protective clothing, and refurbishing and rehabilitating equipment. Some operators also use offsite services.

Using these methods, operators are able to achieve volume reduction of 80:1 for incinerable waste, which is waste that can be broken down using an incinerator, and 5:1 for compactable waste.

1.1.3 Disused Radioactive Sealed Sources

A wide variety of organizations, including universities, hospitals, industrial facilities and government departments, are users of sealed sources. These sources are used for industrial, medical, commercial, academic and research applications.

Most radioactive sealed sources are physically small, but their radioactivity may range from tens to billions of becquerels. When radioactive sealed sources are no longer required or have decayed beyond their useful life and are not intended to be used for the practice for which authorizations have been granted, they become disused radioactive sealed sources. They may then be returned to the manufacturer in Canada or to their country of origin. They may also be sent to a licensed waste management facility.

In Canada, some source manufacturers recycle radioactive sealed sources at the end of their useful life by reusing decayed sources for other applications, re-encapsulating them, or reprocessing them for other useful applications.

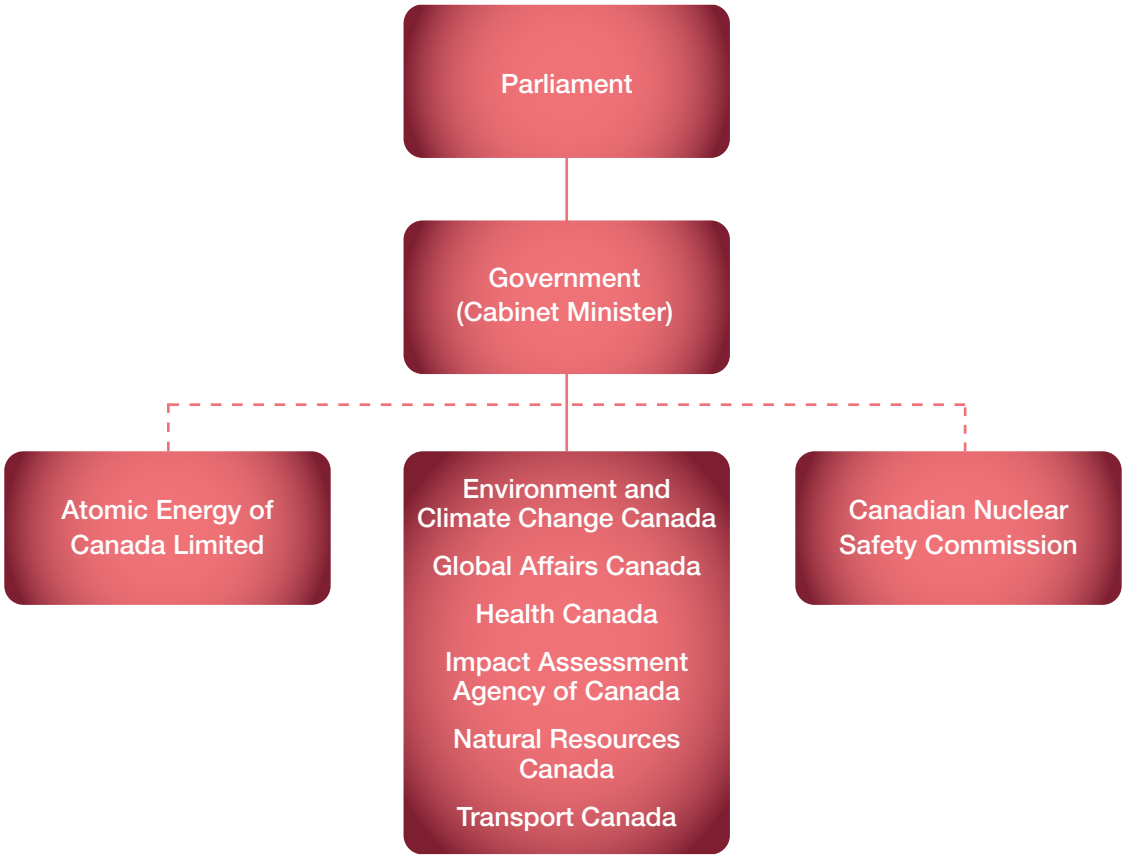
1.2 Key Federal Organizations for Oversight, Regulation and Management of Radioactive Waste in Canada

Natural Resources Canada (NRCan) is the lead federal government department responsible for developing and implementing uranium, nuclear energy and radioactive waste management policies in Canada. NRCan performs this function with the support of other federal government departments that have responsibilities for managing radioactive waste in Canada.

In accordance with Canada's Radioactive Waste Policy Framework, the owners of radioactive waste are responsible for the funding, organization, development and management of their respective waste, in addition to the operation of long-term waste management facilities, as required.

In the case of historic LLW, the Government of Canada has taken responsibility for its management on a case-by-case basis.

Figure 2. Federal responsibilities for managing radioactive waste



Environment and Climate Change Canada administers the Canadian *Environmental Protection Act*. It also runs the National Pollutant Release Inventory (NPRI). The NPRI is Canada's public inventory of releases, disposals and transfers. Facilities that meet the reporting thresholds must report to the NPRI any releases from the facilities to air, water or land.

Global Affairs Canada is the federal department responsible for promoting nuclear cooperation and safety, both bilaterally and multilaterally. It also implements key non-proliferation and disarmament agreements in Canada and abroad.

Health Canada is the federal department responsible for helping the people of Canada maintain and improve their health. In the area of radiation protection, Health Canada contributes to maintaining and improving the health of Canadians by providing guidance and information to Canadians on the risks from natural and artificial sources of radiation.

The Impact Assessment Agency of Canada (IAAC) is responsible for administering the *Impact Assessment Act* (IAA), the primary federal legislation that defines the requirements for assessing the environmental, health, social and economic impacts of proposed projects. Under the IAA, the IAAC leads reviews of major projects and collaborates with the CNSC to review projects that are also subject to regulation under the NSCA. Nuclear projects to be assessed under the IAA are subject to an integrated impact assessment carried out by a review panel.

Transport Canada's mission is to develop and administer policies, regulations and services for a national transportation system that is safe and secure, efficient, affordable, integrated and environmentally friendly. Transport Canada establishes policies, regulations and standards to protect the safety, security and efficiency of Canada's rail, marine, road and air transportation systems. Its oversight covers the transportation of dangerous goods, such as nuclear substances, and assurance that related developments can be sustained.

1.2.1 Atomic Energy of Canada Limited

Atomic Energy of Canada Limited (AECL) is a Crown corporation whose sole shareholder is the Government of Canada. For close to 70 years, AECL has been a world leader in developing peaceful and innovative applications of nuclear technology. Its mandate is to enable nuclear science and technology, and to manage the federal government's decommissioning and radioactive waste liabilities. AECL delivers its mandate through a long-term contract with the private sector for the management and operation of its sites under a Government-owned, Contractor-operated (GoCo) model. Canadian Nuclear Laboratories (CNL) manages AECL's sites, which includes operating the nuclear laboratories, and delivering decommissioning and waste management activities. Activities related to decommissioning and waste management are necessary to address liabilities and reduce hazards that are the result of decades of nuclear research at AECL sites. AECL is also responsible for the cleanup and safe, long-term management of historic LLW at other sites across Canada for which the Government of Canada has accepted responsibility. This includes the Port Hope Area Initiative (PHAI) and the activities associated with the Low-level Radioactive Waste Management Office.

1.2.2 Regulation of Radioactive Waste in Canada

Radioactive waste in Canada is managed in a safe, secure and environmentally responsible manner in accordance with the requirements of Canada's independent nuclear regulator, the Canadian Nuclear Safety Commission (CNSC).

While federal departments or agencies have been assigned specific roles and responsibilities in regard to the safe management of radioactive waste, it is the CNSC that is responsible for the regulation of radioactive waste in Canada. The mandate of the CNSC includes:

- Regulating the use of nuclear energy and materials to protect health, safety, security and the environment;
- Implementing Canada's international commitments on the peaceful use of nuclear energy;
- Disseminating objective scientific, technical and regulatory information to the public.

In regard to radioactive waste, the CNSC regulates Canada's radioactive waste management facilities to ensure that they are operated safely; it imposes rigorous reporting requirements on the operators of radioactive waste management facilities, and verifies that facilities comply with established safety requirements through inspections and audits. The CNSC's regulatory decisions are fully independent from the Government of Canada. In addition, the nuclear industry is subject to the provincial and territorial acts and regulations in force where nuclear-related activities are carried out. Where there is an overlap of jurisdictions and responsibilities, the CNSC takes the lead in harmonizing regulatory activities, including the formation of joint regulatory groups involving provincial and territorial regulators.

1.2.3 Key Policy and Legislation Governing Radioactive Waste in Canada

Policy Framework for Radioactive Waste

Radioactive waste in Canada is managed in accordance with Canada's *Policy Framework for Radioactive Waste*. The principles outlined in the document govern the institutional and financial aspects for disposal of radioactive waste by waste producers and owners. In summary, the principles are as follows:

- The federal government will ensure that radioactive waste disposal is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner.
- The federal government has the responsibility to develop policy, to regulate, and to oversee producers and owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans.
- The waste producers and owners are responsible, in accordance with the principle of "polluter pays," for the funding, organization, planning, development and operation of disposal and other facilities required for their waste. It is recognized that arrangements may be different for HLW, ILW, LLW, and/or uranium mining and milling waste.

The *Nuclear Safety and Control Act* (NSCA)

The Government of Canada established the NSCA to govern the development, production and use of nuclear energy, and the production, possession and use of nuclear substances, equipment and information. The CNSC, Canada's independent nuclear regulator, is established under the NSCA.

The CNSC's regulatory framework consists of regulations and associated regulatory policies, standards and guides that apply to all nuclear industries including, but not limited to, the following: nuclear power reactors; non-power nuclear reactors including research reactors; nuclear substances and radiation devices used in industry, medicine and research; the nuclear fuel cycle, from uranium mining through to waste management; and the import and export of controlled nuclear and dual-use substances, equipment and technology identified as a proliferation risk.

The *Nuclear Fuel Waste Act*

The NFWA governs the long-term management of nuclear fuel waste (HLW) in Canada. This Act sets out responsibilities for both the federal government and the nuclear fuel waste owners. It required the nuclear energy corporations to establish a waste management organization to develop and implement a long-term solution for the nuclear fuel waste produced in Canada. In 2002, the Nuclear Waste Management Organization (NWMO) was created to carry out this work. Under the Act, an important responsibility of the Government was to select an approach for the long-term management of nuclear fuel waste that is in the best interest of Canadians and the environment. On June 14, 2007, the Government of Canada announced that it had selected the Adaptive Phased Management (APM) approach, as recommended by the NWMO, for the long-term management of nuclear fuel waste in Canada. The NWMO is now required to implement the Government's decision pursuant to the NFWA and other relevant legislation.

The Minister of Natural Resources is responsible for administering the NFWA to ensure that the nuclear energy corporations and the NWMO comply with the Act's requirements.

1.3 Waste Resulting from Ongoing Operations

Any waste that is generated from ongoing operations is considered operations waste. It usually consists of any form of disposable material that has been contaminated in the process of its use. For example, operations waste may exist in the form of rags, gloves, paper, cardboard and plastic suits.

Operations waste accumulates on a regular basis and is the responsibility of its producer. Owners or producers of ongoing waste are responsible for its current and long-term management.

1.4 Waste Produced through Decommissioning Activities

Within the nuclear industry, decommissioning refers to those actions taken, in the interest of health, safety, security and protection of the environment, for the purpose of retiring a licensed activity/facility or site permanently from service and rendering it into a permanent end-state condition.

Decommissioning of nuclear facilities, research and power reactors is considered complete once the planned decommissioning activities have been executed, and all materials, waste, equipment and structures have been safely managed, including the remediation of associated land. This ensures that all risks to personnel, the public and the environment have been reduced or eliminated, releasing the site/area from regulatory control requirements.

Table 2 provides an overview of the lifecycle of existing reactor operations in Canada. The dates identified indicate the time cycle for the production of used nuclear fuel, as well as operations and decommissioning waste.

Table 2. Reactor Start of Operation and Shutdown Date

Company – site name	Reactor status as of December 2019	Start of operation	Date of planned shutdown	
POWER REACTORS				
OPG – Bruce A	Operating	1977–1979	2062	
OPG – Bruce B	Operating	1984–1987	2063	
OPG – Darlington	Operating	1990–1993	2056	
OPG – Pickering A	Units 1 and 4 operating; Units 2 and 3 shutdown/ decommissioning	1971–1973	Reactor 2 and 3: 1997	Reactor 1 and 4: 2022
OPG – Pickering B	Operating	1983–1986	2024	
Hydro-Québec – Gentilly-2	Shutdown / decommissioning	1983	2012	
NB Power – Point Lepreau	Operating	1983	2041	
PROTOTYPE, DEMONSTRATION AND RESEARCH REACTORS				
AECL – Douglas Point	Shutdown and partially decommissioned	1968	1984	
AECL – Gentilly-1	Shutdown and partially decommissioned	1972	1977	
AECL – NPD	Shutdown and partially decommissioned	1962	1987	
AECL – NRU	Shutdown and partially decommissioned	1957	2018	
AECL – NRX	Shutdown and partially decommissioned	1947	1993	
AECL – WR-1	Shutdown and partially decommissioned	1965	1985	
AECL – ZED-2	Operating	1960	TBD	
McMaster University – Nuclear Reactor	Operating	1959	2024[1]	
École Polytechnique (SLOWPOKE-2)	Operating	1976	2023[1]	
Saskatchewan Research Council (SLOWPOKE-2)	Decommissioned	1976	2019	
University of Alberta (SLOWPOKE-2)	Decommissioned	1977	2017	
Royal Military College of Canada (SLOWPOKE-2)	Operating	1985	2023[1]	

[1] End date of current operating licence, subject to renewal pending CNSC approval

Decommissioning Waste

A significant quantity of waste results from decommissioning nuclear reactors and their supporting facilities. This decommissioning waste will range from LLW to ILW. The LLW primarily consists of mildly contaminated building materials, while the ILW is associated with reactor core components.

Prior to decommissioning, the fuel bundles are removed from the reactor core. Hence, this HLW is not considered decommissioning waste.

Nuclear Reactor Decommissioning Phases

The CNSC requires that planning for decommissioning take place throughout the lifecycle of a nuclear facility or for the duration of a licensed activity.

In Canada, the typical phases of decommissioning include:

- Phase 1 – Planning for decommissioning: this generally begins at the site selection/design stage (or as early as possible) and continues through operation until preparation of the decommissioning phase.

- Phase 2 – Preparation for decommissioning: this begins with the decision to cease operations or the conduct of activities, and includes activities for permanent shutdown or cessation, and for the transition to a stable state for decommissioning. This phase will begin with reactor shutdown and may last for up to ten years. During this phase, it is expected that several hundred cubic metres of radioactive waste will be produced per reactor.

- Phase 3 – Execution of decommissioning: this phase begins when decommissioning activities commence, which may include decontamination, dismantling and/or clean-up, and any period of storage with surveillance, until the end state is achieved.

- Surveillance during this phase may last for up to 65 years with very small volumes of radioactive waste being produced.

- Dismantling may last for up to 20 years and will generate most of the radioactive waste. This process can begin without the need for storage and surveillance.

- Phase 4 – Completion of decommissioning: this phase involves verifying that all decommissioning activities have been completed satisfactorily, that the final end state has been reached, and that all documentation has been completed. Decommissioning ends with the release of the facility, location or site from regulatory control or, if unrestricted release cannot be achieved, institutional controls are required to be in place.

Decommissioning Status of Reactors and Facilities in Canada

Power Reactors

Hydro-Québec's Gentilly-2 power reactor commenced Phase 2 of decommissioning in 2012. Final decommissioning plans, including estimated waste volumes, are being developed; to date, no decommissioning waste has been reported as produced. Ontario Power Generation Reactor Units 2 and 3 at the Pickering Nuclear Generating Station are in Phase 3 of decommissioning.

Research and Prototype Reactor and Facilities

There are three prototype power reactors in Canada. The Douglas Point and Nuclear Power Demonstration (NPD) reactors are both located in Ontario, at Douglas Point and Rolphton, respectively. The Gentilly-1 reactor is located at Bécancour, Québec. Each of these facilities has been partially decommissioned and is currently in Phase 3 of decommissioning. In-situ decommissioning has been proposed by CNL for the NPD reactor.

Decommissioning projects are ongoing at AECL's facilities at the Chalk River Laboratories and the Whiteshell Laboratories. Phase 1 of the decommissioning of the Whiteshell Reactor 1 (WR-1) at the Whiteshell Laboratories (Pinawa, Manitoba) was completed in 1994; decommissioning is now in Phase 2. In-situ decommissioning has also been proposed for the WR-1 reactor.

The University of Toronto completed decommissioning of its sub-critical assembly in 2000. The Dalhousie University SLOWPOKE facility was decommissioned in 2011. The University of Alberta completed the decommissioning of its SLOWPOKE reactor in 2017. The Saskatchewan Research Reactor completed the decommissioning of its SLOWPOKE reactor in 2019.

Decommissioning and Remediation of AECL Sites

In addition to the preliminary reactor decommissioning activities taking place at AECL's Chalk River Laboratories and Whiteshell Laboratories, other facilities and infrastructures on those sites are being decommissioned as well. These activities can include the dismantling of supporting facilities, such as research or storage buildings that have become contaminated and redundant, or remediating contaminated land. Both LLW and ILW will be generated by the activities. Section 5.0 provides a summary of future decommissioning waste expected to be generated.

1.5 Radioactive Waste Projections

In order to assess future requirements for the management of radioactive waste, inventory projections to the end of 2022, 2030, 2050 and 2100 are provided. The year 2022 was selected given that the next survey of radioactive waste will be conducted that year and will serve as a benchmark to assess the overall projections. The three later projection years (2030, 2050 and 2100) have been selected to align with international reporting requirements. Lastly, 2100 projections were requested from waste owners so that waste from the decommissioning of all reactors would be captured in this reporting cycle.

Table 3. Future Waste Volumes (Projections to 2022, 2030, 2050 and 2100)

Waste category	Waste inventory to the end of 2019	Waste Inventory Projected to 2022	Waste Inventory Projected to 2030	Waste Inventory Projected to 2050	Waste Inventory Projected to 2100
HLW	12,718 m^3	13,577 m^3	15,802 m^3	21,012 m^3	22,853 m^3
ILW	15,681 m^3	18,361 m^3	24,927 m^3	30,087 m^3	32,324 m^3
LLW	2,524,670 m^3	2,616,087 m^3	2,732,717 m^3	3,082,690 m^3	3,410,478 m^3
Uranium Mill Tailings	218 million tonnes	N/A*	N/A*	N/A*	N/A*
Uranium Waste Rock	167 million tonnes	N/A*	N/A*	N/A*	N/A*

*N/A No projections for uranium mill tailings and waste rock inventory are provided as any inventory increase is dependent on production levels that are subject to market price fluctuations for uranium. See section 7.4.

1.6 Long-Term Waste Management Facilities

One of the objectives of the triennial inventory report is to provide a snapshot of current and future waste inventories in order to properly plan for their long-term management. This is of particular interest given that long-term management projects require extended planning periods to consider environmental, socio-economic and cultural impacts.

Under the Government of Canada's *Policy Framework for Radioactive Waste*, waste owners are responsible for the funding, organization, planning, development and operation of the waste management facilities required for their waste.

There are a number of initiatives currently underway to implement long-term solutions for nuclear fuel and radioactive waste. Canada does not reprocess its used fuel and is making progress on a national solution for nuclear fuel waste that involves disposal. The NWMO is implementing a voluntary siting process to find a willing and informed community with a suitable site to host a deep geological repository for the long-term management of nuclear fuel waste. As of December 31, 2019, there are two potential siting areas in Ontario that are engaged in the process. Refer to section 6.1.4 for further details.

AECL is responsible for addressing federal responsibilities for historic low-level radioactive waste across Canada, with the work being undertaken by CNL. In particular, the PHAI is underway and is addressing the bulk of Canada's historic low-level radioactive waste. Under this initiative, CNL is retrieving and transferring approximately 2.1 million cubic metres of largely contaminated soils to two new long-term waste management facilities. More information is available in section 6.1.3.

There are also three proposed disposal facilities for low- and intermediate-level waste currently undergoing environmental assessments. CNL has proposed three projects: a near-surface disposal facility at the Chalk River Laboratories site to dispose of AECL's LLW and the in-situ decommissioning of two of AECL's shut-down prototype and research reactors. Sections 6.1.1, 6.1.2, 6.1.5 and 6.1.6 provide additional information on these projects.

2.0 HIGH-LEVEL RADIOACTIVE WASTE (HLW)

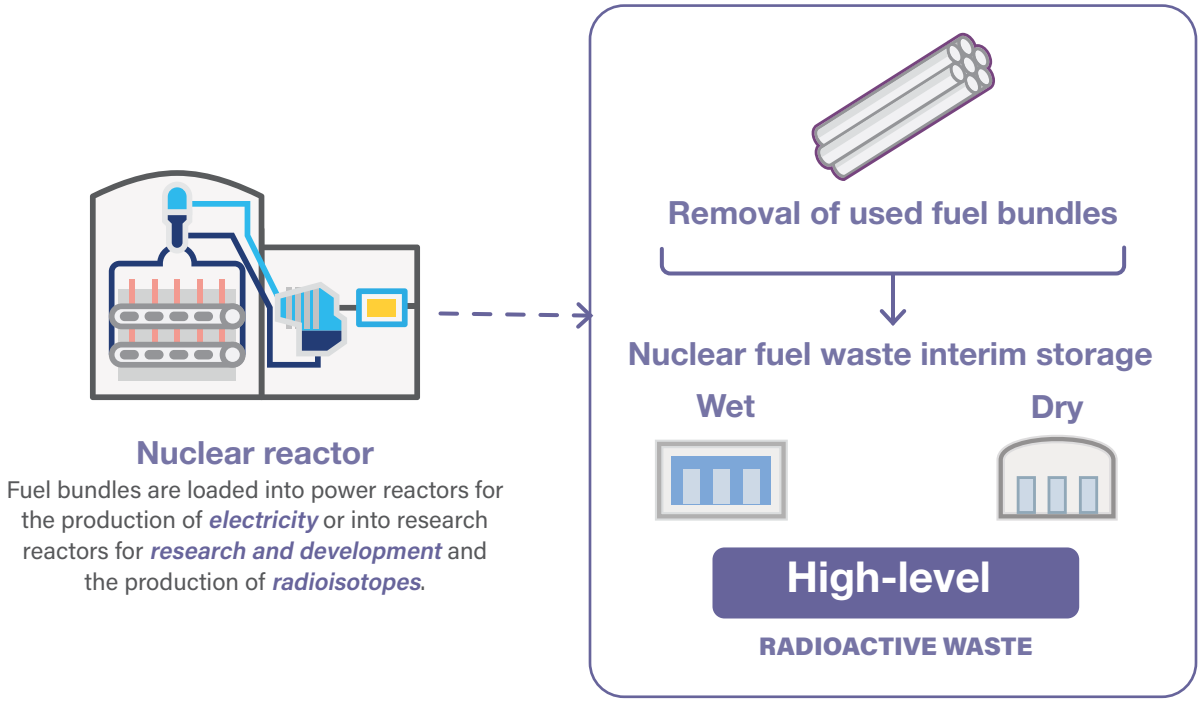
2.1 HLW Definition

HLW, as defined in CSA standard N292.0-19, is used (irradiated) nuclear fuel that has been declared radioactive waste and/or waste that generates significant heat (typically more than 2 kilowatts per cubic metre) via radioactive decay. Some countries and agencies refer to this waste as “spent fuel”; however, in this report it is called HLW because the discharged fuel is considered a waste material even when it is not fully spent.

In this report, most HLW listed is considered nuclear fuel waste as defined by Canadian legislation, namely the NFWA. The Act defines nuclear fuel waste as irradiated fuel bundles removed from a commercial or research nuclear fission reactor. However, the nuclear industry in Canada uses the expression “used nuclear fuel,” which is consistent with the relevant CSA standard. In Canada, most HLW is used nuclear fuel resulting from the nuclear fuel cycle, and includes waste from nuclear power plants, prototype and demonstration power reactors, and research and isotope production reactors. Non-fuel high-level radioactive waste also exists in Canada, typically taking the form of disused sealed sources. A total inventory of approximately 3 m^3 exists in this form.

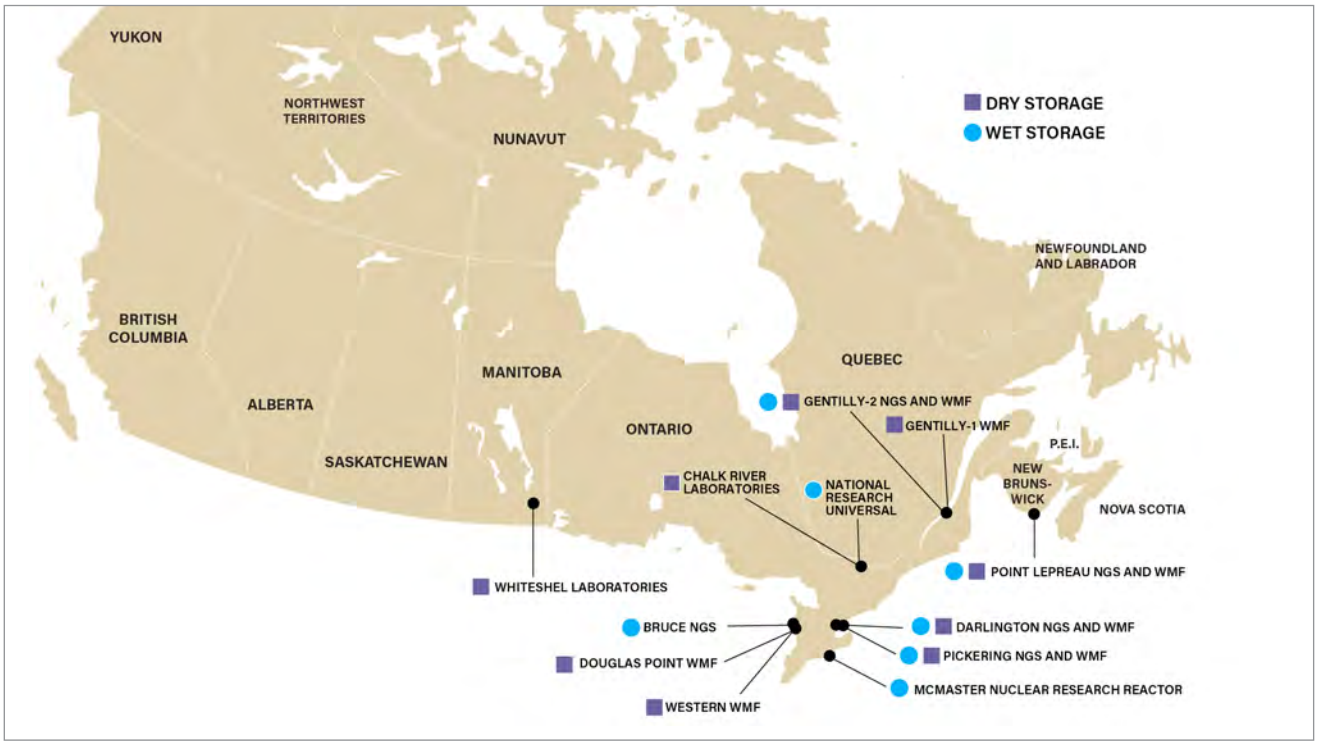
The majority of HLW is generated when nuclear fuel is removed from the reactors during operations or prior to decommissioning activities.

Figure 3. Processes that Generate High-Level Radioactive Waste



2.2 HLW Locations

Almost all nuclear generating stations and research reactor sites store HLW (nuclear fuel waste) on site in either wet or dry interim storage (refer to Table 4).



2.3 HLW Inventory

As of December 31, 2019, the total inventory of HLW in Canada was 12,718 m^3 (or 3,094,591 nuclear fuel bundles).

The total HLW inventory to the end of 2019 for power reactors was approximately 12,443 m^3 (or 3,051,795 bundles).

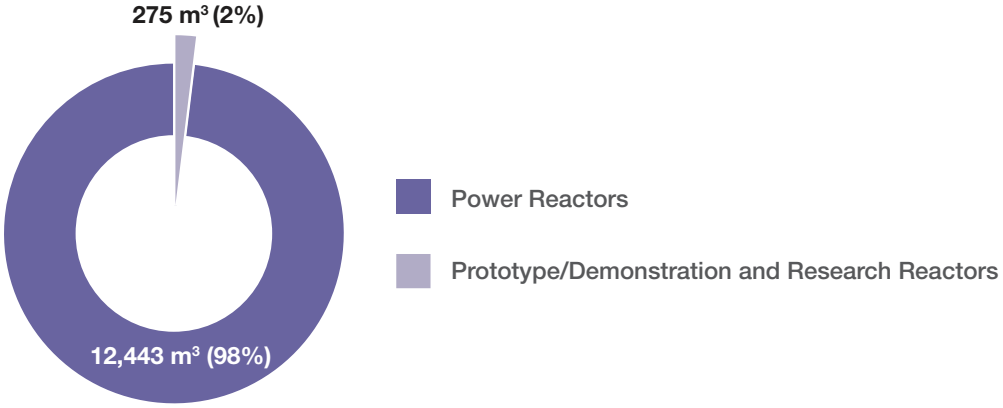
As of December 31, 2019, 275 m^3 (42,796 bundles) are associated with the three shut-down prototype/demonstration reactors (Douglas Point, Gentilly-1, and NPD) and other inventory from nuclear research.

Table 4. HLW Inventory – 2019

Reactor Type	Nuclear Fuel Waste Generated in 2019 (2019 Accumulation Rate)		On-Site Nuclear Fuel Waste Inventory to December 31, 2019	
	Number of Fuel Bundles	Est Vol. (m^3)	Number of Fuel Bundles	Est. Vol. (m^3)
Power Reactors	89,590	359	3,051,795	12,443
Prototype/Demonstration/Research Reactors	285	6	42,796	275
TOTAL HIGH-LEVEL RADIOACTIVE WASTE	**89,875**	**365**	**3,094,591**	**12,718**

Note: Est. Vol. stands for Estimated Volume.

Figure 4. HLW – Inventory (m^3) – 2019



HLW Generated in 2019

The operating power reactors generated 89,590 used nuclear fuel bundles or 359 m^3 of HLW in 2019, while 285 used nuclear fuel assemblies—6 m^3 of HLW—were generated at CRL as HLW from research reactors.

High-Level Waste from Power Reactors

In Canada, there are 22 power reactors owned by three provincial electric utilities. Ontario Power Generation Inc. (OPG) owns 20 reactors while Hydro-Québec and New Brunswick Power each own one reactor. Hydro-Québec's Gentilly-2 reactor and two reactors at the Pickering Nuclear Generating Station are now in safe shutdown. The 19 operating reactors have a total generation capacity of 15,000 megawatts of electricity.

HLW, a by-product of nuclear power generation, is currently safely managed in facilities licensed for interim storage at power reactor sites in Ontario, Québec and New Brunswick. The waste will remain at these sites until a suitable long-term solution becomes operational.

High-Level Waste from Prototype and Research Reactors

Chalk River Laboratories, Chalk River, Ontario

There is one operating reactor at Chalk River Laboratories: the Zero Energy Deuterium (ZED-2) reactor. Research and development activities at this reactor support aspects of nuclear science such as reactor development and environmental science.

The used fuel from past operation of the National Research Universal (NRU) reactor, the National Research Experimental (NRX) reactor and the NPD reactor is also being managed at Chalk River Laboratories.

Whiteshell Laboratories, Pinawa, Manitoba

The Whiteshell Laboratories (WL) are shut down and undergoing decommissioning. The WR-1 reactor has been partially decommissioned (currently in storage with surveillance). The HLW (nuclear fuel bundles) was removed prior to decommissioning of the reactor and is safely managed on the WL site. In-situ decommissioning is the proposed decommissioning solution for the WR-1 reactor.

The SLOWPOKE Demonstration Reactor at the Whiteshell Laboratories site has been fully decommissioned.

University Reactors

The table below lists all university reactors currently in operation in Canada. A small amount of fuel waste is stored at the research reactor at McMaster University in Hamilton, Ontario, while the other university reactors do not store HLW on site.

Licensee	Location	Type and capacity
McMaster University	Hamilton, Ontario	Pool-type 5 MW(t)
École Polytechnique	Montréal, Québec	SLOWPOKE-2, 20 kW(t)
Royal Military College of Canada	Kingston, Ontario	SLOWPOKE-2, 20 kW(t)

2.4 HLW Projections

Future HLW projections for 2022, 2030, 2050 and 2100 are 13,577 m^3, 15,802 m3, 21,012 m^3 and 22,853 m^3, respectively. These projections are based on the life expectancy of existing power reactors, including announced refurbishment and life extension plans.

The projected HLW (nuclear fuel waste) inventory to 2050 and 2100 for the existing prototype/demonstration and research reactors owned by AECL is approximately 271 m^3 in both cases.

Figure 5. HLW Projections – 2050

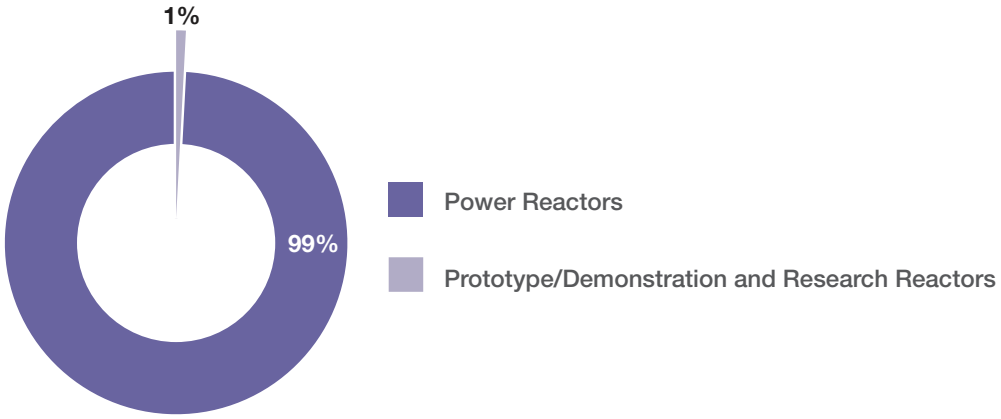


Figure 6. HLW Projections — 2100

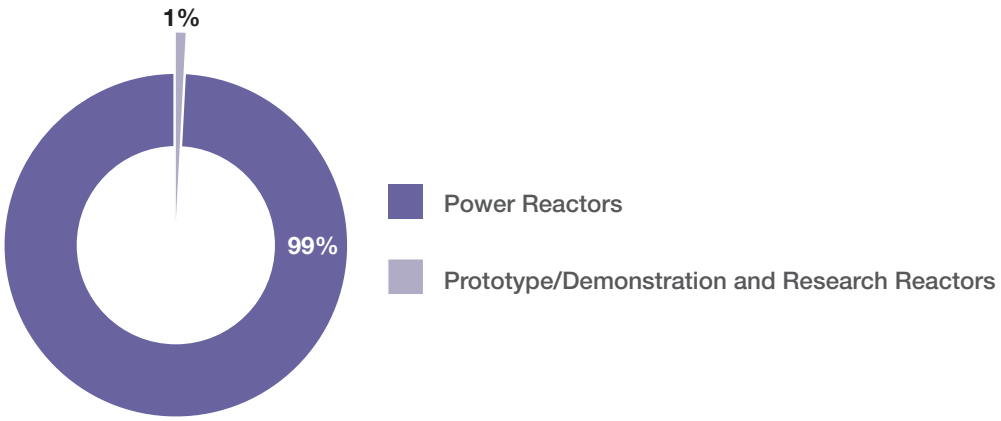


Table 5. HLW Projections – 2022, 2030, 2050, 2100

Reactor Type	HLW Inventory 2022		HLW Inventory 2030		HLW Inventory 2050		HLW Inventory 2100	
	Number of Fuel Bundles	Est. Vol. (m^3)	Number of Fuel Bundles	Est. Vol. (m^3)	Number of Fuel Bundles	Est. Vol. (m^3)	Number of Fuel Bundles	Est. Vol. (m^3)
Power Reactors	3,264,188	13,305	3,810,401	15,530	5,088,507	20,741	5,539,829	22,582
Prototype/ Demonstration/ Research Reactors	42,859	272	42,899	272	42,794	271	42,794	271
TOTAL HIGH-LEVEL RADIOACTIVE WASTE PROJECTIONS	**3,307,047**	**13,577**	**3,853,300**	**15,802**	**5,131,301**	**21,012**	**5,582,623**	**22,853**

Note: Est. Vol. stands for Estimated Volume.

Canada's Plan for the Long-Term Management of HLW

Currently, Canada's HLW is safely stored on an interim basis at licensed facilities. The HLW will remain at these sites until a suitable solution becomes available for its long-term management.

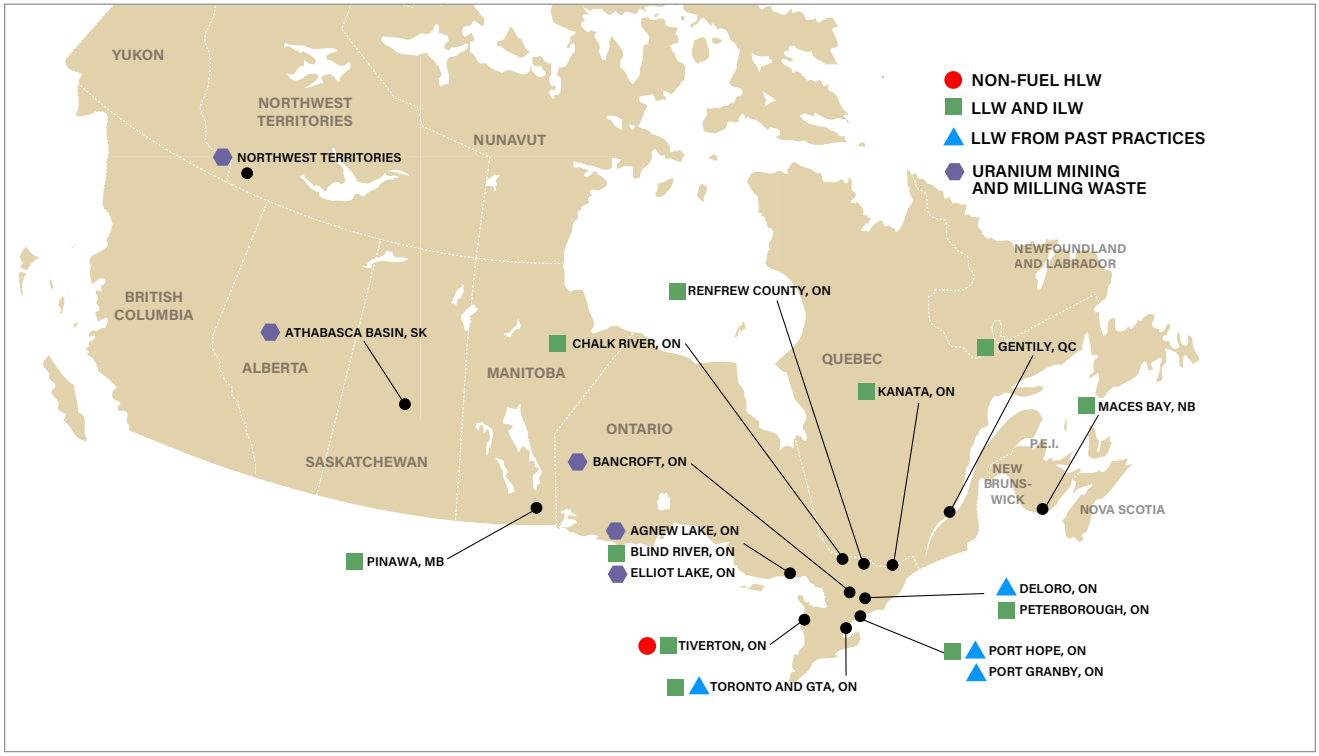
When HLW (used nuclear fuel) is removed from a reactor, it must be carefully managed and safely isolated from living organisms indefinitely. The Nuclear Waste Management Organization (NWMO) was established in 2002, in accordance with the NFWA to assume responsibility for long-term management of Canada's nuclear fuel waste. In 2007, the APM approach was selected by Canada for the long-term management of this waste. The APM approach is both a technical method and a management system with an emphasis on adaptability that provides containment and isolation of this waste in a deep geological repository. The end point of this plan is to identify a safe site, within a willing host community, to build a repository for managing the waste over the long term. This high-technology national infrastructure initiative will unfold over many decades and will be subject to extensive regulatory approvals and oversight. More information is available at www.nwmo.ca.

3.0 INTERMEDIATE-LEVEL RADIOACTIVE WASTE (ILW)

3.1 ILW Definition

ILW, as defined in CSA standard N292.0-19, is waste that typically exhibits sufficient levels of penetrating radiation to warrant shielding during handling and interim storage. While this type of radioactive waste generally requires little or no provision for heat dissipation during its handling, transportation and long-term management, some ILW may require heat management in the short term (e.g., refurbishment waste) because of its total radioactivity level. Ion-exchange resins and filters are examples of ILW.

3.2 Non-Fuel Waste Locations



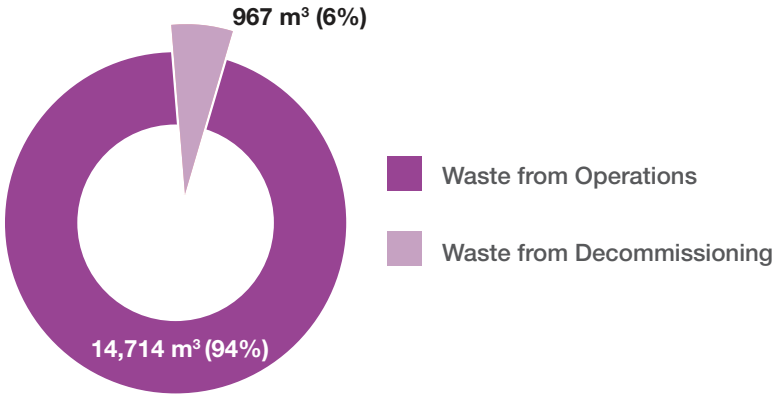
3.3 ILW Inventory

At the end of 2019, there were 15,681 m^3 of ILW stored in Canada. This includes approximately 157 m^3 of liquid ILW stored in tanks at CRL. ILW is safely managed throughout the country at interim storage facilities. The ILW generated in 2019 was approximately 182 m^3.

Table 6. ILW Inventory Summary – 2019

Overal Category	ILW inventory to December 31, 2019 (m^3)
Total from Operations	14,714
Total from Decommissioning	967
Grand Total	**15,681**

Figure 7. ILW Inventory – 2019



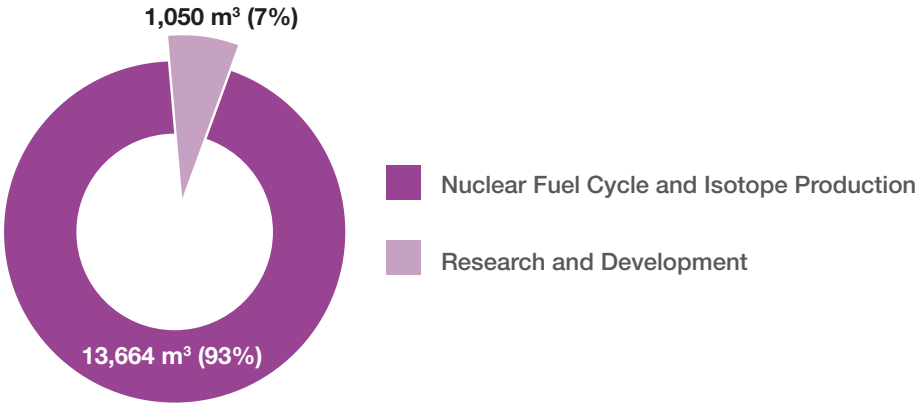
3.3.1 ILW Resulting from Ongoing Operations

The total ILW inventory from operations at the end of 2019 was 14,714 m^3. Waste from the nuclear fuel cycle and isotope production account for 13,664 m^3 of that total. Nuclear Fuel Cycle and isotope production includes waste from power reactors as well as facilities for the production of isotopes.

Table 7. ILW Inventory from Operations and Decommissioning – 2019

Sector	ILW Accumulation Rate in 2019 (m^3)	ILW Inventory to Dec. 31, 2019 (m^3)
WASTE FROM OPERATIONS		
Nuclear Fuel Cycle and Isotope Production	144	13,664
Research and Development	25	1,050
WASTE FROM DECOMMISSIONING		
Nuclear Fuel Cycle and Isotope Production	0	0
Research and Development	13	967
TOTAL INTERMEDIATE-LEVEL WASTE INVENTORY	**182**	**15,681**

Figure 8. ILW Inventory From Operations – 2019



Power Reactors

In 2019, 169 m³ of ILW was generated from operational activities, with the 19 operating power reactors in Canada generating 144 m³ of that volume.

OPG and Bruce Power together operated 18 reactors and generated 134 m³ of ILW from operations in 2019. New Brunswick Power generated 7 m³ ILW from operations in 2019. Hydro-Quebec reported that, while the Gentilly-2 site is in phase 2 decommissioning, it had generated 3 m³ of ILW through ongoing operations. No ILW was generated in 2019 as reported by Canada's radioisotope production facilities, uranium refining and conversion facilities, and nuclear fuel fabrication facilities.

Nuclear Research and Development

Nuclear research and development activities at AECL generated 25 m³ of ILW in 2019.

3.3.2 ILW Produced through Decommissioning Activities

As of December 31, 2019, the total inventory of ILW from decommissioning activities consisted of 967 m³ for research and prototype reactors. The waste generation rate for 2019 was 13 m³ of ILW. No nuclear power plants have been decommissioned in Canada yet, and so there has not been any ILW generated by the nuclear fuel cycle; the entire volume of ILW from decommissioning activities currently in inventory is owned by AECL.

3.4 ILW Projections

Projections for ILW were provided by the waste owners for 2022, 2030, 2050 and 2100, as described in the overview given in section 1.7.

The ILW inventory projected to 2050 from operations and decommissioning is 30,087 m³. For 2100, when decommissioning of all power and research reactors is anticipated to be completed, that volume is expected to rise to 32,324 m³.

ILW Projections from Operations

The projected inventory of ILW from operations is expected to increase over time. The volumes from operations projected to 2022, 2030, 2050 and 2100 are 17,144 m^3, 21,228 m^3, 23,002 m^3 and 23,688 m^3, respectively.

Waste from operations will continue to be a major contributor to the ILW inventory until approximately 2040, when Phase 3 of the decommissioning of some operating power reactors (Bruce B, Gentilly-2 and Pickering A and B) and Phase 3 of the decommissioning of some research/prototype reactors (Gentilly-1 and Douglas Point) will begin.

Projection of ILW volumes assumes that no new major nuclear facilities, including new nuclear power reactors, will be commissioned before 2050 and, therefore, there will be no new sources of ILW from ongoing operations. It is also assumed that the 2019 waste generation rates will remain constant in the future unless otherwise forecast by the producers (e.g., electric utilities).

ILW Projections from Decommissioning Activities

The inventory of ILW from decommissioning is projected to rise to 7,085 m^3 by 2050, and then to increase further to 8,636 m^3 by 2100.

Projected inventories of decommissioning ILW were provided by the waste owners and determined based on decommissioning plans submitted to the CNSC. Preliminary decommissioning plans exist for many sites with uncertainties with respect to timing and waste volumes.

Table 8. ILW Projections – 2022, 2030, 2050, 2100

Sector	ILW Inventory 2022 (m^3)	ILW Inventory 2030 (m^3)	ILW Inventory 2050 (m^3)	ILW Inventory 2100 (m^3)
WASTE FROM OPERATIONS				
Nuclear Fuel Cycle and Isotope Production	15,744	19,690	21,404	21,940
Research and Development	1,400	1,538	1,598	1,748
WASTE FROM DECOMMISSIONING				
Nuclear Fuel Cycle and Isotope Production	0	158	258	1,545
Research and Development	1,217	3,541	6,827	7,091
TOTAL INTERMEDIATE-LEVEL RADIOACTIVE WASTE PROJECTIONS	**18,361**	**24,927**	**30,087**	**32,324**

Figure 9. ILW Projections – 2050

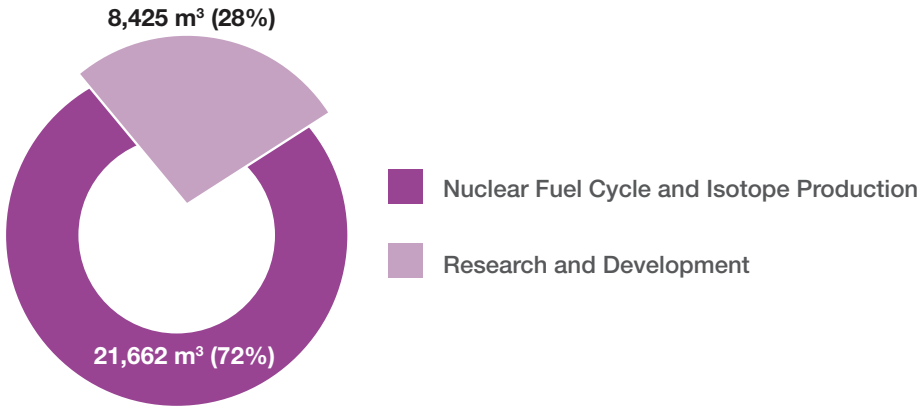
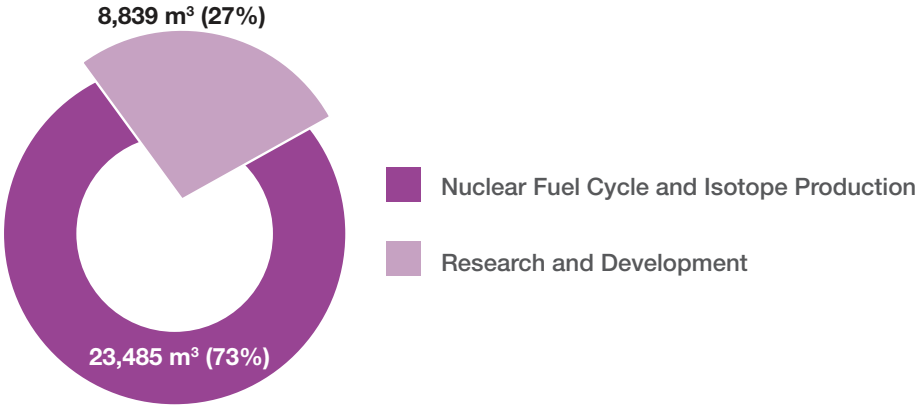


Figure 10. ILW Projections – 2100



4.0 LOW-LEVEL RADIOACTIVE WASTE (LLW)

4.1 LLW Definition

LLW, as defined in CSA standard N292.0-19, contains material with radionuclide content above established clearance levels and exemption quantities, and has generally limited amounts of long-lived radioactivity. LLW generally does not require significant shielding during handling and interim storage. LLW requires isolation and containment for up to a few hundred years; however, longer periods are required for LLW containing long-lived radium or longer-lived uranium.

Examples of LLW are contaminated materials, rags and protective clothing. Low-level radioactive waste also includes contaminated soil and related waste resulting from very early operations of Canada's radium industry.

4.2 LLW Inventory

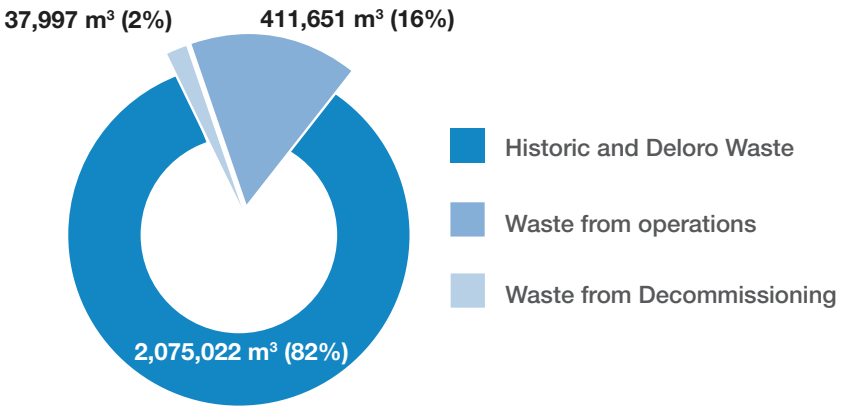
At the end of 2019, there were roughly 2.5 million m^3 of LLW stored in Canada. Most of Canada's LLW is characterized as historic waste—mainly contaminated soils. Only 18% of Canada's LLW results from ongoing operations and decommissioning activities. At present, LLW is safely managed throughout the country, either in situ or at interim storage/long-term management facilities.

Table 9. LLW Inventory Summary – 2019

Overall Category	LLW Inventory to Dec. 31, 2019 (m^3)
Total for Historic & Deloro Waste	2,075,022
Total from Operations	411,651
Total for Decommissioning	37,997
Grand Total	**2,524,670**

As of December 31, 2019, the total LLW inventory, excluding historic waste, amounted to 449,648 m^3. The LLW generated in 2019 was approximately 8,951 m^3.

Figure 11. LLW Inventory – 2019



4.2.1 Historic Waste

AECL is responsible for the cleanup and long-term management of historic waste in Canada. This work is undertaken by CNL.

In some instances, remedial actions are required on contaminated properties not owned by the federal government, but where the original owner no longer exists. In these situations, the federal government may make a determination to accept responsibility for management of this waste on a case-by-case basis. In March 2001, the Government of Canada and the local municipalities in the Port Hope area of southern Ontario entered into an agreement on community-developed proposals to address the cleanup and long-term management of the bulk of Canada's historic waste, thereby launching the PHAI. In 2012, the Government of Canada announced $1.28 billion in funding to implement the PHAI. As of December 2019, the cleanup is underway with waste retrievals and transfers taking place in the communities. For more information, visit the project's website at http://www.phai.ca/.

Historic waste is located at various locations across Canada, including sites in Ontario, Alberta, and the Northwest Territories. In some cases, the waste takes the form of uranium ore contamination. At many of these sites, materials have been placed in interim storage pending the development and implementation of a long-term management approach. Ongoing site monitoring, inspection and maintenance are conducted at all storage and in-situ sites by CNL.

The waste at some of these sites includes artefacts or surface-contaminated building materials. Other sites contain radium-contaminated soil with low radioactivity.

Origin of Historic LLW

Historic LLW originated from past handling, transportation and use of uranium ore. In the 1930s, uranium (pitchblende ore) was discovered at Port Radium, in the Northwest Territories. By 1932, Eldorado Gold Mines Limited had established a mine in Port Radium and a refining facility in Port Hope, Ontario. As the ore was shipped to southern Ontario, it first traveled along the Northern Transportation Route (NTR), a 2,200-km route comprised of waterways and portages between Port Radium, Northwest Territories, and Fort McMurray, Alberta. There, rail cars were loaded with the ore, and it was shipped to Port Hope, Ontario, to be refined.

Between the 1930s and the 1960s, some spillage occurred at the transfer points along the route as the ore was transferred to planes, boats, trucks and trains, and then to the refinery. Discovery of instances of contamination began in the early 1970s and continued with formal identification of contamination along the NTR, at the refinery in Port Hope and surrounding area, and at other areas in southern Ontario associated with radium recovery operations and radium dial paintin.

Inventory of Historic LLW in Canada

The total inventory of historic LLW is approximately 2.1M m^3.

Port Hope Area, Ontario

The majority of historic LLW in Canada (>98%) is located in the Port Hope area. The Historic waste located there includes 550,000 m^3 of LLW managed at the Welcome Waste Management Facility (Municipality of Port Hope) and 765,622 m^3 of LLW (as of December 31, 2019) managed at the Port Granby Long-Term Waste Management Facility (Municipality of Clarington). Another 720,000 m^3 of material is located throughout the Municipality of Port Hope and is planned to be remediated as part of the PHAI.

Greater Toronto Area (GTA), Ontario

Several small site owners in the GTA have been working with AECL/CNL over the years to manage their small low-level waste volumes associated with former radium dial painting operations and other activities from the 1930s. There is a total of 4,900 m^3 of waste remaining under federal responsibility after processing, reclassification, or identification of proper ownership/liability.

Deloro Waste

Deloro waste is LLW that was produced from reprocessing uranium mill tailings in order to extract cobalt at Deloro, Ontario. While it is a result of past practices for which the original owner cannot be reasonably held responsible, it is not waste the federal government has accepted responsibility for; therefore, it is listed as a separate volume under LLW resulting from historic practices as it does not meet the full criteria to be defined as "historic waste."

The Government of Ontario has accepted responsibility for this waste, and the Ontario Ministry of the Environment has completed remediation of the former Deloro Mine Site. Approximately 34,500 m^3 of LLW-contaminated soil and historic tailings are stored at the site.

4.2.2 LLW Resulting from Ongoing Operations

LLW accumulates on a regular basis as the result of ongoing nuclear-related operations, at power and research reactors, and at nuclear science and technology facilities. Owners or producers of ongoing waste are responsible for its current and long-term management.

The total inventory of LLW inventory from ongoing operations at the end of 2019 consisted of 411,651 m^3.

Nuclear Fuel Fabrication Facilities and Power Reactors

In 2019, a total of 3,434 m^3 of LLW was generated during operations activities, with the 19 operating nuclear power reactors in Canada generating 779 m^3 of this volume.

Ontario Power Generation and Bruce Power together operated a total of 18 reactors and generated 665 m^3 of LLW in 2019. New Brunswick Power generated 71 m^3 of LLW through ongoing operations. A total of 43 m^3 of LLW was generated in 2019 as a result of uranium refining and conversion, and nuclear fuel fabrication.

Table 10. LLW Inventory – 2019

Sector	LLW Accumulation Rate in 2019 (m^3)	LLW Inventory to Dec. 31, 2019		
		Waste (m^3)	Cont. Soil (m^3)	Total (m^3)
WASTE FROM OPERATIONS				
Nuclear Fuel Cycle and Isotope Production	779	118,793	0	118,793
Research and Development	2,655	136,582	156,276	292,858
WASTE FROM DECOMMISSIONING				
Nuclear Fuel Cycle and Isotope Production	0	1,500	200	1,700
Research and Development	5,517	32,095	4,202	36,297
TOTAL	**8,951**	**288,970**	**160,678**	**449,648**

Note: Cont. Soil stands for Contaminated Soil.

Nuclear Research and Development

The total LLW inventory produced from nuclear research and development, as of December 31, 2019, was 329,155 m^3. AECL indicates that it is managing 160,478 m^3 of contaminated soil resulting from its long history of nuclear research and development. This soil also includes waste that was removed from various locations across Canada, including several sites within Ontario in the 1970s. In addition, some LLW from other producers (mostly hospitals and universities) is managed at AECL's Chalk River Laboratories.

Figure 12. LLW Inventory from Operations – 2019

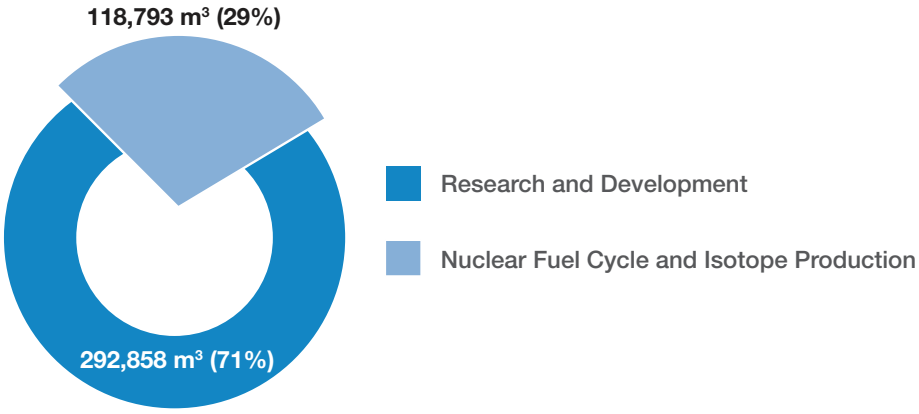
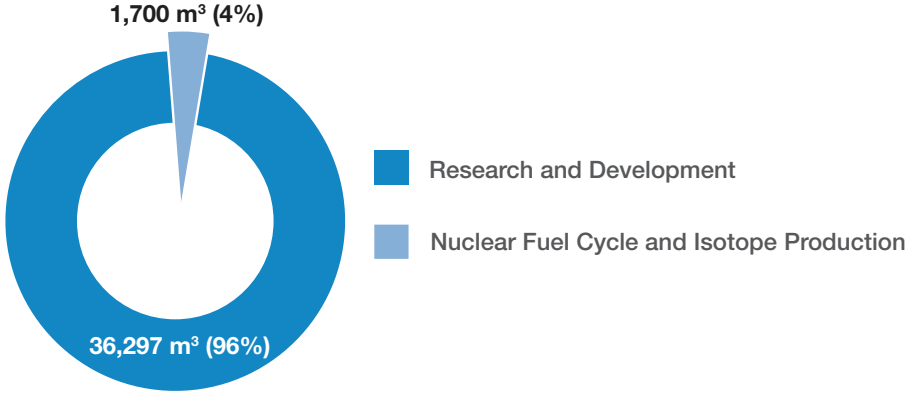


Figure 13. LLW Inventory from Decommissioning – 2019



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4.2.3 LLW Produced through Decommissioning Activities

As of December 31, 2019, the total inventory of LLW in Canada resulting from all decommissioning activities was 37,997 m^3. The decommissioning waste generation rate for 2019 was 5,517 m^3 of LLW.

4.3 LLW Projections

Projections for LLW were reported by the waste owners for 2022, 2030, 2050, and 2100.

Due to anticipated waste reduction activities, including incineration, waste volumes are projected to decrease in some instances.

The LLW inventory from operations and decommissioning projected to 2050 is 970,490 m^3 and is expected to reach 1,298,278 m^3 by 2100.

Projections of LLW from Operations

The total LLW inventory from ongoing operations as of December 31, 2019, is 411,651 m^3. The LLW volume will increase to approximately 421,347 m^3 by 2050 and to 442,042 m^3 by 2100.

Waste from operations will continue to be a major contributor to the LLW inventory until approximately 2040, when Phase 4 decommissioning of some operating power reactors (Bruce B, Gentilly-2 and Pickering A and B) as well as Phase 4 decommissioning of some research/prototype reactors (Gentilly-1 and Douglas Point) begins.

The projection of LLW volumes assumes that no new major nuclear facilities, including new nuclear power reactors, will be commissioned before 2050 and, therefore, there will be no new sources of LLW from ongoing operations. It is also assumed that the 2019 waste generation rates will remain constant in the future unless otherwise forecast by the producers (e.g., electric utilities).

Table 11. LLW Projections – 2022, 2030, 2050, 2100

Sector	LLW Inventory 2022 (m^3)	LLW Inventory 2030 (m^3)	LLW Inventory 2050 (m^3)	LLW Inventory 2100 (m^3)
WASTE FROM OPERATIONS				
Nuclear Fuel Cycle and Isotope Production	108,851	114,201	112,706	110,001
Research and Development	294,994	299,281	308,641	332,041
WASTE FROM DECOMMISSIONING				
Nuclear Fuel Cycle and Isotope Production	1,000	6,638	127,826	309,210
Research and Development	99,042	200,397	421,317	547,026
TOTAL	**503,887**	**620,517**	**970,490**	**1,298,278**

Projections of LLW from Decommissioning Activities

The projected inventories of LLW to 2050 and 2100 from decommissioning are 549,143 m^3 and 856,236 m^3, respectively.

Projected inventories of decommissioning LLW were provided by the waste owners and determined based on decommissioning plans submitted to the CNSC. Preliminary decommissioning plans exist for many sites, with uncertainties about timing and waste volumes.

Figure 14. LLW Inventory Projections – 2050

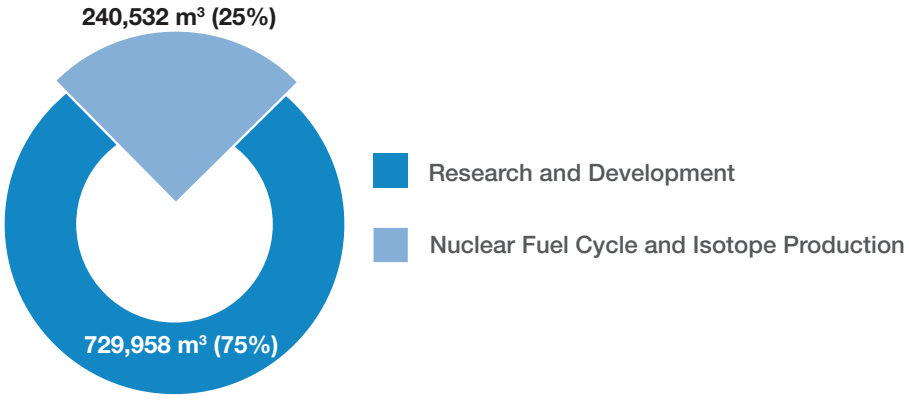
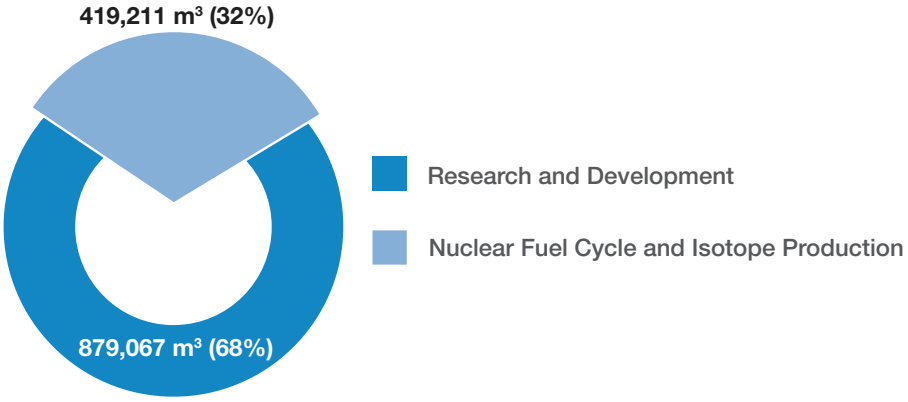


Figure 15. LLW Inventory Projections – 2100

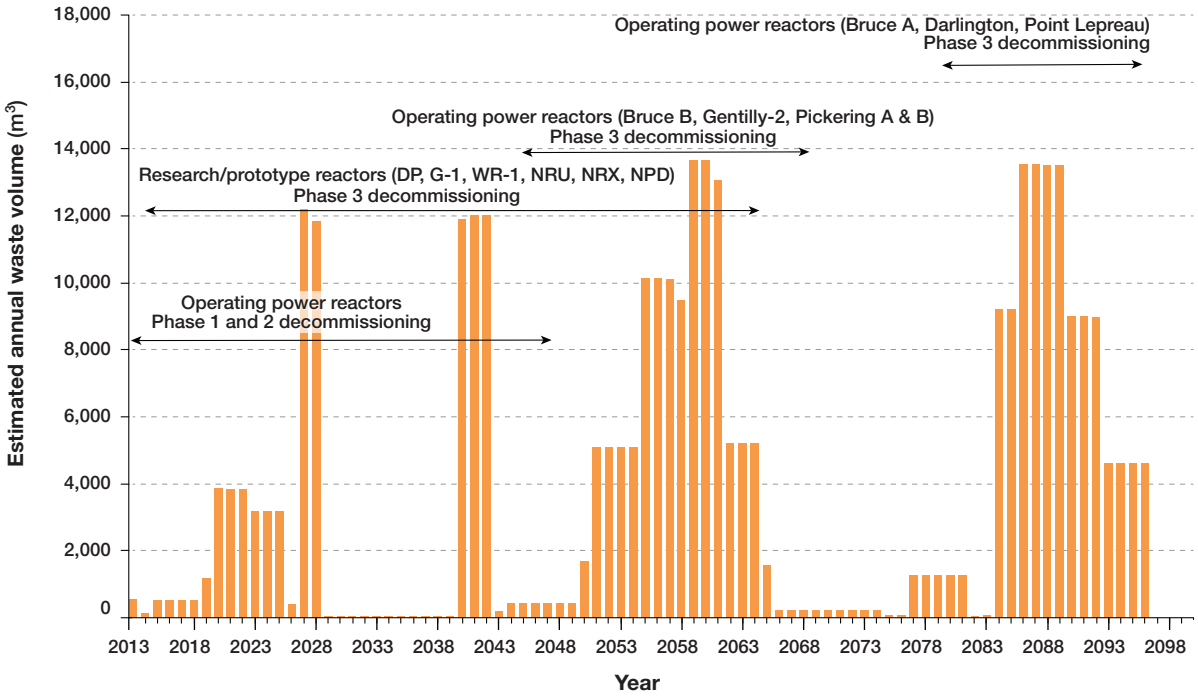


5.0 DECOMMISSIONING SCHEDULE AND ASSOCIATED L&ILW GENERATION

As per sections 3.4 and 4.4, projected inventories of LLW and ILW from decommissioning were provided by waste owners and determined based on decommissioning plans submitted to the CNSC.

The following chart depicts the projected annual decommissioning waste volumes for the power reactors, prototype/demonstration power reactors, and the Whiteshell Laboratories and Chalk River Laboratories facilities through 2100. This timeline was selected to include complete Phase 3 decommissioning of all currently operating power reactors. It also provides an overview of planned decommissioning activities that would generate large volumes of LLW and ILW. Various assumptions, including uncertainties about timing and waste volumes, were considered for these estimates.

Figure 16. Annual Volume of Radioactive Waste from decommissioning of Existing Nuclear Facilities to 2100



1407
967
1363
1364
1393

6.0 LONG-TERM MANAGEMENT

Radioactive waste volumes depicted in this inventory provide an understanding of the timeline for the generation of various types of radioactive waste. This permits an understanding at a national level of the need for long-term radioactive waste management facilities. The sections below provide an overview of the planned, long-term waste management facilities in Canada to manage HLW and L&ILW.

6.1 Proposed Long-Term Radioactive Waste Management Projects

6.1.1 NWMO's Proposed Deep Geological Repository

The NWMO is currently in the process of selecting a community that is both willing and possessing of the technical features to be an appropriate choice for a Deep Geological Repository. The facility is expected to be built about 500 metres underground. This facility would contain and isolate all of Canada's nuclear fuel waste, according to current forecasts. For more information please visit https://www.nwmo.ca/.

6.1.2 CNL's Proposed Near-Surface Disposal Facility (NSDF)

CNL has submitted a proposal to the CNSC for a near-surface disposal facility (NSDF) at the Chalk River Laboratories to address AECL's existing and future LLW. The project would be an engineered containment mound comprising 10 separate cells. The NSDF's total capacity is expected to be 1,000,000 m3.

For more information: http://www.cnl.ca/

6.1.3 Long-Term Management Facilities for Historic Waste

The Port Hope Area Initiative involves the construction of two long-term waste management facilities in Clarington and Port Hope in southeastern Ontario. They are both near-surface facilities consisting of engineered containment mounds for historic low-level waste. One facility, located in Port Hope, is expected to contain approximately 1,300,000 m^3. The other facility, located in neighbouring Clarington, Ontario, is expected to contain approximately 810,000 m^3 of material. The bulk of this waste is soil that was contaminated through waste management practices stemming from industrial uranium refining activities in the 1930s in Port Hope. For more information, go to http://www.phai.ca/.

6.1.4 In-Situ Decommissioning of the WR-1 and NPD Reactors

CNL has submitted proposals to the CNSC for the in-situ decommissioning (management on site) of AECL's WR-1 reactor at the Whiteshell Laboratories in Pinawa, Manitoba, and of AECL's Nuclear Power Demonstration reactor in Rolphton, Ontario. These projects would have the above-grade structure dismantled and the below-grade areas grouted in place with an engineered cap to prevent water infiltration. Following the decommissioning activities, the sites would be considered to be licensed disposal facilities under the NSCA, intended to responsibly manage the inventory (radionuclides and other waste) at the sites.

Waste owners are making progress in the long-term management of their LLW and ILW. Of the total volume of LLW projected by 2100, over 75% of this volume has a planned long-term solution. For ILW, waste owners will continue to develop long-term solutions to their ILW. In terms of used nuclear fuel, it will be entirely managed under the NWMO's APM plan to site and build a deep geological repository.

6.2 Waste Emplacement Projections into Long-Term Waste Management Facilities

The following table provides an overview of the volumes of waste to be emplaced in long-term waste management facilities by 2030, 2050 and 2100. Based on current proposed facilities (subject to environmental assessment and regulatory review), by 2050, Canada would have made significant progress on the long-term management of the vast majority of projected LLW and HLW.

Table 12. Long-Term Management Site Projections to 2100

Facility	Emplacement by 2022		Emplacement by 2030		Emplacement by 2050		Emplacement by 2100	
WASTE AND PACKAGING	**Number of Fuel Bundles**	**Volume including Package (m^3)**	**Number of Fuel Bundles**	**Volume including Package (m^3)**	**Number of Fuel Bundles**	**Volume including Package (m^3)**	**Number of Fuel Bundles**	**Volume including Package (m^3)**
NWMO Deep Geological Repository	0	0	0	0	840,000	51,100 [1]	5,565,000	338,600 [1]
WASTE FROM OPERATIONS AND DECOMMISSIONING	**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**		**Volume (m^3)**	
AECL Near Surface Disposal Facility	0		497,546		727,826		876,935	
WR-1 Reactor In-Situ Decommissioning	0		2,248		2,248		2,248	
NPD Reactor In-Situ Decommissioning	0		2,678		2,678		2,678	
HISTORIC WASTE	**Volume (m^3)**				**Volume (m^3)**		**Volume (m^3)**	
Port Hope Long-Term WMF	982,000		1,270,000		1,270,000		1,270,000	
Port Granby Long-Term WMF	802,800		802,800		802,800		802,800	

[1] Based on assumed use of a 48-bundle container in a 1 m x 1 m x 2.92 m bentonite buffer box.

7.0 URANIUM MINING AND MILLING WASTE

7.1 Uranium Mining and Milling Waste Definition

This waste is a byproduct generated from uranium mining and milling activities, and includes both mill tailings and waste rock, as described below.

Uranium Mill Tailings

Uranium mill tailings are generated during the milling (processing) of uranium ore to produce uranium concentrate. Uranium concentrate, once refined and converted, is used to make fuel for Canadian and foreign power reactors. Today, tailings are placed in mined-out, open pits converted to tailings management facilities (TMFs). However, this was not always the case. Historically, tailings were placed in natural containment areas such as lakes or valleys, or disposed of as backfill in underground mines, or placed in engineered surface containment areas.

At all of the newer operations in Saskatchewan, tailings are managed in TMFs that feature hydraulic containment during operation (so that all groundwater flow is towards the tailings facility), and passive long-term containment following decommissioning. Details of each facility can be found in the annual reports prepared for the CNSC by the waste owners.

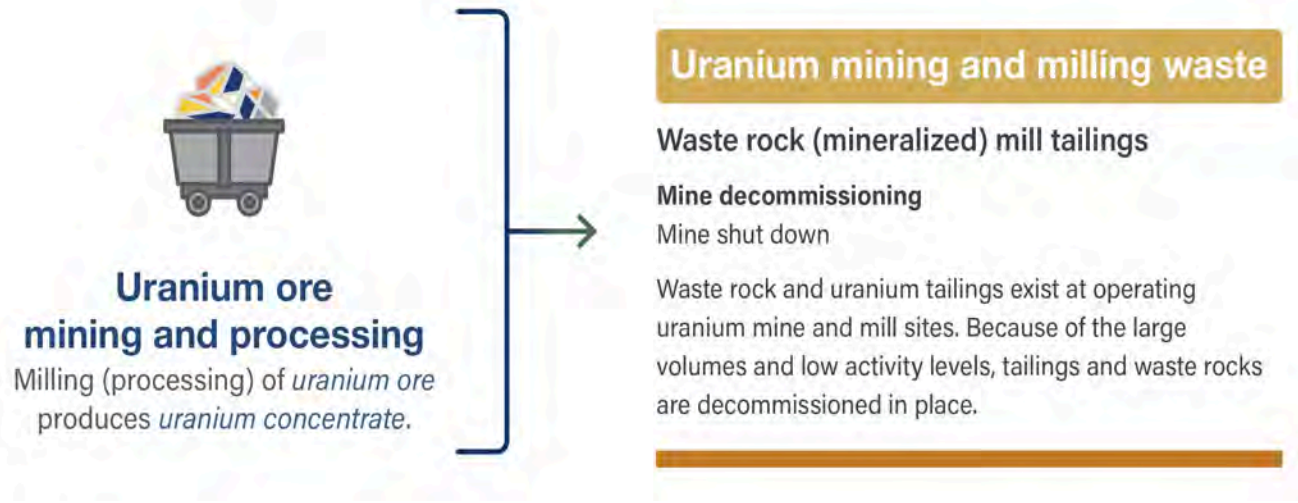
Waste Rock

Waste rock refers to the non-ore material that is removed during mining to access the ore. Today, waste rock is separated into mineralized and non-mineralized waste rock depending on the relative concentration of uranium present in the material. Historically, waste rock has been stored on the surface or used as backfill in underground mines. However, in the past, inventories of waste rock were not consistently tracked and, often, mineralized and non-mineralized wastes were stockpiled together.

Mineralized waste rock can include sub-economical concentrations of uranium, in addition to elevated levels of other elements such as sulphur, arsenic or nickel that could potentially cause adverse environmental effects. Non-mineralized waste rock has very low concentrations of uranium and levels of other elements below applicable standards.

Due to the potential for contaminant transport, when exposed at surface, mineralized waste rock is typically used as mine backfill or stored in mined-out pits converted to TMFs. However, there are no special long-term storage requirements for non-mineralized waste rock.

Figure 17. How Uranium Mining and Milling Waste is Generated



7.2 Uranium Mining and Milling Waste Locations

7.3 Uranium Mining and Milling Waste Inventory

Uranium mill tailings are recorded by mass, in tonnes, since this is how the mining industry commonly tracks and reports materials. Waste amounts can be converted to volume (m^3), using assumed or measured densities. A typical dry density for tailings would be 1.0 to 1.5 tonnes/m3. However, tailings densities vary significantly from site to site, and according to the location or depth at a specific site.

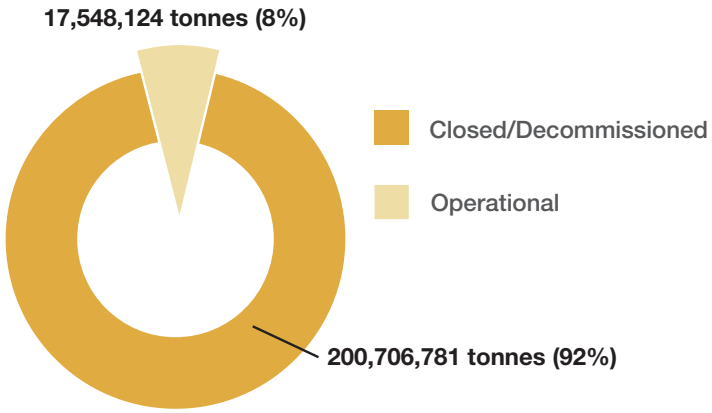
Table 13. Uranium Mine and Mill Tailings Accumulation Rate and Inventory - 2019

Mine/Mill Category	Accumulation Rate (Tailings) in 2019 (tonnes/yr)	Total Mass of Tailings as of Dec. 31, 2019 (tonnes)
Operational	75,286	17,548,124
Closed/Decommissioned	0	200,760,781
Totals	**75,286**	**218,308,905**

Uranium Mill Tailings

The total inventory of tailings is 218,220,346 tonnes. As of December 31, 2019, the inventory of tailings at closed/decommissioned sites was about 201 million tonnes, while about 17.5 million tonnes was from the operating sites. The tailings generated in 2019 were approximately 0.75 million tonnes.

Figure 18. Uranium Mine Tailings Inventory – 2019



Waste Rock

The total inventory of mineralized waste rock as of December 31, 2019, was 36,454,876 tonnes. Non-mineralized waste rock accounted for 130,696,484 tonnes as of December 31, 2019.

The status of the waste rock piles is inherently dynamic due to fluctuations in uranium prices, which determine the ratio of ore to waste rock. As a result, the annual generation rate can be deceptive, and the total inventory of waste rock is used to provide a more representative value.

The following table summarizes the waste rock inventory mass and site status for operating sites, closed/decommissioned sites and development sites in Canada as of December 31, 2019. The 2019 inventory of waste rock is rounded to the nearest 100 tonnes. For waste rock inventory by owner, see Annex 1, Table A.12.

Table 14. Waste Rock Inventory - 2019

Mine/Mill Category	Waste rock inventory	
	Mineralized (tonnes)	**Non-mineralized** (tonnes)
Operational	13,473,595	130,696,484
Closed/Decommissioned	23,200,000	0
Totals	**36,673,876**	**130,696,484**

7.3.1 Decommissioning Waste (Uranium Mining and Milling Waste)

Owing to the large volumes of generated waste and low activity levels, uranium mine sites are decommissioned in place. Decommissioning of surface tailings sites usually includes improvement or construction of dams to provide long-term containment, flooding or covering of tailings to reduce acid generation and the release of gamma radiation and radon gas, and management/monitoring of tailings and effluent.

Waste rock and uranium tailings exist at operating uranium mine and mill sites in northern Saskatchewan and at closed or decommissioned sites in Saskatchewan, Ontario and the Northwest Territories.

7.4 Uranium Mining and Milling Waste Projections

The known resources of uranium ore at mines that are currently in operation will be exhausted prior to 2050. No projections of uranium mine tailings or waste rock are provided due to the uncertainty associated with estimating the volume of waste from potential projects. The following sections provide a brief qualitative assessment of factors affecting future uranium mining and milling waste.

Status of Future Uranium Mining and Milling Waste

Operating Sites

Future uranium production rates could increase depending on timing and market conditions. Ore grades from Cigar Lake are extremely high (15% uranium) and, as a result, have reduced the tailings production rates at the McClean Lake Mill relative to previous uranium production from the McClean Lake Mine. Cameco Corporation will continue to blend Key Lake special waste with high grade ore from McArthur River to produce a mill feed of 4% uranium. At Rabbit Lake, which has been under care and maintenance since 2016, mixing of tailings with waste rock or till prior to deposition is also being considered should operations resume. Due to these possibilities, it is difficult to forecast the final tailings mass from the operating mill sites.

Closed or Decommissioned Sites

Decommissioning of uranium mill tailings generally involves management in place. The current mass of tailings at all inactive or decommissioned sites is approximately 201 million tonnes and is assumed to remain unchanged through 2050.

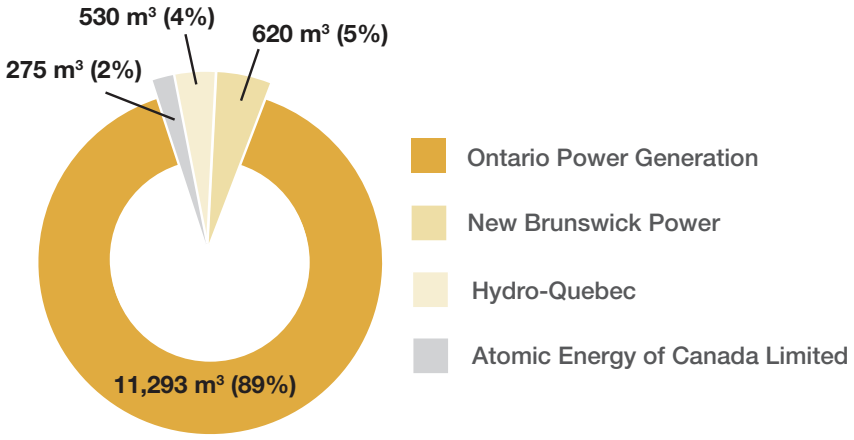
ANNEX 1 – Detailed Radioactive Waste Inventory and Projection Tables

Table A.1 High-Level Radioactive Waste Inventory (by owner) - 2019

Company – Site Name	Reactor Status as of December 2019	Nuclear Fuel Waste Generated in 2019 (2019 Accumulation Rate) Wet Storage		On-Site Nuclear Fuel Waste Inventory to December 31, 2019[1]				
				Wet Storage	Dry Storage	Total Inventory		
		Number of Fuel Bundles	Est. Vol. (m^3)	Number of Fuel Bundles	Number of Fuel Bundles	Number of Fuel Bundles	Est. Vol. (m^3)	Mass of Uranium[1] (kg)
POWER REACTORS								
OPG – Bruce A	Operating	19,032	76	365,480	0	365,480	1,492	6,896,750
OPG – Bruce B	Operating	22,762	91	370,810	0	370,810	1,514	7,045,710
Western WMF	Operating			0	615,542	615,542	2,512	11,710,238
OPG – Darlington	Operating	22,886	92	340,392	0	340,392	1,389	6,518,918
Darlington WMF	Operating			0	260,649	260,649	1,064	4,974,978
OPG – Pickering A	2/4 Units Operating	6,772	27	271,533	0	271,533	1,108	5,342,043
OPG – Pickering B	Operating	12,886	52	157,276	0	157,276	642	3,116,651
Pickering WMF	Operating			0	385,230	385,230	1,572	7,652,154
Hydro-Québec – Gentilly-2	Shutdown/ decommissioning	0	0	5,725	124,200	129,925	530	2,469,204
NB Power – Point Lepreau	Operating	5,252	21	33,460	121,498	154,958	620	2,942,632
Subtotal Power Reactors		**89,590**	**359**	**1,544,676**	**1,507,119**	**3,051,795**	**12,443**	**58,669,278**
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS								
AECL – Douglas Point	Shutdown and partially decommissioned	0	0	0	22,256	22,256	89	299,827
AECL – Gentilly-1	Shutdown and partially decommissioned	0	0	0	3,213	3,213	13	67,596
AECL – National Research Universal Reactor[2]	Shutdown	0	0	804	0	804	3	2,646
AECL – Waste Management Area B (spent research reactor fuel)[2][3]	Operating	280	5	0	9,334	9,334	120	22,646
AECL – Waste Management Area G	Shutdown and partial decommissioning	0	0	0	4,886	4,886	20	65,385
AECL – Whiteshell Laboratories	Shutdown and partially decommissioned	0	0	0	2,290	2,290	29	23,834
McMaster University – Nuclear Reactor[3]	Operating	5	1	13	0	13	1	13
Subtotal Research Reactors		**285**	**6**	**817**	**41,979**	**42,796**	**275**	**481,947**
TOTAL HIGH-LEVEL RADIOACTIVE WASTE		**89,875**	**365**	**1,545,493**	**1,549,098**	**3,094,591**	**12,718**	**59,151,225**

[1] Inventory includes depleted uranium, enriched uranium, natural uranium, plutonium and thorium in spent fuel.
[2] Inventory is reported as fuel bundles, rods, fuel assemblies and/or other items.
[3] Data as of July 31, 2019.

Figure 19. HLW Inventory by Producer – 2019



HLW reported for Bruce Power in Table A.1 are captured under Ontario Power Generation for the purposes of this chart.

Table A.2 High-Level Radioactive Waste Projections (by owner) – 2022, 2030, 2050, 2100

Company – Site Name	HLW Inventory 2022			HLW Inventory 2030		
	Number of Fuel Bundles	Est. Vol. (m^3)	Mass (Millions of Tonnes)	Number of Fuel Bundles	Est. Vol. (m^3)	Mass (kg)
POWER REACTORS						
OPG – Bruce A[1]	644,844	2,631	12,213,990	784,179	3,199	14,853,134
OPG – Bruce B[1]	815,106	3,326	15,573,415	970,920	3,961	18,550,398
OPG – Darlington[1]	643,229	2,624	12,339,062	804,781	3,284	15,438,114
OPG – Pickering A[1]	380,844	1,554	7,566,989	391,901	1,599	7,786,681
OPG – Pickering B[1]	480,309	1,960	9,543,260	518,764	2,117	10,307,322
Hydro-Québec – Gentilly-2[1][6]	129,925	530	2,471,173	129,925	530	2,471,173
NB Power – Point Lepreau[1]	169,931	680	3,237,186	209,931	840	3,999,186
Subtotal Power Reactors	**3,264,188**	**13,305**	**62,945,075**	**3,810,401**	**15,530**	**73,406,008**
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS						
AECL – Douglas Point	22,256	89	299,827	22,256	89	299,827
AECL – Gentilly-1	3,213	13	67,596	3,213	13	67,596
AECL – Chalk River Laboratories (items)[2]	9,334	120	22,646	9,334	120	22,646
AECL – Chalk River Laboratories	804	3	2,646	804	3	2,646
AECL – Chalk River Laboratories (bundles)[3]	4,886	20	65,395	4,886	20	65,395
AECL – Whiteshell Laboratories	2,301	29	21,540	2,301	29	21,540
McMaster University – Nuclear Reactor[2][4]	65	1	72	105	1	116
Subtotal Research Reactors	**42,859**	**275**	**479,722**	**42,899**	**275**	**479,766**
TOTAL HIGH-LEVEL RADIOACTIVE WASTE	**3,307,047**	**13,580**	**63,424,797**	**3,853,300**	**15,805**	**73,885,774**

Company – Site Name	HLW Inventory 2050			HLW Inventory 2100		
	Number of Fuel Bundles	Est. Vol. (m^3)	Mass (Millions of Tonnes)	Number of Fuel Bundles	Est. Vol. (m^3)	Mass (kg)
POWER REACTORS (CONTINUED)						
OPG – Bruce A[1]	1,109,734	4,528	21,019,472	1,217,833	4,969	23,066,975
OPG – Bruce B[1]	1,426,954	5,822	27,263,383	1,693,051	6,908	32,347,432
OPG – Darlington[1]	1,245,488	5,082	23,892,196	1,322,614	5,396	25,371,704
OPG – Pickering A[1]	391,901	1,599	7,786,681	391,901	1,599	7,786,681
OPG – Pickering B[1]	518,764	2,117	10,307,322	518,764	2,117	10,307,322
Hydro-Québec – Gentilly-2[1][6]	129,925	530	2,471,173	129,925	530	2,471,173
NB Power – Point Lepreau[1][5]	265,741	1,063	5,062,366	265,741	1,063	5,062,366
Subtotal Power Reactors	**5,088,507**	**20,741**	**97,802,593**	**5,539,829**	**22,582**	**106,413,653**
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS (CONTINUED)						
AECL – Douglas Point	22,256	89	299,827	22,256	89	299,827
AECL – Gentilly-1	3,213	13	67,596	3,213	13	67,596
AECL – Chalk River Laboratories (items)[2]	9,334	120	22,646	9,334	120	22,646
AECL – Chalk River Laboratories	804	3	2,646	804	3	2,646
AECL – Chalk River Laboratories (bundles)[3]	4,886	20	65,395	4,886	20	65,395
AECL – Whiteshell Laboratories	2,301	29	21,540	2,301	29	21,540
McMaster University – Nuclear Reactor[2][4]	0	0	0	0	0	0
Subtotal Research Reactors	**42,794**	**275**	**479,650**	**42,794**	**274**	**479,650**
TOTAL HIGH-LEVEL RADIOACTIVE WASTE	**5,131,301**	**21,015**	**98,282,243**	**5,582,623**	**22,856**	**106,893,303**

[1] Mass of uranium reported for power reactor operators is approximately 19 kg per bundle, but differs between owners and facilities.
[2] Inventory is reported as the number of irradiated fuel rods, fuel assemblies, units and items.
[3] Number of bundles includes 4,825 bundles from NPD as well as partial bundles from Pickering, Bruce, and Douglas Point.
[4] McMaster University Reactor fuel bundles are planned to be repatriated in the U.S.A, so projections do not account for foreign waste.
[5] In an effort to be consistent with industry and the 2020 Preliminary Decommissioning Plan and Cost Study, NB Power's current/forecast inventory of non-fuel HLW (radioactive waste with a contact dose rate greater than 125 mSv/h) has been included in the tables as ILW.
[6] Hydro-Québec's HLW projections for 2100 may include non-fuel HLW.

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Table A.3 Non-Fuel High-Level Radioactive Waste Inventory – 2019

Facility	Description of Stored Waste	Storage Method	On site waste inventory as of December 19, 2019 (m^3)
OPG – Bruce NGS	Disused Cobalt-60 Sealed Sources	Pool Storage	3

Table A.4 Non-Fuel High-Level Radioactive Waste Projections (by owner), 2022, 2030, 2050, 2100

Facility	Non-Fuel HLW Inventory 2021	Non-Fuel HLW Inventory 2030	Non-Fuel HLW Inventory 2050	Non-Fuel HLW Inventory 2100
OPG – Bruce NGS	N/A	N/A	N/A	N/A
AECL	0	0	2	2

N/A means Not Available.

Table A.5 Intermediate-Level Waste Inventory from Operations (by owner) – 2019

Site name	Responsible Party	ILW Accumulation Rate in 2019 (m^3)	ILW Inventory to Dec. 31, 2019 (m^3)
NUCLEAR FUEL CYCLE & ISOTOPE PRODUCTION			
Western Waste Management Facility	OPG	125	11,293[2]
Darlington Waste Management Facility	OPG	9	628
Pickering Waste Management Facility	OPG	0	1,012
Radioactive Waste Operations Site-1	OPG	0	5
Gentilly-2	Hydro-Québec	3	358
Point Lepreau[3]	NB Power	7	362
Nordion Kanata	Nordion	0	5
Best Theratronics Kanata	Best Theratronics	0	1
Subtotal (Nuclear Fuel Cycle)		**144**	**13,664**
RESEARCH AND DEVELOPMENT			
Chalk River Laboratories[4]	AECL	25	1,050[1]
Subtotal (Nuclear R&D)		**25**	**1,050**
Subtotal (Operations)		**169**	**14,714**

[1] Prior estimates were based on a conservative assumption that all waste stored within a structure that could contain ILW would be categorized as ILW until better characterization data became available. Between 2016 and 2019, retrieval and processing operations were conducted on selected legacy wastes in storage, and records were verified to extrapolate the current volumes.
[2] Includes station in-tank spent resin volumes assumed to be eventually transferred to the Western WMF and stored over the long term.
[3] The decrease in NB Power ILW volumes from December 31, 2016, to December 31, 2019, can be attributed to NB Power's long-term LLW/ILW volume reduction strategy that involves incineration, metal melt recycling, or compaction via Energy Solutions' Bear Creek Radioactive Waste Processing Facility in Oak Ridge, TN.
[4] LLW not intended for the proposed Near-Surface Disposal Facility is included in ILW.

Table A.6 Intermediate-Level Waste Inventory from Decommissioning (by owner) – 2019

Site Name	Responsible Party	ILW Accumulation Rate in 2019 (m^3)	ILW Inventory to Dec. 31, 2019 (m^3)
RESEARCH AND DEVELOPMENT			
Douglas Point[1][2]	AECL	0	6
NPD[1][2]	AECL	0	389
Chalk River Laboratories[1]	AECL	13	332
Whiteshell Laboratories[1][2]	AECL	0	240
Subtotal (Decommissioning)		**13**	**967**
Subtotal (Operations)		**169**	**14,714**
TOTAL INTERMEDIATE-LEVEL RADIOACTIVE WASTE		**182**	**15,681**

[1] LLW not intended for the proposed Near-Surface Disposal Facility is included in ILW.
[2] Volumes have decreased as a result of off-site supplier processing services and/or transfer to the Chalk River Laboratories.

Figure 20. ILW Inventory by Producer - 2019

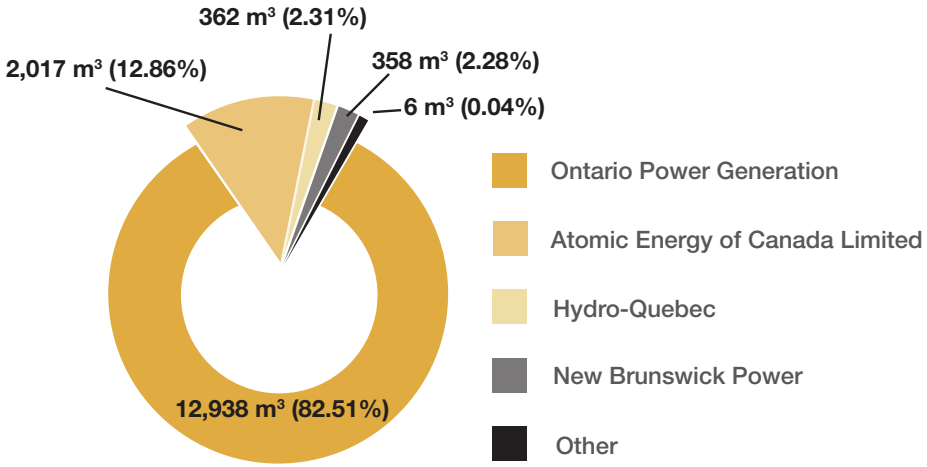


Table A.7 Intermediate-Level Waste Projections from Operations (by owner) – 2022, 2030, 2050, 2100

Site Name	Responsible Party	ILW Inventory 2022 (m^3)	ILW Inventory 2030 (m^3)	ILW Inventory 2050 (m^3)	ILW Inventory 2100 (m^3)
NUCLEAR FUEL CYCLE & ISOTOPE PRODUCTION					
Western Waste Management Facility	OPG	12,463	15,226	17,166	17,702
Darlington Waste Management Facility	OPG	1,523	2,653	2,653	2,653
Pickering Waste Management Facility	OPG	1,012	1,012	1,012	1,012
Radioactive Waste Operations Site-1	OPG	5	5	5	5
Gentilly-2	Hydro-Québec	358	358	358	358
Point Lepreau	NB Power	382	435	210[1]	210[1]
Best Theratronics Kanata	Best Theratronics	1	1	0	0
Subtotal (Nuclear Fuel Cycle)		**15,744**	**19,690**	**21,404**	**21,940**
RESEARCH AND DEVELOPMENT					
Chalk River Laboratories[2]	AECL	1,400	1,538	1,598	1,748
Subtotal (Nuclear R&D)		**1,400**	**1,538**	**1,598**	**1,748**
Subtotal (Operations)		**17,144**	**21,228**	**23,002**	**23,688**

[1] Significant projected volume reduction due to incineration (reduction rate of 80:1) and return shipment of corresponding ash/non-processable waste.
[2] LLW not intended for the proposed Near-Surface Disposal Facility is included in ILW.

Table A.8 Intermediate-Level Waste Projections from Decommissioning (by owner) – 2022, 2030, 2050, 2100

Site Name	Responsible Party	ILW Inventory 2022 (m^3)	ILW Inventory 2030 (m^3)	ILW Inventory 2050 (m^3)	ILW Inventory 2100 (m^3)
NUCLEAR FUEL CYCLE					
Western Waste Management Facility	OPG	0	158	258	358
Gentilly-2	Hydro-Québec	0	0	0	620
Point Lepreau	NB Power	0	0	0	567
Subtotal (Nuclear Fuel Cycle)		0	158	258	1,545
RESEARCH AND DEVELOPMENT					
Douglas Point	AECL	6	6	6	264
Gentilly-1	AECL	0	0	319	319
NPD	AECL	389	389	389	389
Chalk River Laboratories[1][2]	AECL	548	1,711	4,678	4,684
Whiteshell Laboratories	AECL	274	1,435	1,435	1,435
Subtotal (Nuclear R&D)		1,217	3,541	6,827	7,091
Subtotal (Decommissioning)		**1,217**	**3,699**	**7,085**	**8,636**
Subtotal (Operations)		**17,144**	**21,228**	**23,002**	**23,688**
TOTAL INTERMEDIATE-LEVEL RADIOACTIVE WASTE		**18,361**	**24,927**	**30,087**	**32,324**

[1] As of December 31, 2019, "CRL Radioisotope Production and Use" data has been included with the Chalk River Laboratories volumes. In previous inventory reports, this was captured as a separate line item.
[2] LLW not intended for the proposed Near-Surface Disposal Facility is included in ILW.

Table A.9 Historic & Deloro Low-Level Radioactive Waste Inventory – 2019

Site Name		Responsible Party	Total (m^3)
HISTORIC & DELORO WASTE	Port Hope (PHAI)	AECL	720,000
	Welcome (PHAI)	AECL	550,000
	Port Granby (PHAI)	AECL	765,622
	Greater Toronto Area	AECL	4,900
	Deloro	Ontario Ministry of the Environment	34,500
	TOTAL		**2,075,022**

1665
375
375

SITE TRANSITION

Table A.10 Low-Level Waste Inventory from Operations (by owner) – 2019

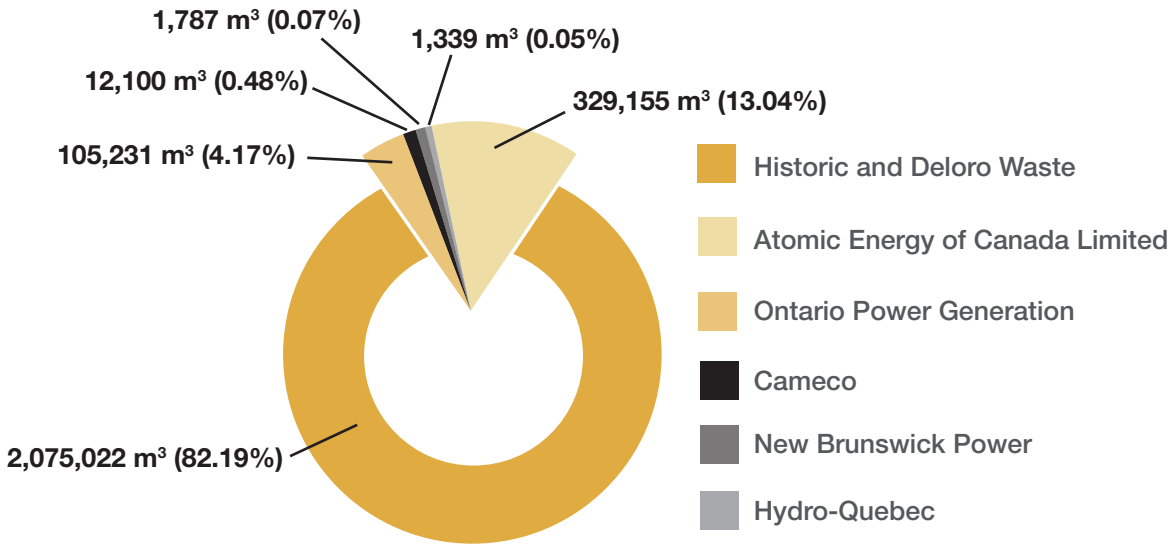
Site Name	Responsible Party	LLW Accumulation Rate in 2019 (m^3)	LLW Inventory to Dec. 31, 2019		
			Waste (m^3)	Cont. Soil (m^3)	Total (m^3)
NUCLEAR FUEL CYCLE & ISOTOPE PRODUCTION					
Western Waste Management Facility	OPG	665	104,906[2]	0	104,906
Radioactive Waste Operations Site-1	OPG	0	325	0	325
Gentilly-2	Hydro-Québec	0	1,339	0	1,339
Point Lepreau[3]	NB Power	71	1,787	0	1,787
Port Hope Conversion Facility	Cameco Corp.	N/A	4,000	0	4,000
Blind River Refinery	Cameco Corp.	N/A	4,400	0	4,400
Cameco Fuel Manufacturing	Cameco Corp.	N/A	2,000	0	2,000
BWXT Toronto	BWXT	34	33	0	33
BWXT Peterborough	BWXT	9	2	0	2
Best Theratronics Kanata	Best Theratronics	N/A	1	0	1
Subtotal (Nuclear Fuel Cycle)		**779**	**118,793**	**0**	**118,793**
RESEARCH AND DEVELOPMENT					
Chalk River Laboratories	AECL	2,655	136,582[1]	156,276	292,858
Subtotal (Nuclear R&D)		**2,655**	**136,582**	**156,276**	**292,858**
Subtotal (Operations)		**3,434**	**255,375**	**156,276**	**411,651**

[1] Volume reduced since 2016, as some material was categorized as packaged waste and included waste that was to be generated in the future.
[2] Includes LLW volumes currently stored off-site at EnergySolutions Canada, but which are assumed to eventually return to and be stored over the long term at the Western WMF.
[3] The decrease in NB Power LLW volumes from December 31, 2016, to December 31, 2019, can be attributed to NB Power's long-term LLW/ILW volume reduction strategy that involves incineration, metal melt recycling, or compaction via Energy Solutions' Bear Creek Radioactive Waste Processing Facility in Oak Ridge, TN.

Table A.11 Low-Level Waste Inventory from Decommissioning (by owner) – 2019

Site Name	Responsible Party	LLW Accumulation Rate in 2019 (m^3)	LLW Inventory to Dec. 31, 2019		
			Waste (m^3)	Cont. Soil (m^3)	Waste (m^3)
NUCLEAR FUEL CYCLE					
Port Hope Conversion Facility	Cameco Corp.	0	1,500	200	1,700
Subtotal (Nuclear Fuel Cycle)		0	1,500	200	1,700
RESEARCH AND DEVELOPMENT					
Douglas Point	AECL	0	92	0	92
Gentilly-1	AECL	0	161	0	161
NPD[2]	AECL	0	2,289	0	2,289
Chalk River Laboratories	AECL	4,588	12,692	4,202	16,894
Whiteshell Laboratories	AECL	929	16,861	0	16,861
Subtotal (Nuclear R&D)		**5,517**	**32,095**	**4,202**	**36,297**
Subtotal (Decommissioning)		**5,517**	**33,595**	**4,402**	**37,997**
Subtotal (Operations)		**3,434**	**255,375**	**156,276**	**411,651**
TOTAL LOW-LEVEL RADIOACTIVE WASTE		**8,951**	**288,970**	**160,678**	**449,648**

Figure 21. LLW Inventory by Producer - 2019



* Does not include 36 cubic metres of low-level waste from other waste producers

Table A.12 Low-Level Waste Projections from Operations (by owner) – 2022, 2030, 2050, 2100

Site Name	Responsible Party	LLW Inventory 2022 (m^3)	LLW Inventory 2030 (m^3)	LLW Inventory 2050 (m^3)	LLW Inventory 2100 (m^3)
NUCLEAR FUEL CYCLE AND ISOTOPE PRODUCTION					
Western Waste Management Facility	OPG	105,026	111,399	110,939	108,252
Radioactive Waste Operations Site-1	OPG	325	325	325	325
Gentilly-2	Hydro-Québec	593[1]	593	593	593
Point Lepreau	NB Power	1,571	983	849	831
Port Hope Conversion Facility	Cameco Corp.	500	350	0	0
Blind River Refinery	Cameco Corp.	700	500	0	0
Cameco Fuel Manufacturing	Cameco Corp.	100	50	0	0
BWXT Toronto	BWXT	33	0	0	0
BWXT Peterborough	BWXT	2	0	0	0
Best Theratronics Kanata	Best Theratronics	1	1	0	0
Subtotal (Nuclear Fuel Cycle)		**108,851**	**114,201**	**112,706**	**110,001**
RESEARCH AND DEVELOPMENT					
Chalk River Laboratories	AECL	294,994	299,281	308,641	332,041
Subtotal (Nuclear R&D)		**294,994**	**299,281**	**308,641**	**332,041**
Subtotal (Operations)		**403,845**	**413,482**	**421,347**	**442,042**

[1] Projection considers ongoing waste reduction program at a ratio of 80:1

Table A.13 Low-Level Waste Projections from Decommissioning (by owner) – 2022, 2030, 2050, 2100

Site Name	Responsible Party	LLW Inventory 2022 (m^3)	LLW Inventory 2030 (m^3)	LLW Inventory 2050 (m^3)	LLW Inventory 2100 (m^3)
NUCLEAR FUEL CYCLE					
Western Waste Management Facility	OPG	0	6,638	7,734	172,163
Gentilly-2	Hydro-Québec	0	0	0	17,033
Point Lepreau	NB Power	0	0	92	14
Port Hope Conversion Facility	Cameco Corp.	1,000	0	0	0
Blind River Refinery	Cameco Corp.	0	0	120,000	120,000
Subtotal (Nuclear Fuel Cycle)		**1,000**	**6,638**	**127,826**	**309,210**
RESEARCH AND DEVELOPMENT					
Douglas Point	AECL	92	422	422	731
Gentilly-1	AECL	208	741	908	908
NPD	AECL	2,289	2,289	2,289	2,289
Chalk River Laboratories	AECL	79,425	151,728	372,481	497,881
Whiteshell Laboratories	AECL	17,028	45,217	45,217	45,217
Subtotal (Nuclear R&D)		**99,042**	**200,397**	**421,317**	**547,026**
Subtotal (Decommissioning)		**100,042**	**207,035**	**549,143**	**856,236**
Subtotal (Operations)		**403,845**	**413,482**	**421,347**	**442,042**
TOTAL LOW-LEVEL RADIOACTIVE WASTE		**503,887**	**620,517**	**970,490**	**1,298,278**

Table A.14 Uranium Mine and Mill Tailing Accumulation Rate and Inventory (by owner) – 2019

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Territory/ Province	Tailings Facility	Accumulation Rate (Tailings) in 2019 (tonnes/yr)	Total Mass of Tailings as of Dec. 31, 2019 (tonnes)	Tailings Facility Status
OPERATING SITES						
Key Lake	Cameco Corp.	Saskatchewan	Deilmann Tailings Management Facility	907	6,177,572	Operating since 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	Rabbit Lake In-Pit Tailings Management Facility	542	9,126,693	Operating since 1985
McClean Lake	Orano Canada Inc.	Saskatchewan	JEB Tailings Management Facility	73,837	2,243,859	Operating since 1999
			Sub-total Operating Sites	**75,286**	**17,548,124**	
CLOSED/DECOMMISSIONED SITES						
Cluff Lake	Orano Canada Inc.	Saskatchewan	Tailings Management Area (TMA)	0	3,230,000	Decommissioned since 2006/ ongoing monitoring
Key Lake	Cameco Corp.	Saskatchewan	Surface Tailings (Old Tailings Pond)	0	3,579,781[2]	Closed since 1996/ ongoing monitoring
Rabbit Lake	Cameco Corp.	Saskatchewan	Surface Tailings	0	6,500,000	Closed since 1985/ ongoing monitoring
Beaverlodge	Cameco Corp.	Saskatchewan	Surface, Surface and Sub-aqueous Tailings	0	5,700,000[1]	Decommissioned since 1982/ ongoing monitoring
Gunnar	Saskatchewan Research Council	Saskatchewan	Surface Tailings	0	4,400,000	Closed since 1964
Lorado	Saskatchewan Research Council	Saskatchewan	Surface Tailings	0	360,000	Decommissioned 2015/ ongoing monitoring
Port Radium	Crown-Indigenous Relations and Northern Affairs Canada	Northwest Territories	Surface Tailings – Four Areas	0	907,000	Decommissioned since 1984/ ongoing monitoring
Rayrock	Crown-Indigenous Relations and Northern Affairs Canada	Northwest Territories	North and South Tailings Pile	0	71,000	Closed since 1959/ ongoing monitoring
Quirke 1 and 2 - Elliot Lake	Rio Algom Ltd.	Ontario	Quirke Mine TMA	0	46,000,000	Decommissioned / ongoing monitoring
Panel - Elliot Lake	Rio Algom Ltd.	Ontario	Panel Mine TMA, Main Basin and South Basin	0	16,000,000	Decommissioned / ongoing monitoring
Denison - Elliot Lake	Denison Mines Corp.	Ontario	Denison Tailings Management Area (TMA1,TMA2)	0	63,800,000	Decommissioned / ongoing monitoring

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Territory/ Province	Tailings Facility	Accumulation Rate (Tailings) in 2019 (tonnes/yr)	Total Mass of Tailings as of Dec. 31, 2019 (tonnes)	Tailings Facility Status
CLOSED/DECOMMISSIONED SITES						
Spanish-American - Elliot Lake	Rio Algom Ltd.	Ontario	Spanish American TMA	0	450,000	Decommissioned / ongoing monitoring
Stanrock/Can-Met - Elliot Lake	Denison Mines Corp.	Ontario	Stanrock TMA	0	5,750,000	Decommissioned / ongoing monitoring
Stanleigh - Elliot Lake	Rio Algom Ltd.	Ontario	Stanleigh TMA	0	19,953,000	Decommissioned / ongoing monitoring
Lacnor - Elliot Lake	Rio Algom Ltd.	Ontario	Lacnor Waste Management Area (WMA)	0	2,700,000	Decommissioned / ongoing monitoring
Nordic - Elliot Lake	Rio Algom Ltd.	Ontario	Nordic WMA	0	12,000,000	Decommissioned / ongoing monitoring
Milliken - Elliot Lake	Rio Algom Ltd.	Ontario	Milliken	0	150,000	Decommissioned / ongoing monitoring
Pronto - Elliot Lake	Rio Algom Ltd.	Ontario	Pronto WMA	0	2,100,000	Decommissioned / ongoing monitoring
Agnew Lake Mines - Espanola	Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry	Ontario	Dry TMA	0	510,000	Decommissioned since 1990/Ongoing Monitoring
Dyno - Bancroft	EnCana West Ltd.	Ontario	Surface Tailings	0	600,000	Closed since 1960/ ongoing monitoring
Bicroft - Bancroft	Barrick Gold Corp.	Ontario	Bicroft TMA	0	2,000,000	Closed since 1964/ ongoing monitoring
Madawaska - Bancroft	EnCana West Ltd.	Ontario	Surface Tailings – Two Areas	0	4,000,000	Decommissioned / ongoing monitoring
			Sub-total Decommissioned Sites	**0**	**200,760,781**	
			TOTAL	**75,286**	**218,308,905**	

[1] Tailings volume does not include 4,300,000 tonnes that have been used as backfill.
[2] Based on monthly production reports between 1983 and 1996. In 1996, tailings placement switched to the Deilmann TMF.

Table A.15 Uranium Waste Rock Inventory (by owner) – 2019

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Waste Rock Inventory		Waste Rock Site Status as of December 2019
			Mineralized (tonnes)	Non-Mineralized (tonnes)	
Key Lake	Cameco Corp.	Saskatchewan	1,123,058	68,028,327	Operating since 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	1,348,389	11,157,174	Suspended July 2016
McClean Lake	Orano Canada Inc.	Saskatchewan	10,200,000	51,200,000	Operating since 1999
McArthur River	Cameco Corp.	Saskatchewan	116,501	226,811	Operating since 1999
Cigar Lake	Cameco Corp.	Saskatchewan	685,647	84,172	Operating since 2014
Subtotal Operational Sites			**13,473,595**	**130,696,484**	
Cluff Lake	Orano Canada Inc.	Saskatchewan	18,400,000[1]		Decommissioned since 2006/ Ongoing Monitoring
Beaverlodge	Cameco Corp.	Saskatchewan	4,800,000[1]		Decommissioned since 1982/ Ongoing Monitoring
Totals			**36,673,595**	**130,696,484**	

[1] Inventory added to total for mineralized waste rock.