Inventory of Radioactive Waste in Canada

Low-Level Radioactive Waste Management Office

Ottawa, Canada
2012

Inventory of Radioactive Waste in Canada
March 2012

LLRWMO-01613-041-10003
CC3-1/2012
978-1-100-54191-4

Canada

Inventory of Radioactive Waste in Canada

Low-Level Radioactive Waste Management Office
1900 City Park Drive, Suite 200
Ottawa, Ontario Canada
K1J 1A3

Executive Summary

This report presents the inventory of radioactive waste in Canada to the end of 2010. It is intended to provide an overall review on the production, accumulation and projections of radioactive waste in Canada. The data presented in this report has been gathered from many sources including regulatory documents, published reports and supplemental information provided by the nuclear regulator, waste producers and waste management facilities.

Radioactive waste has been produced in Canada since the early 1930s when the first radium mine began operating at Port Radium in the Northwest Territories. Radium was refined for medical use and uranium was later processed at Port Hope, Ontario. Research and development on the application of nuclear energy to produce electricity began in the 1940s at the Chalk River Laboratories (CRL) of Atomic Energy of Canada Limited (AECL).

At present, radioactive waste is generated in Canada from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operations; nuclear research; and radioisotope manufacture and use.

Radioactive waste is primarily grouped into three categories: nuclear fuel waste, low- and intermediate-level radioactive waste, and uranium mining and milling waste.

In accordance with Canada’s Radioactive Waste Policy Framework, the owners of radioactive waste are responsible for the funding, organization, management and operation of long-term waste management facilities required for their waste. The policy recognizes that arrangements may be different for each of the three waste categories.

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

The following table presents a summary of the quantity of radioactive waste produced in 2010 and the cumulative inventory to the end of 2010.

Waste Data to 2010

Waste Category	Waste Produced in 2010	Waste Inventory to the End of 2010
Nuclear Fuel Waste	298 m^3	9,075 m^3
Intermediate-Level Radioactive Waste	208 m^3	32,906 m^3
Low-Level Radioactive Waste	5,116 m^3	2,338,000 m^3
Uranium Mill Tailings	0,7 million tonnes	214 million tonnes
Waste Rock	N/A	175 million tonnes

Note : N/A - not available

In order to assess the future requirements for the management of radioactive waste, a projection of the inventory to the end of 2011 and 2050 is also provided in the table above. The year 2050 is selected as a future reference because it is forecasted as the end of operation for the last constructed power reactors, Darlington Generating station (Ontario Power Generation, 2010a).

Waste Inventory Projections to 2011 and 2050

Waste Category	Waste Inventory to the End of 2011	Waste Inventory to the End of 2050
Nuclear Fuel Waste	9,400 m^3	20,000 m^3
Intermediate-Level Radioactive Waste	33,400m^3	67,000 m^3
Low-Level Radioactive Waste	2,343,000 m^3	2,594,000 m^3

Table of Contents

Page

1.0 INTRODUCTION . . . 1

1.1 Policy and Legislative Framework for Radioactive Waste Management in Canada . . . 1

2.0 REPORT OBJECTIVE . . . 2

3.0 REPORT SCOPE AND ORGANIZATION . . . 2

4.0 SOURCES . . . 3

4.1 Nuclear Fuel Waste . . . 3

4.2 Low- and Intermediate-Level Radioactive Waste . . . 7
4.2.1 Ongoing Waste . . . 8
4.2.1.1 Operations . . . 8
4.2.1.2 Decommissioning . . . 13
4.2.2 Historic Waste . . . 14

4.3 Uranium Mining and Milling Waste . . . 15
4.3.1 Operating Sites . . . 19
4.3.2 Closed or Decommissioned Sites . . . 20
4.3.3 Development Sites . . . 21

5.0 CURRENT INVENTORY AND ACCUMULATION RATE . . . 22

5.1 Nuclear Fuel Waste . . . 22

5.2 Low- and Intermediate-Level Radioactive Waste . . . 24
5.2.1 Ongoing Waste . . . 25
5.2.1.1 Operations . . . 28
5.2.1.2 Decommissioning . . . 28
5.2.2 Historic Waste . . . 29

5.3 Uranium Mining and Milling Waste . . . 30
5.3.1 Uranium Mill Tailings . . . 30
5.3.2 Waste Rock . . . 34

6.0 PROJECTIONS . . . 34

6.1 Nuclear Fuel Waste . . . 34

Table of Contents (cont'd)

Page

6.2 **Low- and Intermediate-Level Radioactive Waste** 36
- 6.2.1 Ongoing Waste 38
  - 6.2.1.1 Operations 38
  - 6.2.1.2 Decommissioning 39
- 6.2.2 Historic Waste 40

6.3 **Uranium Mining and Milling Waste** 40
- 6.3.1 Operation Sites 41
- 6.3.2 Closed or Decommissioned Sites 41
- 6.3.3 Development Sites 41

7.0 SUMMARY 42

8.0 SOURCES OF INFORMATION 43

Appendix A - Policy Framework for Radioactive Waste

List of Tables

Table 4.1 Summary of CNSC Power Reactor Operating Licences 5
Table 4.2 Summary of CNSC Research Reactor Operating Licences 6
Table 4.3 Uranium Refinery, Conversion Facility and Fuel Fabrication Plant Licences 9
Table 4.4 Summary of CNSC Waste Management Licences 12
Table 4.5 Uranium Mine and Mill Facility Licences 16
Table 5.1 Nuclear Fuel Waste Accumulation Rate and Inventory, 2010 22
Table 5.2 LLRW Accumulation Rate and Inventory, 2010 25
Table 5.3 ILRW Accumulation Rate and Inventory, 2010 26
Table 5.4 Uranium Mill Tailings Accumulation Rate and Inventory, 2010 31
Table 5.5 Waste Rock Inventory, 2010 33
Table 6.1 Projected Nuclear Fuel Waste Inventory to 2011 and 2050 35
Table 6.2 Projected L&ILRW Inventory to 2011 and 2050 37
Table 7.1 Summary of Current and Future Inventories 42

Table of Contents (cont'd)

Page

List of Figures

Figure 4.1	Radioactive Waste Sites in Canada as of December 31, 2010	4
Figure 4.2	Nuclear Reactor Sites	7
Figure 4.3	Process Flowchart for Uranium Refining and Conversion	9
Figure 4.4	Process Flowchart for Nuclear Fuel Fabrication	10
Figure 4.5	Process Flowchart for CANDU Reactor Operations	10
Figure 4.6	Process Flowchart for CANDU Reactor Decommissioning	13
Figure 4.7	Uranium Mine and Mill Tailings Sites in Canada	17
Figure 4.8	Uranium Mine and Mill Tailings Sites near Elliot Lake, Ontario	18
Figure 4.9	Uranium Mine and Mill Tailings Sites near Bancroft, Ontario	19
Figure 5.1	Nuclear Fuel Waste Inventory, 2010	24
Figure 5.2	Ongoing LLRW Accumulation Rates, 2010	26
Figure 5.3	Ongoing ILRW Accumulation Rates, 2010	26
Figure 5.4	L&ILRW Inventory, 2010	27
Figure 5.5	Ongoing L&ILRW Inventory, 2010	27
Figure 5.6	Inventory of Uranium Mill Tailings, 2010	33
Figure 5.7	Waste Rock Inventory, 2010	33
Figure 6.1	Nuclear Fuel Waste Inventories Projection, 2050	36
Figure 6.2	Nuclear Fuel Waste Inventory, 2010 and Projection to 2050	36
Figure 6.3	LLRW Inventories, 2010 and 2050	38
Figure 6.4	ILRW Inventories, 2010 and 2050	38
Figure 6.5	Annual Volume of Radioactive Waste from Decommissioning of Power Reactors to 2105	40
Figure 7.1	Summary of Radioactive Waste Inventories, 2010	42

1.0 INTRODUCTION

This report provides the annual accumulation rate and inventory of radioactive waste in Canada to the end of 2010.

Radioactive waste has been produced in Canada since the early 1930s when the first radium mine in Canada began operating at Port Radium in the Northwest Territories. Ore from the mine was processed at Port Hope, Ontario, first to extract radium for medical use and, later, for uranium. Research and development on the application of nuclear energy to produce electricity began in the 1940s at the Chalk River Laboratories (CRL) of Atomic Energy of Canada Limited (AECL).

At present, radioactive waste is generated in Canada from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operations; nuclear research; and radioisotope manufacture and use.

1.1 Policy and Legislative Framework for Radioactive Waste Management in Canada

The components of Canada's 1996 Radioactive Waste Policy Framework consist of a set of principles governing the institutional and financial arrangements for disposal of radioactive waste by waste producers and owners and these include:

- 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; and

- The waste producers and owners are responsible, in accordance with the principle of "polluter pays", for the funding, organization, management and operation of disposal and other facilities required for their waste. This recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste and uranium mine and mill tailings.

Radioactive waste is currently managed in a safe and environmentally responsible manner by storing the waste under the requirements of the Canadian Nuclear Safety Commission (CNSC), Canada’s independent nuclear regulator.

In accordance with Canada’s Radioactive Waste Policy Framework (see Appendix A), the owners of radioactive waste are responsible for the funding, organization, management, and operation of long-term waste management facilities required for their waste. The policy recognizes that arrangements may be different for each of the waste categories.

The *Nuclear Safety and Control Act* (NSCA) was passed by Parliament on March 20, 1997. The NSCA established the Canadian Nuclear Safety Commission, as Canada's nuclear regulator, and authorizes it to make regulations. The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect health, safety, security and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy.

The CNSC regulatory framework consists of regulations and associated regulatory policies, standards and guides that apply to all nuclear industries including, but not limited to: 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 controlled nuclear and dual-use substances, equipment and technology identified as a proliferation risk.

The 2002 *Nuclear Fuel Waste Act* is a key piece of legislation that governs the long-term management of nuclear fuel waste 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 manage the full range of long-term nuclear fuel waste management activities. In 2002, the Nuclear Waste Management Organization was created to carry out this important work. Under the Act, an important responsibility, among others, 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.

2.0 REPORT OBJECTIVE

The objective of this report is to:

- provide an overall review on the production, accumulation and projections of radioactive waste in Canada.

3.0 REPORT SCOPE AND ORGANIZATION

The scope of the report includes radioactive waste of the following three categories:

- high level radioactive waste;
- low- and intermediate-level radioactive waste; and
- uranium mining and milling waste.

The data on radioactive waste inventory are based on regulatory documents, published reports and supplemental information provided by the nuclear regulator, waste generators and waste management facilities. Regulatory documents include: annual or quarterly compliance reports, annual safety reviews and decommissioning reports submitted to the CNSC. The following sections of this report are outlined as follows:

- Section 4 of this report describes the sources and producers of each of the three categories of radioactive waste.
- Section 5 summarizes the accumulation rates during 2010 and waste inventory to the end of 2010.
- Section 6 presents projections for nuclear fuel waste, and low- and intermediate level waste to 2011 and 2050.
- Section 7 summarizes current and future inventories.

Appendix A provides the Federal Policy Framework for Radioactive Waste.

4.0 SOURCES

This section briefly identifies how radioactive waste is produced, where it is located and the producers and owners of the waste. Information on the operations and status of nuclear facilities and waste management facilities is as of December 31, 2010. Figure 4.1 provides a map showing where radioactive waste is currently located.

4.1 Nuclear Fuel Waste

For the purpose of this report, nuclear fuel waste includes nuclear fuel bundles, other fuel forms and some liquids. These waste forms can also be referred to as High Level Radioactive Waste (HLRW). Nuclear fuel waste is discharged from:

- the CANDU power reactors;
- prototype and demonstration power reactors; and
- research and isotope production reactors.

In terms of liquid HLRW, Canada has approximately 300,000 litres in storage at Chalk River Laboratories, Ontario from the production of medical isotopes and Cold War-era fuel processing experiments.

Power Reactors

There are 22 power reactors in Canada 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. Bruce Power Inc. currently leases and operates the Bruce nuclear power plants from OPG. The Bruce plants consist of eight CANDU nuclear reactors. These 22 reactors have a total generation capacity of 15,000 megawatts of electricity.

As of December 31, 2010, 17 nuclear power reactors were operating, producing about 15% of

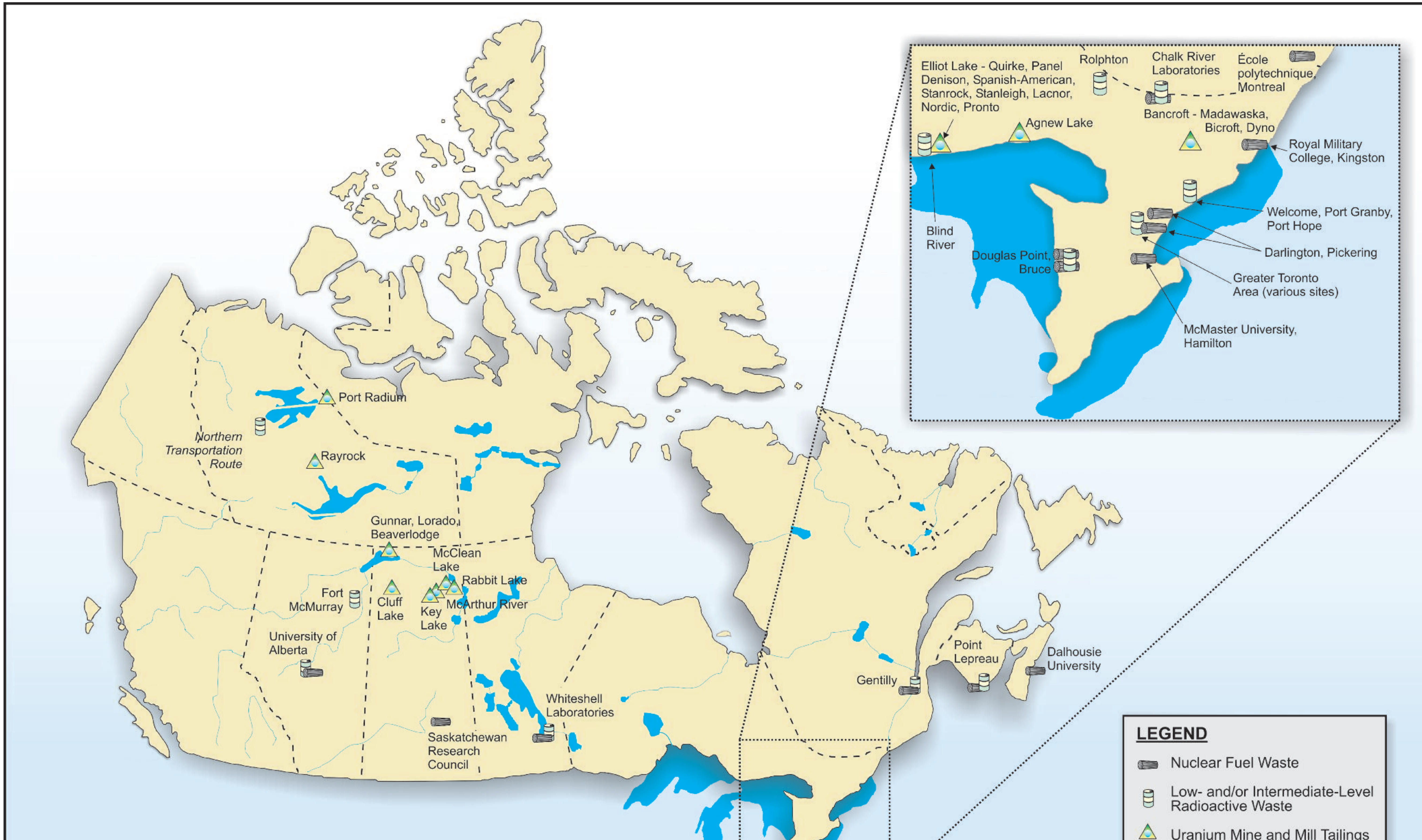


Figure 4.1: Radioactive Waste Sites in Canada
as of December 31, 2010

Canada's electricity. At present, nuclear power meets approximately 50% of Ontario's electricity needs (CNSC, 2010).

Ontario Power Generation Inc. has 16 reactors in operation (including six reactors operated by Bruce Power Inc.); two reactors are in voluntary layup; and two reactors are undergoing refurbishment. Refurbishment work by Bruce Power Inc. began at Bruce A, Units 1 and 2 in 2005. The reactors are scheduled for return to commercial operation in 2012. New Brunswick Power began refurbishment of the Point Lepreau Generating Station in 2008 and it is scheduled to return to commercial operation sometime in 2012. The reactor owned by Hydro-Québec, Gentilly-2, is operational.

Nuclear fuel waste, a by-product of nuclear power generation, is currently safely managed in facilities licensed for interim storage at nuclear reactor sites in Ontario, Quebec, New Brunswick and at Atomic Energy of Canada Limited's nuclear research site in Manitoba and Chalk River Laboratories in Ontario. The waste will remain at these sites until a deep geological repository becomes operational.

Table 4.1: Summary of CNSC Power Reactor Operating Licences

Facility and Location	Licensee	Type and Number of Units/Capacity
Bruce Generating Station A, Tiverton, Ontario	Bruce Power Inc.	CANDU-PHW 4 x 750 MW(e)
Bruce Generating Station B, Tiverton, Ontario	Bruce Power Inc.	CANDU-PHW 4 x 840 MW(e)
Pickering Generating Station A, Pickering, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 500 MW(e)
Pickering Generating Station B, Pickering, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 500 MW(e)
Darlington Generating Station, Bowmanville, Ontario	Ontario Power Generation Inc.	CANDU-PHW 4 x 850 MW(e)
Gentilly-2 Generating Station, Bécancour, Quebec	Hydro-Québec	CANDU-PHW 600 MW(e)
Point Lepreau Generating Station, Point Lepreau, New Brunswick	New Brunswick Power Corporation	CANDU-PHW 600 MW(e)

Notes : Nuclear fuel waste from these reactors is stored at the respective sites.
MW(e) - megawatt (nominal electrical power output)

Research Reactors

There are three prototype power reactors, Douglas Point, Nuclear Power Demonstration (NPD) and Gentilly-1, located at Douglas Point and Rolphton, Ontario, and Bécancour, Quebec, respectively. Each of these facilities has been partially decommissioned and is in Phase 2 decommissioning (storage-with-surveillance). All three reactors await dismantling. Nuclear fuel waste from the Douglas Point and Gentilly-1 reactors is in dry storage at the on-site waste management facilities. Nuclear fuel waste from the NPD reactor was transferred to a waste management facility at AECL's Chalk River Laboratories (AECL-CRL).

Nuclear fuel waste is also produced by the research and radioisotope production reactors at AECL and at research reactors located at universities. There are two nuclear research laboratories in Canada: AECL-CRL in Chalk River, Ontario is operational, and AECL's Whiteshell Laboratories (AECL-WL) in Pinawa, Manitoba is undergoing decommissioning. There are two operational research and radioisotope production reactors at AECL-CRL: the National Research Universal (NRU) and Zero Energy Deuterium-2 (ZED-2) reactors. Waste generated at these sites are stored in waste management facilities at each site. There are six research reactors operating at universities in Canada as of December 31, 2010. The nuclear fuel waste as well as low-level and intermediate-level radioactive waste produced at these sites is either shipped to AECL-CRL or to a licensed facility in the United States for processing.

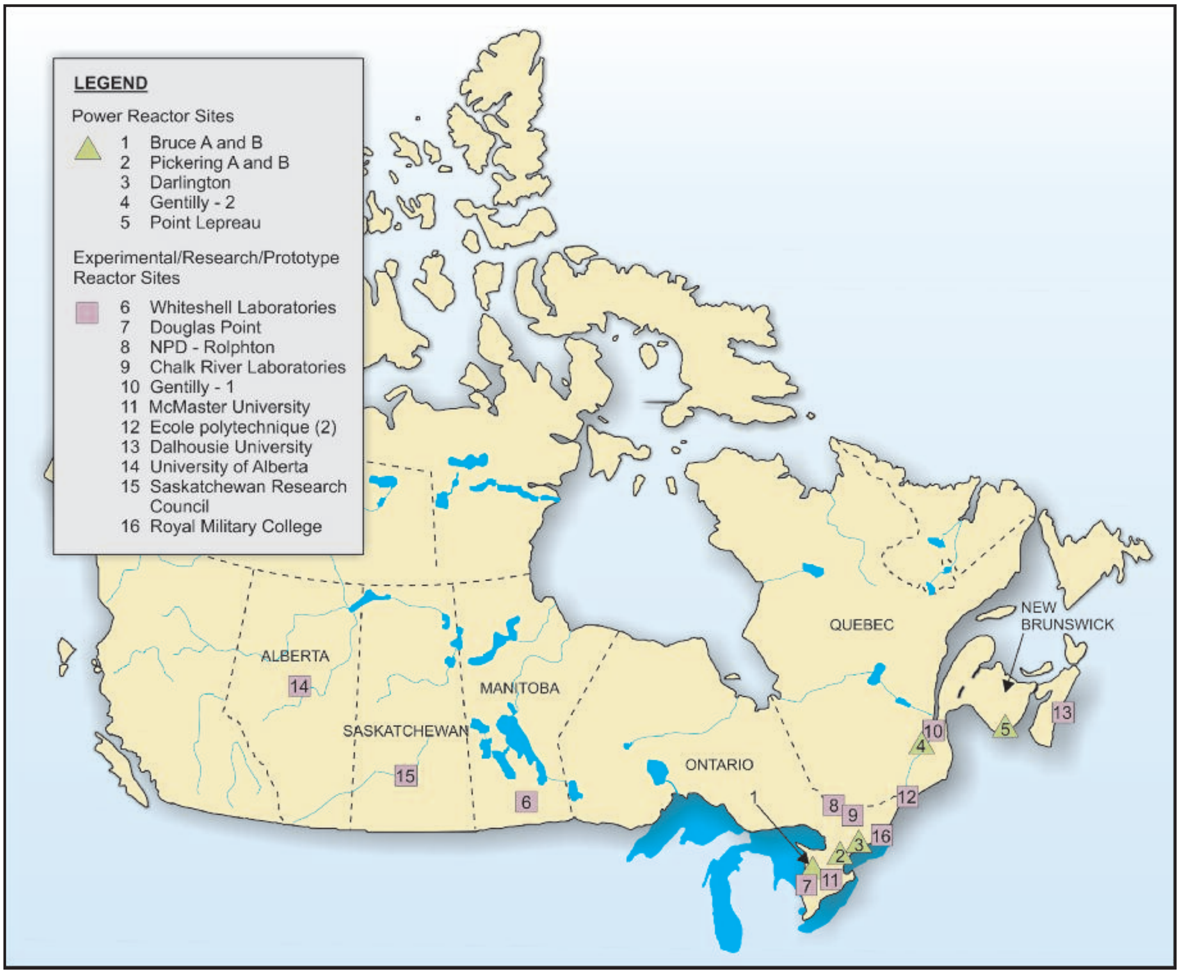
Table 4.1 lists power reactors operating under CNSC Licences and Table 4.2 lists research reactors operating under CNSC Licences. Figure 4.2 shows the location of these reactors.

Table 4.2: Summary of CNSC Research Reactor Operating Licences

Location	Licensee	Type and Capacity
Hamilton, Ontario	McMaster University	Pool-type 5 MW(t)
Montréal, Québec	École polytechnique	Subcritical Assembly
Montréal, Québec	École polytechnique	SLOWPOKE-2, 20 kW(t)
Halifax, Nova Scotia	Dalhousie University	SLOWPOKE-2, 20 kW(t)
Edmonton, Alberta	University of Alberta	SLOWPOKE-2, 20 kW(t)
Saskatoon, Saskatchewan	Saskatchewan Research Council	SLOWPOKE-2, 20 kW(t)
Kingston, Ontario	Royal Military College of Canada	SLOWPOKE-2, 20 kW(t)
Chalk River, Ontario	Atomic Energy of Canada	NRU and ZED-2

Notes: MW(t) - megawatt (thermal power)
kW(t) - kilowatt (thermal power)

Figure 4.2: Nuclear Reactor Sites



4.2 Low- and Intermediate-Level Radioactive Waste

Low- and intermediate-level radioactive waste (L&ILRW) includes all non-fuel waste arising from the activities associated with nuclear electricity generation, from nuclear research and development, and from the production and use of radioisotopes in medicine, education, research, agriculture and industry. Examples of LLRW are contaminated materials, rags and protective clothing. It also includes contaminated soils and related waste resulting from the very early operations of Canada's radium industry. Ion exchange resins and filters are examples of ILRW. L&ILRW is grouped into two broad categories, as follows:

- *Ongoing Waste:* L&ILRW that is generated from ongoing activities of companies that are currently in business, for example, nuclear electricity generators. Owners or producers of ongoing waste are responsible for its management.

- *Historic Waste:* LLRW that was managed in the past in a manner no longer considered acceptable but for which the current owner cannot reasonably be held responsible. The federal government has accepted responsibility for long-term management of this waste.

4.2.1 Ongoing Waste

Ongoing waste results from operation, maintenance and decommissioning of facilities related to:

- the nuclear fuel cycle;
- nuclear research and development; and
- production and use of radioisotopes.

4.2.1.1 Operations

Nuclear Fuel Cycle

The nuclear fuel cycle includes: uranium mining, refining and conversion; nuclear fuel fabrication; and nuclear power reactor operations. Waste associated with uranium mining are dealt with in a separate section. There are five licensed uranium processing and fuel fabrication facilities operating in Ontario.

During refining, the ore concentrate from uranium milling operations is upgraded to uranium trioxide. The uranium trioxide is then converted to ceramic grade uranium dioxide for fabrication into fuel for CANDU reactors, or processed into uranium hexafluoride for foreign light water reactors. Approximately one quarter of the uranium mined in Canada is used for domestic nuclear electricity production. Cameco Corporation operates Canada's only refinery facility at Blind River, Ontario, and the only conversion facility at Port Hope, Ontario.

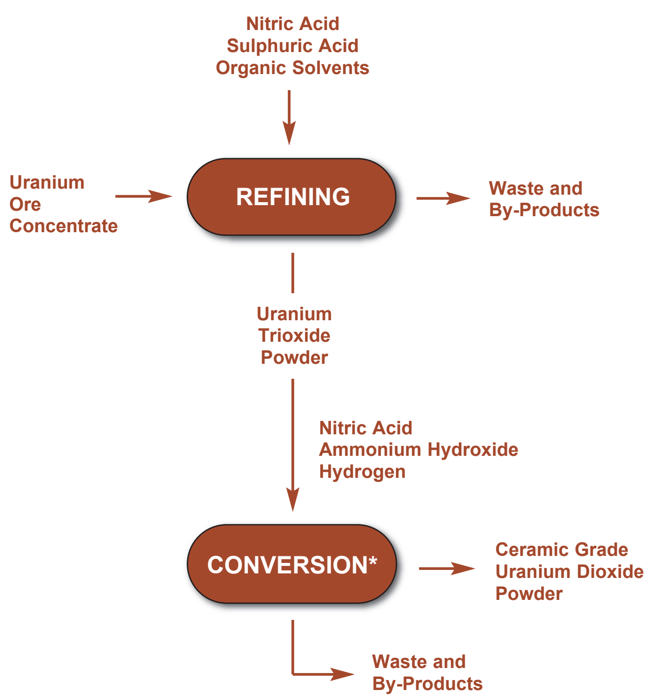
During fuel fabrication, uranium dioxide is formed into pellets, then sintered and sheathed in zirconium to form fuel bundles for power reactors. General Electric Canada Incorporated and Cameco Fuel Manufacturing both have fuel fabrication facilities in Canada. General Electric Canada produces fuel pellets and fuel bundles at facilities in Toronto and Peterborough, Ontario, respectively. Cameco Fuel Manufacturing produces both pellets and bundles at a facility in Port Hope, Ontario. Table 4.3 provides a list of CNSC licensees involved in uranium refining, conversion and fuel fabrication activities.

Table 4.3: Uranium Refinery, Conversion Facility and Fuel Fabrication Plant Licences

Licensee and Location	Licensed Activity
General Electric Canada Incorporated, Toronto, Ontario	Fuel Pellets
General Electric Canada Incorporated, Peterborough, Ontario	Fuel Bundles
Cameco Fuel Manufacturing, Port Hope, Ontario	Fuel Pellets and Bundles
Cameco Corporation, Blind River, Ontario	Uranium Trioxide
Cameco Corporation, Port Hope, Ontario	Uranium Hexafluoride Natural and Depleted Uranium Metal and Alloys Uranium Dioxide Ammonium Diuranate

Figure 4.3 summarizes the input and output streams and L&ILRW resulting from the refining and conversion of uranium. Figure 4.4 shows the process associated with nuclear fuel fabrication and fuel bundle production and the resulting L&ILRW.

Figure 4.3: Process Flowchart for Uranium Refining and Conversion



BY-PRODUCTS

Ammonium Nitrate Fertilizer
Raffinates (recycled)

WASTE

Combustible Waste
Uncontaminated and contaminated scrap lumber, pallets, rags, paper, cardboard, rubber and plastic

Organic Liquid Waste

Non-Combustible Waste
Uncontaminated insulation, pipe-racks, light bulbs, metal turnings, paint cans, cell gaskets, concrete, glass

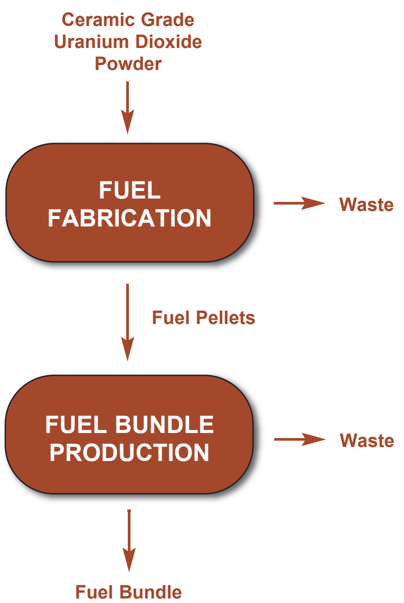
Contaminated air filters, fibreglass, PVC ductwork, floor sweepings, sandblast sand, insulation, sample bottles, scrap metal, anodes

Recyclable scrap metal

Radioactive drain waste

*In addition to ceramic grade uranium dioxide powder for CANDU reactors, Cameco also produces uranium hexafluoride for light water reactors.

Figure 4.4: Process Flowchart for Nuclear Fuel Fabrication

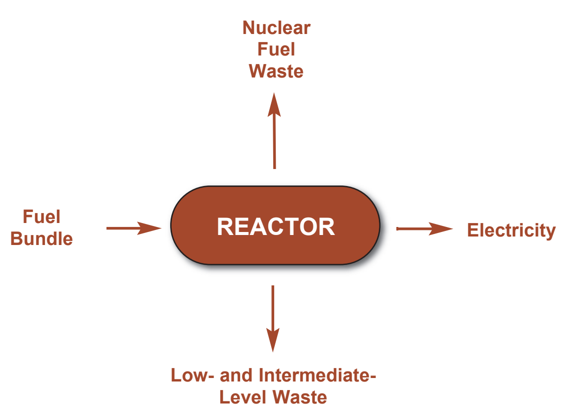


WASTE

Contaminated rags, paper, gloves
Contaminated oils and oil sludges
Contaminated equipment and construction materials
Filters and dust collectors

Figure 4.5 summarizes the input and output streams and L&ILRW produced from reactor operations. Waste include natural uranium, neutron activation or fission products. Both solid and liquid waste are produced.

Figure 4.5: Process Flowchart for CANDU Reactor Operations



LOW- and INTERMEDIATE-LEVEL WASTE

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

There were 17 radioactive waste management facilities under CNSC Licence as of the end of 2010. These facilities are listed in Table 4.4. Some of these facilities are licensed to manage only L&ILRW while some are licensed to manage both L&ILRW and nuclear fuel waste.

Nuclear Research and Development

Currently, there are two nuclear research facilities in Canada licensed by the CNSC and operated by AECL. These facilities are the Chalk River Laboratories in Chalk River, Ontario and the Whiteshell Laboratories in Pinawa, Manitoba. Operational waste produced at these two sites are stored in waste management facilities at each site. The Chalk River facility (AECL-CRL) has two operating reactors, the NRU reactor and the zero power ZED-2 reactor. Research and development activities at AECL-CRL include the application of nuclear science, reactor development, environmental science and L&ILRW management.

Whiteshell Laboratories (AECL-WL) is shutdown and undergoing decommissioning. The AECL-WL decommissioning licence was renewed in December 2008 for a period of ten years. This allows AECL to complete Phase 1 of the decommissioning program. The WR-1 reactor has been partially decommissioned (currently in storage with surveillance) and the SLOWPOKE Demonstration Reactor has been fully decommissioned.

AECL-CRL waste management sites, which began operation during the early years of nuclear research and development in Canada, will require remediation or decommissioning in the future. These sites are managed safely by AECL under CNSC licences. The waste include both the original waste stored at the sites and any soils contaminated by the waste. These waste were generated by AECL as a result of Cold War activities up to 1963 and research and development work associated with the development of CANDU reactors, the advancement of nuclear science and the production of radioisotopes.

Six research reactors at universities operate under licences issued by the CNSC (see Table 4.2). These reactors are used for neutron activation analyses and other nuclear research. Operation of these research reactors produces small quantities of L&ILRW compared with the power reactor sites. Waste from the research reactor sites is generally sent to AECL-CRL for management by AECL.

Production and Use of Radioisotopes

Radioisotopes, as sealed or unsealed sources, have industrial, medical and educational applications. In Canada, these radioisotopes are produced primarily at AECL-CRL. Radioisotopes are primarily marketed by Nordion Inc. (Nordion), located in Ottawa, Ontario. In addition to radioisotope production at AECL-CRL, Ontario Power Generation Inc., Hydro-Québec, Bruce Power Inc., TRIUMF (University of British Columbia) and the McMaster Nuclear Reactor (McMaster University) produce radioisotopes that are shipped to Nordion and other marketers for further processing, packaging and distribution to secondary manufacturers, repackagers or clients. Waste that are generated during production are managed by the respective producers.

When radioisotopes have outlived their useful application, they become radioactive waste. These waste (or spent sources) are generally shipped to AECL-CRL for management.

Table 4.4: Summary of CNSC Waste Management Licences

Facility and Location	Licensee
Radioactive Waste Operations Site 1, Bruce Nuclear Power Development, Tiverton, Ontario	Ontario Power Generation Inc.
WWMF, Bruce Nuclear Power Development, Tiverton, Ontario	Ontario Power Generation Inc.
Pickering Waste Management Facility, Pickering, Ontario	Ontario Power Generation Inc.
Darlington Waste Management Facility, Bowmanville, Ontario	Ontario Power Generation Inc.
Gentilly-2 Radioactive Waste Management Facility, Bécancour, Quebec	Hydro-Québec
Point Lepreau Solid Radioactive Waste Management Facility, Point Lepreau, New Brunswick	New Brunswick Power Corp.
Douglas Point Radioactive Waste Management Facility, Douglas Point, Ontario	AECL
Gentilly-1 Radioactive Waste Management Facility, Bécancour, Quebec	AECL
NPD Waste Management Facility, Rolphton, Ontario	AECL
Port Hope Long-Term Waste Management Facility, Port Hope, Ontario	AECL[a]
Pine Street Consolidation, Port Hope, Ontario	AECL
Various locations for small decontamination projects	AECL
Chalk River Laboratories Waste Management Areas, Chalk River, Ontario	AECL
Whiteshell Laboratories Waste Management Areas, Pinawa, Manitoba	AECL
Port Granby Long-Term Waste Management Facility, Clarington, Ontario	Cameco Corporation
University of Alberta Waste Management Facility, Edmonton, Alberta	University of Alberta
University of Toronto Waste Management Facility, Toronto, Ontario	University of Toronto

Notes : AECL - Atomic Energy of Canada Limited
WWMF - Western Waste Management Facility

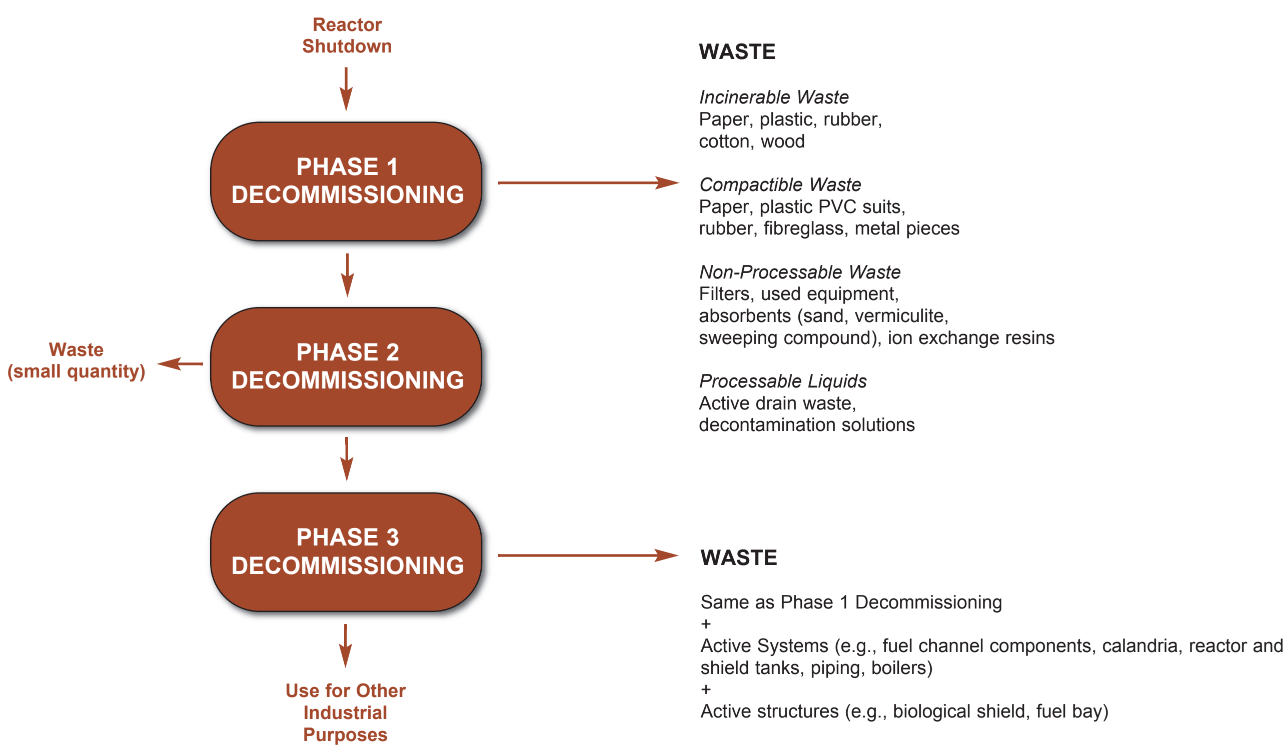
[a] Operation of the Western Waste Management Facility was transferred from Cameco to AECL as of March 31, 2010. It is now considered part of the Port Hope Long-Term Waste Management Facility.

4.2.1.2 Decommissioning

Waste is also generated when nuclear facilities are decommissioned, (i.e. decontaminated and dismantled) at the end of their operational life (see Figure 4.6). Consideration must be given to the health and safety of workers and the public, and to protection of the environment, during decommissioning. Most of Canada's decommissioning waste will be generated in the future although some inventory already exists from decommissioning projects completed to date.

The most significant quantities of waste will result from the decommissioning of nuclear reactors and their supporting facilities. Waste will range from highly radioactive materials associated with the reactor core to other building components and materials only mildly contaminated during reactor operations.

Figure 4.6: Process Flowchart for CANDU Reactor Decommissioning



Based on current plans submitted to the CNSC, power reactors will be decommissioned in three major phases as summarized in Figure 4.6. Spent fuel will be removed from the reactor core prior to decommissioning. Phase 1 (preparation for storage-with-surveillance) will begin soon after reactor shutdown and last up to ten years. The purpose of Phase 1 is to isolate and stabilize the remaining reactor components for a long-term storage period to allow time for radioactivity levels to decay so that worker doses and the volume of radioactive waste generated by final decommissioning will be reduced. Phase 1 decommissioning is expected to produce several hundred cubic metres of L&ILRW per reactor. Phase 2 (storage-with-surveillance) may last up to

65 years with very small amounts of waste generated. Phase 3 (dismantling) may last up to twenty years and will generate the majority of radioactive waste. At the end of Phase 3, the site would be suitable for either restricted or unrestricted use. Proposed facility decommissioning timelines displayed in this report were provided by the waste owners and can be found in the preliminary decommissioning plans submitted to the CNSC for each facility.

4.2.2 Historic Waste

As described earlier, historic waste is low-level radioactive waste for which the federal government has accepted responsibility for long-term management. The Low-Level Radioactive Waste Management Office (LLRWMO) is the federal government's agent for the cleanup and long-term management of historic waste.

There are several large historic waste sites as well as numerous smaller sites throughout Canada. At many of the 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 these sites.

Waste at some of these sites include artifacts or surficially contaminated building materials. Other sites contain large volumes of radium-contaminated soil with low radioactivity. Contaminated soils from cleanups at small sites, and contaminated artifacts and building materials from larger sites, are removed to the LLRWMO storage buildings at AECL-CRL. Larger volumes of contaminated soils that cannot be accommodated at the LLRWMO storage buildings are managed at or near the source (see the following). No additional waste is expected to be added to these sites.

Municipality of Port Hope, Ontario

Historic waste is present in various areas in the Municipality of Port Hope, Ontario. The waste dates back to the 1930s when radium was refined for medical applications at a refinery in the municipality. The waste is primarily soil contaminated with material from the refinery. The LLRWMO is responsible for the monitoring and safe management of the waste at these sites until such time as the sites are remediated under the Port Hope Area Initiative (PHAI). Remediation, including the establishment of new long-term waste management facilities for the waste, will be carried out under the Port Hope Area Initiative Management Office (PHAI MO).

Welcome and Port Granby, Ontario

LLRW is located at the Welcome Waste Management Facility (WMF) in the Municipality of Port Hope, Ontario and the Port Granby Waste Management Facility in the Municipality of Clarington, Ontario. These two facilities were closed in 1955 and 1988 respectively. The PHAI MO has taken on the operation of the Welcome WMF from Cameco Corporation who maintains responsibility for the Port Granby WMF. Both of these sites were originally assumed by Cameco from Eldorado Nuclear Limited, a federal Crown corporation. At Port Granby WMF, Cameco and the federal government share financial responsibility for capital and extraordinary operating costs, including decommissioning costs, associated with the management of the waste at these facilities. The waste at both sites is included in the Port Hope Area Initiative.

Other Locations

Historic waste is stored at various other locations across Canada including sites in Ontario, Alberta, and the Northwest Territories. The LLRWMO is responsible for the cleanup and the long-term management of the waste at these sites.

4.3 Uranium Mining and Milling Waste

Low-level radioactive waste arising from the mining and milling of uranium consists of both mill tailings and waste rock.

Uranium mill tailings are a specific type of LLRW that are generated during the milling (processing) of uranium ore to produce uranium concentrate. As noted previously, 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, placed in engineered surface containment areas, or disposed as backfill in underground mines.

Owing to the large volumes and low activity levels, tailings 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.

At all of the newer operations in Saskatchewan, tailings are managed in mined-out pits converted to TMFs. The TMFs feature hydraulic containment during operation (that is, the pit is maintained in a partially dewatered state relative to the surrounding natural water table so that all groundwater flow is towards the tailings facility), and passive long term containment following decommissioning. The latter results from a zone of high hydraulic conductivity material which surrounds the much lower hydraulic conductivity consolidated tailings that channels groundwater flow around rather than through the tailings. The high hydraulic conductivity zone may either be constructed as the tailings are emplaced, referred to as pervious surround (i.e., Rabbit Lake TMF), or exist naturally by virtue of the type of rock, referred to as natural surround (i.e., McClean Lake and Key Lake Dielmann TMF). Details of each facility can be found in the annual reports prepared for the CNSC by the waste owners.

Waste rock refers to the non-ore material that is removed during mining to access the mineral bearing unit. Today, waste rock is separated into mineralized and non-mineralized waste depending on the relative concentration of uranium present in the material. However, in the past, inventories of waste rock were not consistently tracked and often mineralized and non-mineralized waste were stockpiled together.

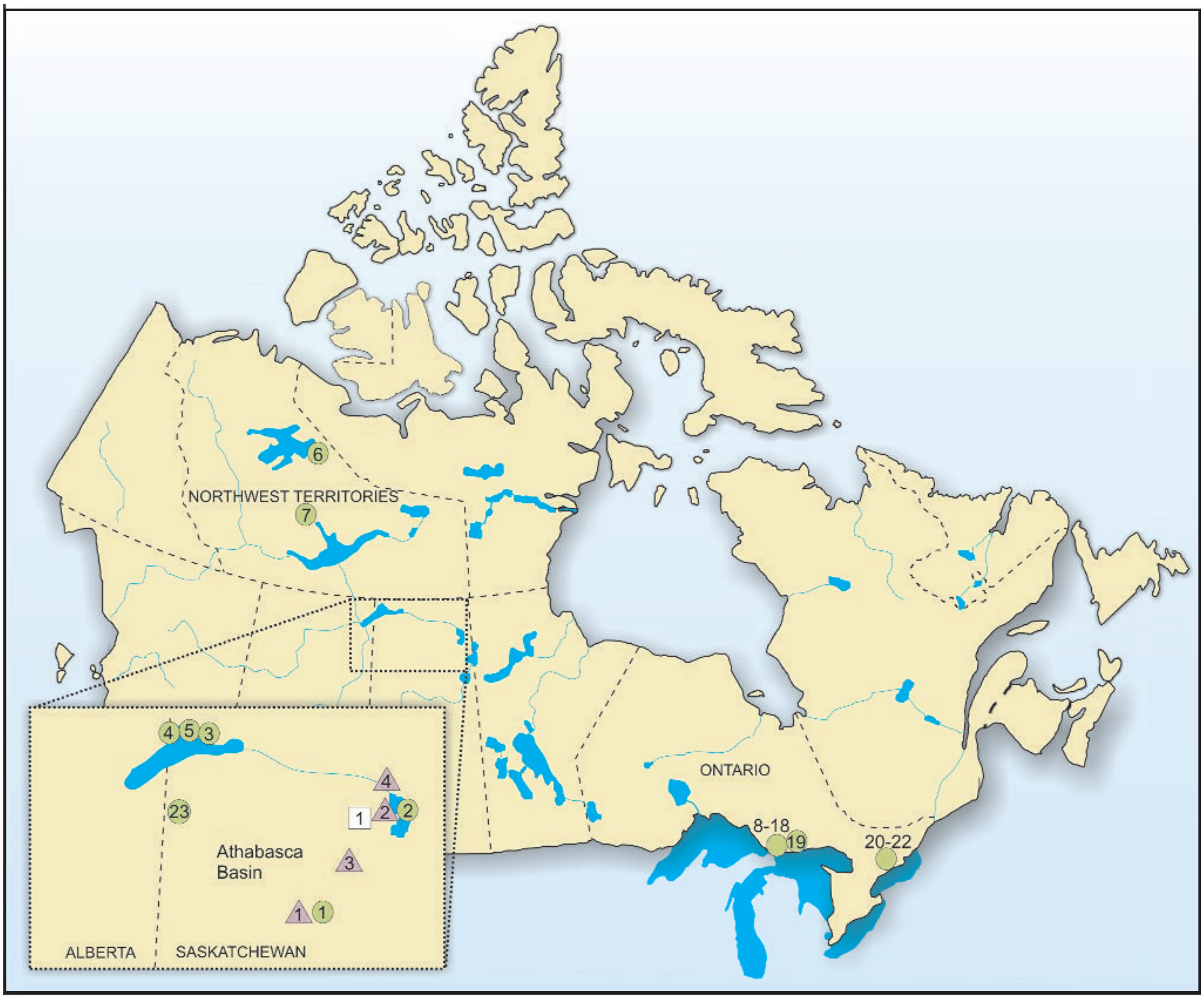
Mineralized waste rock can include sub-economical concentrations of uranium in addition to elevated levels of other elements such as sulphur, arsenic or nickel that could potentially cause deleterious environmental effects. Non-mineralized waste rock consists of the non-ore material with very low concentrations of uranium and levels of other elements below applicable standards. Historically, waste rock has been stored on the surface or used as backfill in underground mines. There are no special long-term storage requirements for non-mineralized waste rock; however, 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.

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. Table 4.5 provides a list of uranium mine and mill facilities licensed by the CNSC. Figure 4.7 shows the locations of uranium mining and milling projects in Canada. Figures 4.8 and 4.9 show the locations of closed/decommissioned mine and tailings sites in the Elliot Lake and Bancroft areas in Ontario.

Table 4.5: Uranium Mine and Mill Facility Licences

Facility and Location	Licensee	Licensed Activity
Key Lake Operation, Saskatchewan	Cameco Corporation	Operations (Milling Only)
McArthur River Operation, Saskatchewan	Cameco Corporation	Operations (Mining Only)
Rabbit Lake Operation, Saskatchewan	Cameco Corporation	Operations
McClean Lake, Saskatchewan	AREVA Resources Canada Inc.	Operations
Cluff Lake Project, Saskatchewan	AREVA Resources Canada Inc.	Decommissioning
Denison Mine, Elliot Lake, Ontario	Denison Mines Inc.	Decommissioning; in Care and Maintenance
Stanrock Mine, Elliot Lake, Ontario	Denison Mines Inc.	Decommissioning; in Care and Maintenance
Madawaska Mine, Bancroft, Ontario	EnCana Corporation	Possession; in Care and Maintenance
Beaverlodge Mining Operations, Beaverlodge, Saskatchewan	Cameco Corporation	Waste Management Facility; Operations
Dyno Mine, Bancroft, Ontario	EnCana Corporation	Possession; in Care and Maintenance
Bicroft Mine, Bancroft, Ontario	Barrick Gold Corp.	Possession; in Care and Maintenance
Port Radium, Northwest Territories	Aboriginal Affairs and Northern Development Canada	Possession; in Care and Maintenance
Rayrock, Northwest Territories	Aboriginal Affairs and Northern Development Canada	Possession; in Care and Maintenance
Elliot Lake Historic Mines, Elliot Lake, Ontario	Rio Algom Limited	Waste Management Facility; Operations
Agnew Lake, Ontario	Ontario Ministry of Northern Development and Mines	Possession; in Care and Maintenance
Cigar Lake Project, Saskatchewan	Cameco Corporation	Construction

Figure 4.7: Uranium Mine and Mill Tailings Sites in Canada

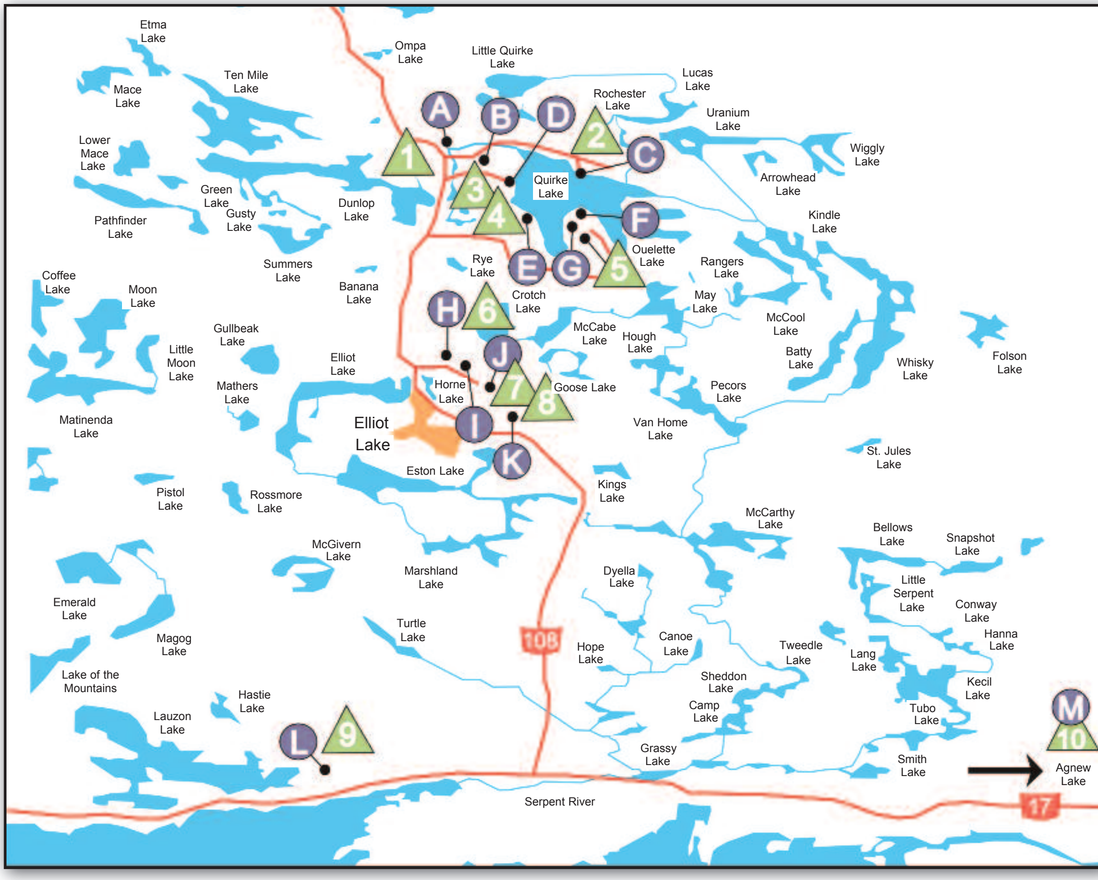


Operating Sites
1 - Key Lake
2 - Rabbit Lake
3 - McArthur River
4 - McClean Lake

Closed/Decommissioned Sites
1 - Key Lake
2 - Rabbit Lake
3 - Beaverlodge
4 - Gunnar
5 - Lorado
6 - Port Radium
7 - Rayrock
8 to 18 - Elliot Lake Sites: Quirke, Panel,Denison, Spanish-American, Stanrock, Stanleigh, Lancor, Nordic, Pronto, Milliken, Buckles
19 - Agnew Lake
20 to 22 - Bancroft Sites: Madawaska, Bicroft, Dyno
23 - Cluff Lake

Development Sites
1 - Cigar Lake

Figure 4.8: Uranium Mine and Mill Tailings Sites near Elliot Lake, Ontario



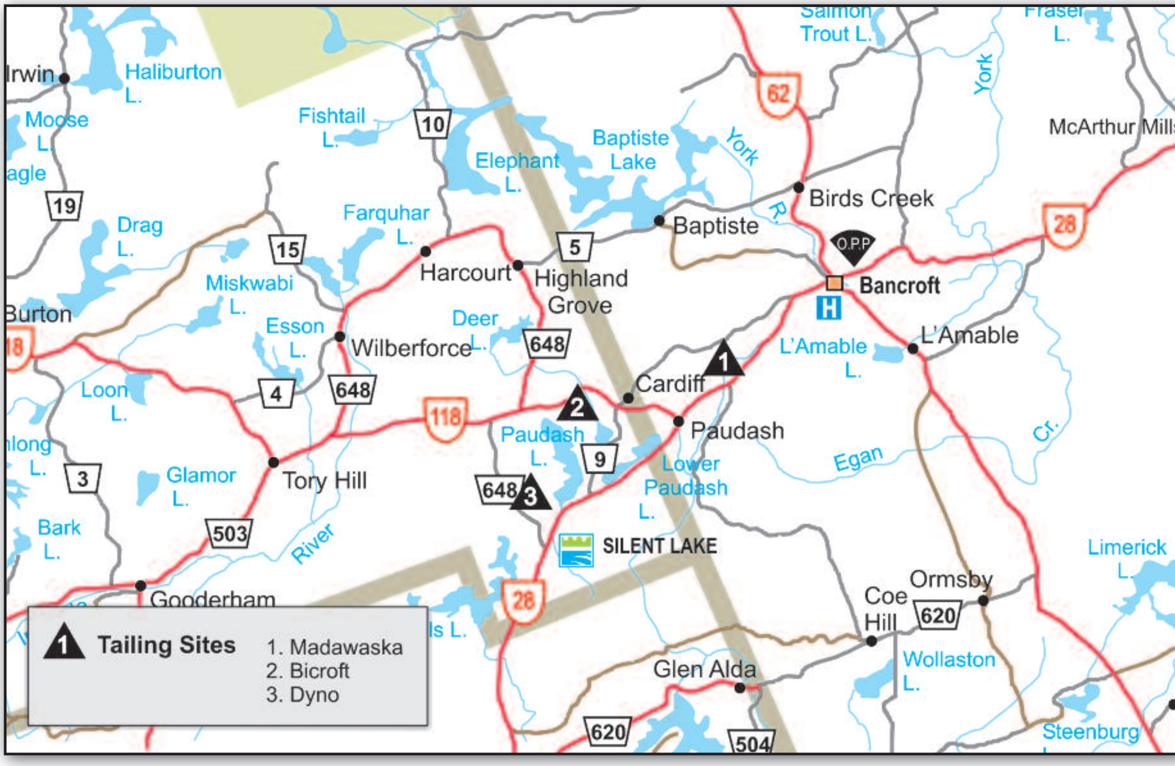
MINE/MILL FACILITIES

A/B - Quirke
C - Panel
D - Denison
E - Spanish-American
F - CANMET
G - Stanrock
H - Stanleigh
I - Milliken
J - Lacnor
K - Nordic
L - Pronto
M - Agnew Lake

TAILINGS AREAS

1 - Quirke
2 - Panel
3 - Denison
4 - Spanish-American
5 - Stanrock
6 - Stanleigh
7 - Lacnor
8 - Nordic/Buckles
9 - Pronto
10 - Agnew Lake

Figure 4.9: Uranium Mine and Mill Tailings Sites near Bancroft, Ontario



4.3.1 Operating Sites

At present, all uranium production in Canada is located in Saskatchewan. Sites with active tailings management facilities include Key Lake and Rabbit Lake, operated by Cameco Corporation, and McClean Lake, operated by AREVA Resources Canada Inc.. The McArthur River mine (operated by Cameco Corporation) is operational, however there is no tailings management facility at this site since the ore is transported to Key Lake for milling. Similarly, ore from the Cigar Lake mine (Cameco Corp.), expected to begin production in 2013, will be transported to Mclean Lake and Rabbit Lake for milling.

The Key Lake site has been operating since 1984. The last ore was mined from the Deilmann Open Pit in 1997, after which mining was stopped. Initial tailings at the Key Lake site were deposited in a purpose-built surface tailings management area until late 1995. In late 1995/early 1996, deposition of tailings was transferred to the Deilmann Tailings Management Facility (DTMF). Since February 1996, all tailings have been deposited in the DTMF. In January 2000, the Key Lake operation began processing ore from the McArthur River mine, which began production in December 1999.

Rabbit Lake, the longest-operating uranium production facility in Saskatchewan, began operating in 1975. Tailings were deposited at a surface tailings management area until 1985 when deposition of tailings into the Rabbit Lake Pit TMF began. Open pit uranium deposits have been mined out, but underground mining at the Eagle Point ore zone continues. In the future, the final processing step for some of the ore originating from Cigar Lake is planned for Rabbit Lake. The McClean Lake site began uranium production in 1999. The McClean Lake JEB mill suspended its operations in June 2010. The mill will reopen by 2013 to process ore from Cigar Lake. The mill has been expanded to process ores from the Cigar Lake development site. Open pit mining of the initial deposit (JEB ore body) began in 1995. Once the ore was removed and stockpiled, the pit was developed as a tailings management facility.

4.3.2 Closed or Decommissioned Sites

Key Lake and Rabbit Lake, operated by Cameco Corporation, each have a closed tailings management area from earlier operations. The Cluff Lake Project, operated by AREVA Resources Canada Inc., ceased production at the end of 2002 and decommissioning began in 2004. There are also three older closed tailings sites or areas in Saskatchewan. The Beaverlodge operation was shut down in 1982 and decommissioned in 1985. Cameco Corporation is managing the decommissioning of this site. The Lorado and Gunnar sites have been closed since 1960 and 1964, respectively, and have not been adequately decommissioned. The Saskatchewan Government is the land owner responsible for both sites. In September 2006, the Government of Canada and the Government of Saskatchewan signed a Memorandum of Agreement to fund the cleanup of these sites. Project CLEANS (Cleanup of Abandoned Northern Sites) is a $47.9 million project to assess and reclaim Gunnar, Lorado and 36 satellite sites in northern Saskatchewan.

There are two closed uranium sites in the Northwest Territories. The Port Radium site was decommissioned in 1984 with further decommissioning work completed in 2007. The Rayrock site was abandoned in 1959 and remediated in 1996 and 1997. Performance monitoring of the Rayrock site began in 1996. Aboriginal Affairs and Northern Development Canada is responsible for these two sites.

There are ten closed uranium tailings sites in and around Elliot Lake, Ontario. Rio Algom Ltd. is responsible for eight of these sites:

i. Quirke, closed since 1992;
ii. Panel, closed since 1990;
iii. Spanish-American, closed since 1959;
iv. Stanleigh, closed since 1996;
v. Lacnor, closed since 1960;
vi. Nordic/Buckles, closed since 1968;
vii. Milliken, closed since 1964; and
viii. Pronto, closed since 1960.

Denison Mines Inc. is responsible for two sites:

i. Denison, closed since 1992; and
ii. Stanrock, closed since 1964.

The Agnew Lake Mine north of Espanola, Ontario, was decommissioned and monitored by Kerr Addison Mines in the 1980s. The site was turned over to the Ontario Ministry of Northern Development and Mines in the early 1990s.

Closed uranium tailings sites in the Bancroft, Ontario area include Madawaska, Dyno and Bicroft mines. The Madawaska Mine has been closed since 1983, while operations at the Dyno and Bicroft sites ceased in the early 1960s. EnCana Corporation has completed decommissioning activities at the Madawaska and Dyno Mine sites. Barrick Gold Corp. has completed decommissioning activities at the Bicroft Mine site.

4.3.3 Development Sites

At the end of 2010, there was one uranium development site in Saskatchewan with a CNSC License. In 1998, the federal and provincial governments approved Cigar Lake Project (operated by Cameco Corporation) for advancement to the next stage of the regulatory approval process, based on the recommendations of a Joint Federal/Provincial Environmental Assessment Panel. Construction of the Cigar Lake mine has been delayed since October 2006 due to an inflow of water which flooded the mine. The mine was dewatered in 2010 and production is expected to begin 2013.

There are presently no tailings at these development sites, and this will continue to be the case, since ore from these sites is expected to be transported to McClean Lake for milling (with some of the final processing at Rabbit Lake to produce uranium concentrate from Cigar Lake ore).

5.0 CURRENT INVENTORY AND ACCUMULATION RATE

This section summarizes the annual rates of waste accumulation during 2010 and the total accumulated waste volumes to the end of 2010.

5.1 Nuclear Fuel Waste

Operation of the CANDU power reactors generates nuclear fuel waste, also known as spent fuel or high-level waste. There is also a small amount of nuclear fuel waste resulting from past operation of nuclear power demonstration reactors, as well as historic and ongoing operation of AECL's research and radioisotope production reactors and research reactors at universities. The *Nuclear Fuel Waste Act* governs long-term management of nuclear fuel waste. At present, nuclear fuel waste is kept in wet or dry storage at the reactor sites and at AECL's waste management facilities at Chalk River, Ontario and Pinawa, Manitoba.

Table 5.1 summarizes the annual accumulation and inventories of nuclear fuel waste from nuclear power and AECL's prototype/demonstration/research reactors to December 31, 2010. Inventories do not include fuel bundles currently in the reactors. These inventories have been provided by the waste owners and are based on December 2010 Fissionable Substances Reports to the CNSC.

In 2010, the 17 operating power reactors produced 74,080 bundles of nuclear fuel waste. This represents approximately 297 m^3 of waste based on a volume of 0.004 m^3 for a typical CANDU fuel bundle. The accumulated nuclear fuel waste inventory to the end of 2010 for the power reactors was 2,203,137 bundles or approximately 8,823 m^3 of waste.

Table 5.1: Nuclear Fuel Waste Accumulation Rate and Inventory, 2010

Site Name	Source Company Name	Nuclear Fuel Waste Generated in 2010		On-Site Waste Inventory to December 31, 2010					Reactor Status as of December 2010
				Dry Storage	Wet Storage	Total Storage			
		No. of Fuel Bundles	Est. Vol. (m^3)	No. of Fuel Bundles	No. of Fuel Bundles	No. of Fuel Bundles	Est. Vol.[a] (m^3)	Mass of Uranium[f] (kg)	
POWER REACTORS									
Bruce A	OPG	9,254	37	49,152	367,091	416,243	1,665	7,917,000	Units 1&2 undergoing refurbishment
Bruce B	OPG	23,499	94	165,110	367,969	533,079	2,132	10,240,000	Operating
Darlington	OPG	21,640	87	56,811	331,692	388,503	1,554	7,425,000	Operating
Pickering A and B	OPG	16,271	65	218,992	406,365	625,357	2,501	12,415,000	Units 2&3 shutdown

Table 5.1: Nuclear Fuel Waste Accumulation Rate and Inventory, 2010...cont'd

Site Name	Source Company Name	Nuclear Fuel Waste Generated in 2010		On-Site Waste Inventory to December 31, 2010					Reactor Status as of December 2010
				Dry Storage	Wet Storage	Total Storage			
		No. of Fuel Bundles	Est. Vol. (m^3)	No. of Fuel Bundles	No. of Fuel Bundles	No. of Fuel Bundles	Est. Vol.[a] (m^3)	Mass of Uranium[f] (kg)	
Gentilly-2	Hydro-Québec	3,416	14	87,000	31,197	118,197	473	2,246,000	Operating
Point Lepreau	NB Power	0	0	81,000	40,758	121,758	498	2,336,000	Shutdown for refurbishment
Subtotal Power Reactors		**74,080**	**297**	**658,065**	**1,545,072**	**2,203,137**	**8,823**	**43,409,000**	
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS									
Douglas Point	AECL	0	0	22,256	0	22,256	89	299,827	Shutdown and partially decommissioned
Gentilly-1	AECL	0	0	3,213	0	3,213	13	67,595	Shutdown and partially decommissioned
Chalk River Laboratories (items)[b]	AECL	70	1	7,024	378	7,402	125	34,957[g]	Operating
Chalk River Laboratories (bundles)[c]	AECL	0	0	4,886	0	4,886	20	65,395[g]	Shutdown and partially decommissioned
Whiteshell Laboratories[d]	AECL	0	0	2,268	0	2,268	9	21,540	Shutdown and partially decommissioned
McMaster Nuclear Reactor	McMaster University	0	0	0	14	14	<1	12.8	Operating
Subtotal Research Reactors[e]		**70**	**1**	**39,647**	**392**	**40,039**	**256**	**489,327**	
TOTAL[e]		**74,150**	**298**	**697,712**	**1,545,464**	**2,243,176**	**9,079**	**43,898,000**	

Notes: AECL = Atomic Energy of Canada Limited

a Nuclear fuel waste volume calculated assuming a typical volume of 0.004 m^3 for a CANDU fuel bundle, except in case of Chalk River Laboratories items.

b For research reactors, inventory is reported as the number of research rods, fuel assemblies, units or items. Area B includes natural, thorium rods fuel.

c Includes fuel bundles from NPD reactor (4,825 bundles) as well as fuel bundles from Pickering, Bruce, and Douglas Point reactors stored at Chalk River Laboratories.

d Includes 360 CANDU bundles and 1,908 research reactor bundles from the WR-1 reactor.

e Totals include CANDU fuel bundles as well as research rods, fuel assemblies, units and items.

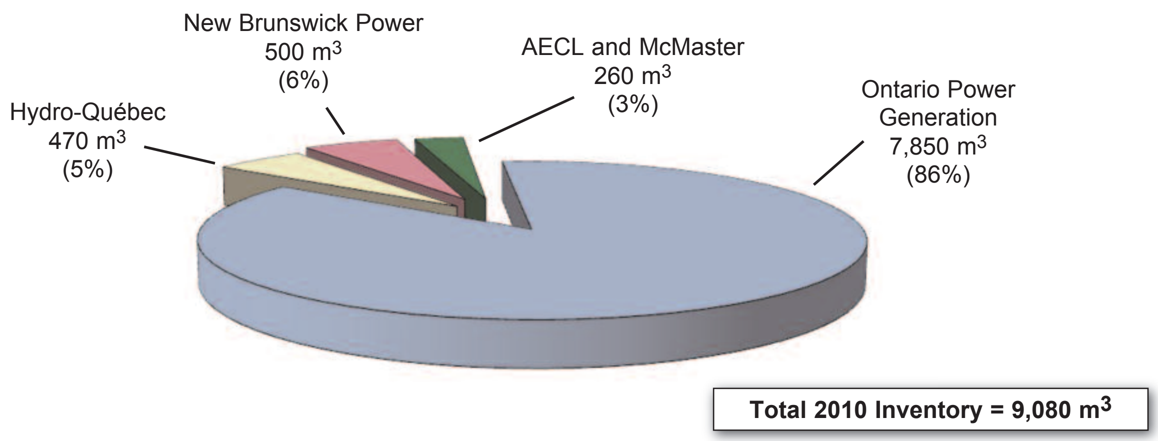
f Reported as spent fuel (depleted or enriched fuel), unless otherwise noted. Estimates for the power reactors have been rounded to the nearest 1,000.

g Spent fuel material includes natural and depleted uranium, thorium and plutonium.

Nuclear fuel waste inventory to the end of 2010 for the three shutdown prototype/demonstration reactors (Douglas Point, Gentilly-1, and NPD) remained at 30,355 bundles (122 m^3). The balance of the nuclear fuel waste inventory consists of 9,684 bundles, research rods, assemblies, units and items (134 m^3), which came from the research reactor operations at AECL's Chalk River and Whiteshell facilities as well as the McMaster Nuclear Reactor (MNR).

Figure 5.1 shows the distribution of nuclear fuel waste inventories by major waste owners. This figure shows the estimated volume of waste to the nearest 10 m^3. The distribution was approximately as follows: Ontario Power Generation, 86%; Hydro-Québec, 5%; New Brunswick Power, 6%; and AECL and McMaster, 3%.

Figure 5.1: Nuclear Fuel Waste Inventory, 2010
(estimated volume)



5.2 Low- and Intermediate-Level Radioactive Waste

At the end of 2010, there was about 2.37 million m^3 of L&ILRW stored in Canada. Approximately 2.34 million m^3 of the waste is considered low-level, with the remaining consisting of intermediate-level waste. At present, waste is being managed in storage sites throughout the country pending the development and licensing of long-term waste management facilities.

Tables 5.2 and 5.3 summarize the 2010 accumulation rates and accumulated inventory for ongoing and historic LLRW and ILRW, respectively.

A breakdown of the sources and accumulation rate of ongoing LLRW and ILRW is illustrated in Figures 5.2 and 5.3.

Figure 5.4 shows the accumulation rate and accumulated inventory for each source. This figure shows the estimated volume of L&ILRW rounded to the nearest 10 m^3.

This section provides further breakdowns for each source of L&ILRW.

5.2.1 Ongoing Waste

About 5,328 m³ of ongoing waste was generated in 2010. Of this waste, 5,120 m³ is LLRW and 208 m³ is ILRW. The total ongoing L&ILRW inventory to the end of 2010 was 649,496 m³ (see Tables 5.2 and 5.3).

Table 5.2: LLRW Accumulation Rate and Inventory, 2010

Waste Source		LLRW[a] Accumulation Rate in 2010 (m^3/yr)	LLRW Inventory to December 31, 2010[a]		
			Waste (m^3)	Contaminated Soil (m^3)	Total (m^3)
A. ONGOING WASTE					
Operations	Nuclear Fuel Cycle	4,110	90,650	0	90,650
	Nuclear R&D[b]	730	118,410	382,880	501,290
	Radioisotope Production and Use[b]	70	19,540	0	19,540
	Subtotal	**4,910**	**228,600**	**382,880**	**611,480**
Decommissioning	Nuclear Fuel Cycle	0	1,650	0	1,650
	Nuclear R&D[b,c]	210	3,130	330	3,460
	Radioisotope Production and Use	0	0	0	0
	Subtotal	**210**	**4,780**	**330**	**5,110**
	Total Ongoing Waste	**5,120**	**233,380**	**383,210**	**616,590**
B. HISTORIC WASTE[d]					
	Port Hope	0	0	720,000	720,000
	Welcome	0	0	454,000	454,000
	Port Granby	0	0	438,200	438,200
	Deloro Mine Site	0	0	38,000	38,000
	Other Locations	0	0	71,000	71,000
	Total Historic Waste	**0**	**0**	**1,721,000**	**1,721,000**
TOTAL		**5,120**			**2,338,000**

Notes: ***Nuclear Fuel Cycle*** includes waste stored at: WWMF, RWOS-1, Gentilly-2, Point Lepreau, Blind River Refinery, Port Hope Conversion Facility and Cameco Fuel Manufacturing.
Nuclear R&D includes waste stored at: Chalk River Laboratories, Whiteshell Laboratories, Douglas Point, Gentilly-1 and NPD Waste Management Facility. No operational I/LLRW exists at the NPD facility.
Radioisotope Production and Use includes waste located at: Chalk River Laboratories.
Historic Waste, Other Locations includes waste located at: various LLRWMO managed sites in the Greater Toronto Area, Chalk River Laboratories (Area D), Fort McMurray, Alberta and along the Northern Transportation Route.

a Waste volumes have been rounded to nearest 10 m³. Volume presented is as-stored waste (i.e., after processing); as-generated volume may be approximately three times greater.

b Chalk River Laboratories waste inventory is based on method of storage and does not necessarily represent the actual breakdown of waste into low and intermediate level radioactive waste.

c Decommissioning waste at Chalk River and Whiteshell Laboratories after January 1, 2005.

d Historic waste volumes have been rounded to nearest 1,000 m³.

Figure 5.2: Ongoing LLRW Accumulation Rates in 2010
(m^3)

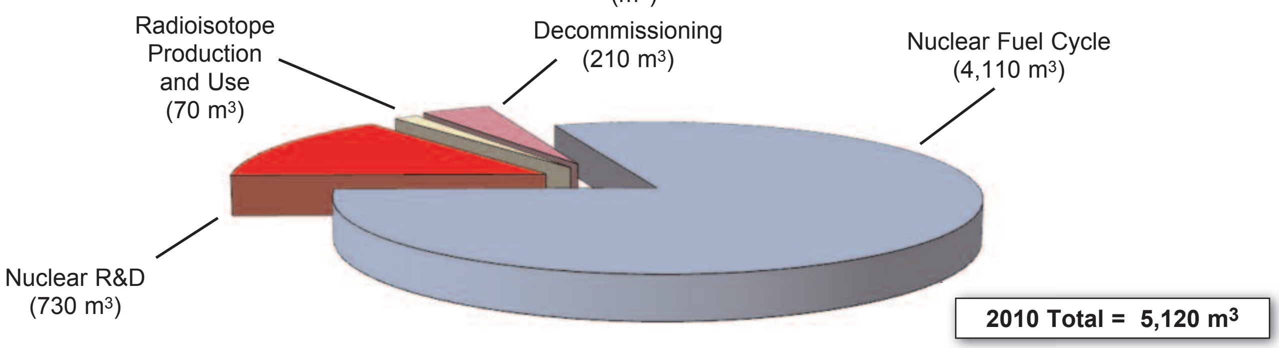


Table 5.3: ILRW Accumulation Rate and Inventory, 2010

Waste Source		LLRW[a] Accumulation Rate in 2010 (m^3/yr)	LLRW Inventory to December 31, 2010[a]		
			Waste (m^3)	Contaminated Soil (m^3)	Total (m^3)
A. ONGOING WASTE					
Operations	Nuclear Fuel Cycle	90	13,090	0	13,090
	Nuclear R&D[b]	100	19,520	0	19,520
	Radioisotope Production and Use[b,d]	10	130	0	130
	Subtotal	**200**	**32,740**	**0**	**32,740**
Decommissioning	Nuclear Fuel Cycle	0	0	0	0
	Nuclear R&D[b,c]	10	170	0	170
	Radioisotope Production and Use	0	0	0	0
	Subtotal	**10**	**170**	**0**	**170**
TOTAL		**210**			**32,910**

Notes:
[a] Waste volumes have been rounded to nearest 10 m³. Volume presented is as-stored waste (i.e., after processing); as-generated volume may be approximately three times greater.
[b] Chalk River Laboratories waste inventory is based on method of storage and does not necessarily represent the actual breakdown of waste into low and intermediate level radioactive waste.
[c] Decommissioning waste at Chalk River and Whiteshell Laboratories after January 1, 2005.
[d] ILRW inventory includes waste processed after January 1, 2004.

Figure 5.3: Ongoing ILRW Accumulation Rates in 2010
(m^3)

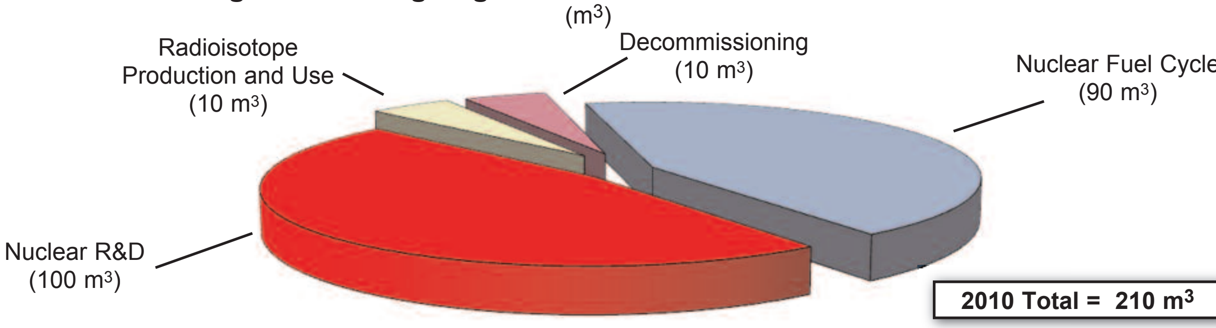


Figure 5.4 provides a breakdown of the total L&ILRW inventory into ongoing and historic sources. Figure 5.5 provides a breakdown of the inventory of ongoing L&ILRW by major source. These figures show the estimated volume of each source of ongoing waste rounded to the nearest 10 m³.

Figure 5.4: L&ILRW Inventory, 2010
(m^3)

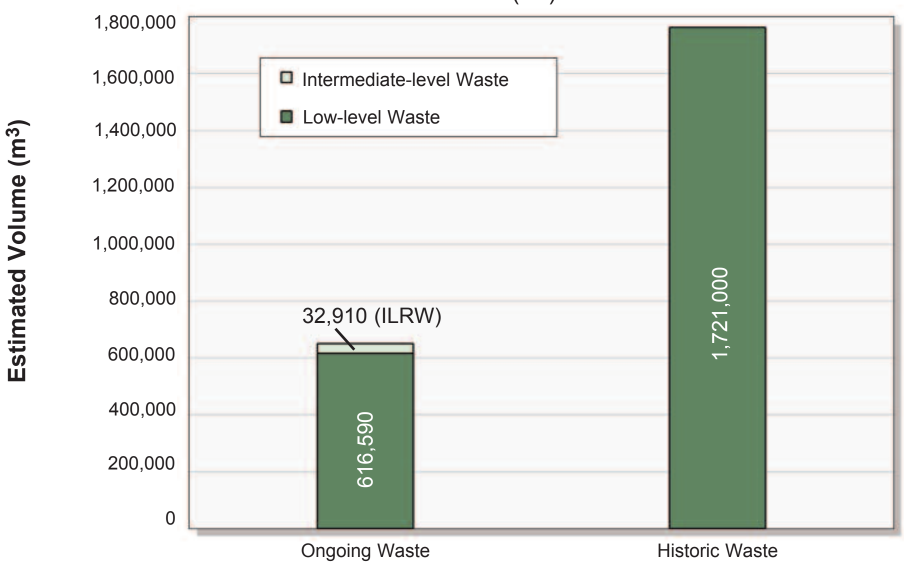
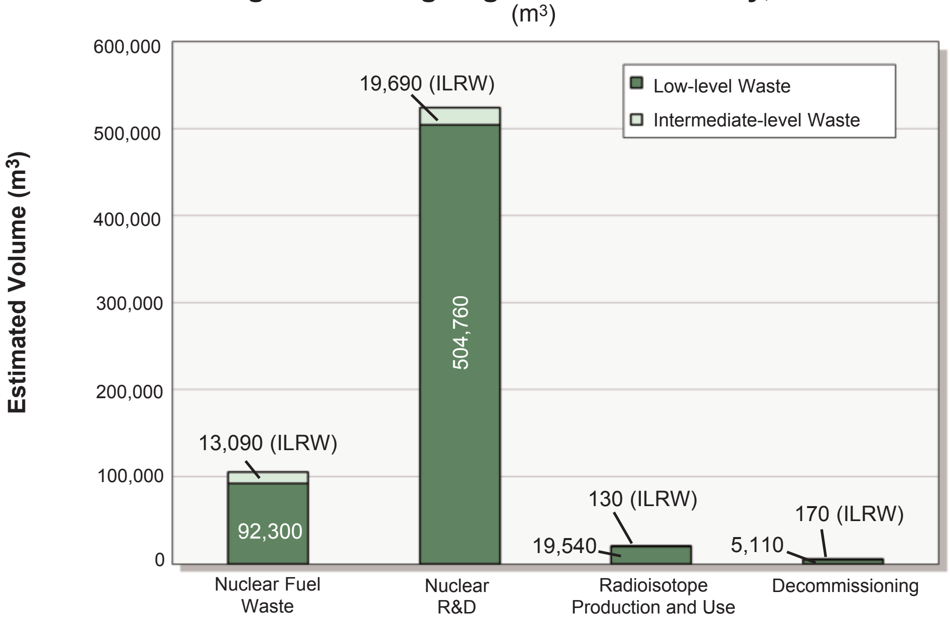


Figure 5.5: Ongoing L&ILRW Inventory, 2010
(m^3)



Note: 382,800 m^3 of contaminated soil is included in the Nuclear R&D ongoing LLRW inventory.

5.2.1.1 Operations

Waste from operations constitutes the majority of L&ILRW. This trend will continue until significant decommissioning of nuclear facilities commences. In 2010, about 4,910 m^3 of low-level waste and 202 m^3 of intermediate-level waste were produced from operational activities. The inventory to the end of 2010 was 644,217 m^3 of low- and intermediate-level waste combined. A detailed breakdown follows.

Nuclear Fuel Cycle

In 2010, the 17 operating power reactors in Canada produced 4,109 m^3 and 93 m^3 of the total amount of LLRW and ILRW, respectively. Ontario Power Generation Inc. (including Bruce Power Inc.), operating a total of 16 reactors, produced the majority of waste (3,800 m^3 of LLRW and 80 m^3 of ILRW), while Hydro-Québec and New Brunswick Power produced a combined 219 m^3 of LLRW and 13 m^3 of ILRW. The uranium refining and conversion companies generated the balance of the total LLRW, which amounted to approximately 90 m^3.

Total waste inventory from nuclear fuel cycle facilities at the end of 2010 was 103,741 m^3 of L&ILRW.

Nuclear Research and Development

Nuclear research and development activities at AECL generated 730 m^3 of LLRW and 100 m^3 of ILRW in 2010. AECL has about 382,880 m^3 of contaminated soils resulting from its long history of nuclear research and development, as well as from historic waste cleanup at several sites within Ontario in the 1970s. In addition, some volumes of L&ILRW from other producers are taken to AECL's Chalk River Laboratories for management. Included in these volumes are historic waste that has been removed from various locations across Canada and consolidated at AECL-CRL.

Total waste inventory attributed to research and development was a combined 520,811 m^3 of L&ILRW at the end of 2010.

Radioisotope Production and Use

Waste in this category is generated by radioisotope users from across Canada and eventually sent to AECL-CRL for storage. In 2010, approximately 72 m^3 of low-level waste and 9 m^3 of intermediate-level waste was received by AECL. The total inventory of radioisotope-related waste increased to 19,665 m^3 of L&ILRW.

5.2.1.2 Decommissioning

A number of decommissioning projects are underway at AECL's Chalk River and Whiteshell Laboratories under the federal government's Nuclear Legacy Liabilities Program, and these are generating L&ILRW. Most of the remaining nuclear infrastructure in Canada is operational or being refurbished. Preliminary decommissioning plans, including estimates of the volume of waste that will be generated during decommissioning, and financial guarantees are in place for the major facilities.

Nuclear Fuel Cycle

There were no decommissioning activities at the nuclear fuel cycle facilities in 2010. The low-level radioactive waste inventory at the end of 2010 was 1,650 m^3. Waste was from the Phase 1 (preparation for storage-with-surveillance) decommissioning activities at the three prototype/demonstration reactors and from Phase 3 (dismantling) of two fuel fabrication facilities.

Nuclear Research and Development

Decommissioning projects are ongoing at Dalhousie University's SLOWPOKE facility and AECL's research facilities in Chalk River and Whiteshell. Phase 1 decommissioning of the WR-1 reactor at Whiteshell was completed in 1994. The University of Toronto completed decommissioning of its sub-critical assembly in 2000.

The waste accumulation rate for 2010 was 205 m^3 of LLRW and 6 m^3 of ILRW arising from decommissioning waste generated at Chalk River and Whiteshell Laboratories. The national waste inventory from decommissioning activities associated with research and development facilities amounted to 3,630 m^3 of L&ILRW at the end of 2010.

Radioisotope Production and Use

There were no decommissioning waste accumulated in 2010 nor was there any inventory at the end of 2010. The Nordion facility in Ottawa, which is the main manufacturer of commercial isotopes, is relatively new and is not expected to generate decommissioning waste in the near future. Commercial isotope users may generate some small volumes of waste in the future during decommissioning or refurbishment of laboratories or other facilities.

5.2.2 Historic Waste

The inventory of historic waste to the end of 2010 was approximately 1.72 million m^3 (see Table 5.2). For 2010, the total inventory of historic waste which the AECL (both the LLRWMO and PHAI MO) manages on behalf of the federal government was approximately 1,244,880 m^3. The waste consists of the following:

Municipality of Port Hope, Ontario		1,174,380 m^3
Other locations:		
	Toronto, Ontario	16,500 m^3
	Chalk River Laboratories, Area D	1,000 m^3
	Fort McMurray, Alberta	43,000 m^3
	Northwest Territories	10,000 m^3
		70,500 m^3

The Municipality of Port Hope inventory consists of waste at the Welcome Waste Management Facility and approximately 720,000 m^3 of in situ and consolidated contaminated soils. This waste is targeted for long-term management in a new waste management facility to be constructed in Port Hope. Ownership of the Welcome Waste Management Facility in the municipality of Port Hope has been transferred from Cameco Corporation to the federal government and AECL has assumed the role of licensee. The Welcome Waste Management Facility contains about 454,380 m^3 of waste and contaminated soils. Cameco Corporation continues to manage its waste management facility at Port Granby in the municipality of Clarington, Ontario. The Port Granby Waste Management Facility contains about 432,00 m^3 of waste and contaminated soils. The total volume of the waste to the end of 2010 was approximately 892,580 m^3.

The Ontario Ministry of the Environment (MOE) is responsible for the cleanup of the former Deloro Mine Site located in Deloro, Ontario. Although not the main contaminant of concern, there is approximately 38,000 m^3 of low-level radioactive contaminated soils and historic tailings at the site.

5.3 Uranium Mining and Milling Waste

The following section summarizes the waste inventory arising from the mining and milling of uranium, which includes both mill tailings and waste rock.

5.3.1 Uranium Mill Tailings

Table 5.4 summarizes the waste accumulation rates, accumulated mass and site status for operating uranium tailings sites, closed/decommissioned sites and development sites in Canada as of December 31, 2010. Figure 5.6 shows the 2010 accumulated inventory of mill tailings rounded to the nearest 100 tonnes.

Uranium mill tailings are presented as 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/m^3. However, tailings densities vary significantly from site to site and with location or depth at a specific site.

At the operating sites, the annual accumulation rate of tailings in 2010 was approximately 0.7 million tonnes with an accumulated inventory to the end of 2010 of 13.3 million tonnes.

Total accumulated inventory of tailings at closed/decommissioned sites to the end of 2010 was about 201 million tonnes.

There are no tailings at the Cigar Lake development site licensed by the CNSC.

Table 5.4: Uranium Mill Tailings Accumulation Rate and Inventory, 2010

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Tailings Site	Accumulation Rate 2010 (tonnes/year)	Accumulated Mass Dec. 31, 2010 (tonnes)	Waste Site Status as of December 2010
OPERATING TAILINGS SITES						
Key Lake[a]	Cameco Corp.	Saskatchewan	Deilmann Tailings Management Facility	349,300	4,082,300	Operating since 1995
Rabbit Lake	Cameco Corp.	Saskatchewan	Rabbit Lake In-Pit TMF	247,990	7,438,860	Operating since 1985
McClean Lake Operation	AREVA Resources Inc.	Saskatchewan	JEB TMF	114,535	1,826,000	Operating since 1999
McArthur River	Cameco Corp.	Saskatchewan	No Tailings on site	0	0	Operating since 1999
Subtotal Operating Sites				**711,825**	**13,347,160**	
CLOSED/DECOMMISSIONED TAILINGS SITES						
Cluff Lake	AREVA Resources Inc.	Saskatchewan	Tailings Management Area	0	3,230,000	Decommissioned since 2006/ongoing monitoring
Key Lake	Cameco Corp.	Saskatchewan	Surface Tailings (Old Tailings Pond)	0	3,590,000	Closed since 1996/ ongoing monitoring
Rabbit Lake	Cameco Corp.	Saskatchewan	Surface Tailings	0	6,500,000	Closed since 1985/ being decommissioned
Beaverlodge	Cameco Corp.	Saskatchewan	Surface Tailings and Underground/Mine Backfill	0	5,800,000[b]	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	Closed since 1960
Port Radium	Aboriginal Affairs and Northern Development Canada	Northwest Territories	Surface Tailings - Four Areas	0	907,000	Decommissioned since 1984/ongoing monitoring
Rayrock	Aboriginal Affairs and Northern Development Canada	Northwest Territories	North and South Tailings Piles	0	71,000	Closed since 1959/ ongoing monitoring
Quirke 1 and 2 - Elliot Lake	Rio Algom Ltd.	Ontario	Quirke Mine Tailings Management Area (TMA)	0	46,000,000	Decommissioned/ ongoing monitoring
Panel - Elliot Lake	Rio Algom Ltd.	Ontario	Panel Mine TMA, Main Basin (North) and South Basin	0	16,000,000	Decommissioned/ ongoing monitoring

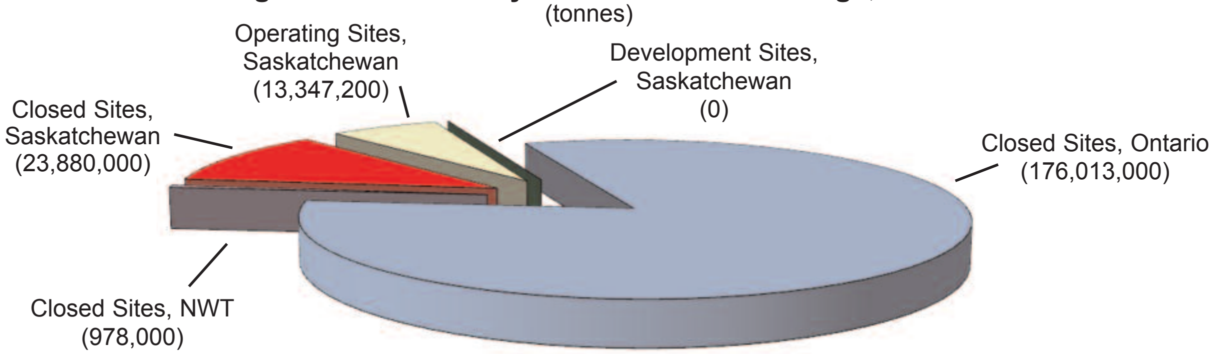
Table 5.4: Uranium Mill Tailings Accumulation Rate and Inventory, 2010 (cont'd)

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Tailings Site	Accumulation Rate 2010 (tonnes/year)	Accumulated Mass Dec. 31, 2010 (tonnes)	Waste Site Status as of December 2010
Denison - Elliot Lake	Denison Mines Inc.	Ontario	Denison Tailings Management Area (TMA1, TMA2)	0	63,800,000	Decommissioned/ ongoing monitoring
Spanish-American - Elliot Lake	Rio Algom Ltd.	Ontario	Spanish American Tailings Management Area	0	450,000	Decommissioned/ ongoing monitoring
Stanrock/ CANMET - Elliot Lake	Denison Mines Inc.	Ontario	Stanrock Tailings Management Area (TMA)	0	5,750,000	Decommissioned/ ongoing monitoring
Stanleigh - Elliot Lake	Rio Algom Ltd.	Ontario	Stanleigh Tailings Management Area (TMA)	0	19,953,000	Decommissioned/ ongoing monitoring
Lacnor - Elliot Lake	Rio Algom Ltd.	Ontario	Lacnor Waste Management Area	0	2,700,000	Decommissioned/ ongoing monitoring
Nordic - Elliot Lake	Rio Algom Ltd.	Ontario	Nordic Waste Management Area	0	12,000,000	Decommissioned/ ongoing monitoring
Milliken - Elliot Lake	Rio Algom Ltd.	Ontario	Milliken	0	150,000	Decommissioned/ ongoing monitoring
Pronto - Blind River	Rio Algom Ltd.	Ontario	Pronto Waste Management Area	0	2,100,000	Decommissioned/ ongoing monitoring
Agnew Lake Mines - Espanola	Ontario Ministry of Northern Development & Mines	Ontario	Dry Tailings Management Area	0	510,000	Decommissioned since 1990/ongoing monitoring
Dyno - Bancroft	EnCana Corporation	Ontario	Surface Tailings	0	600,000	Closed since 1960/ ongoing monitoring
Bicroft - Bancroft	Barrick Gold Corp.	Ontario	Bicroft Tailings Management Area	0	2,000,000	Closed since 1964/ ongoing monitoring
Madawaska - Bancroft	EnCana Corporation	Ontario	Surface Tailings - Two Areas	0	4,000,000	Decommissioned/ ongoing monitoring
Subtotal Closed/Decommissioned Sites				**0**	**200,871,000**	
DEVELOPMENT SITES						
Cigar Lake Project	Cameco Corp.	Saskatchewan	No tailings on site	0	0	Construction
Subtotal Development Sites				**0**	**0**	
TOTAL				**711,825**	**200,871,000**	

Notes: [a] Includes tailings accumulated from the processing of ores from McArthur River (operating since 1999).
[b] Excludes 4,300,000 tonnes that have been used as backfill.

Figure 5.6 : Inventory of Uranium Mill Tailings, 2010

(tonnes)



Total 2010 Inventory = 214,218,200 tonnes

Table 5.5: Mining Waste Rock Inventory, 2010

Mine/Mill Name	Principal Source Company Name/ Responsible Party	Source Company Province	Waste Rock Inventory		Waste Site Status as of December 2010
			Mineralized (tonnes)	Non-mineralized (tonnes)	
Key Lake[b]	Cameco Corp.	Saskatchewan	1,585,580	62,033,000	Operating since 1995
Rabbit Lake[a]	Cameco Corp.	Saskatchewan	2,304,010	22,159,000	Operating since 1985
McClean Lake Operation	AREVA Resources Inc.	Saskatchewan	10,200,000	51,700,000	Operating since 1999
McArthurRiver[b]	Cameco Corp.	Saskatchewan	37,860	161,140	Operating since 1999
Cigar Lake[b]	Cameco Corp.	Saskatchewan	0	213,620	Construction
Cluff Lake	AREVA Resources Inc.	Saskatchewan	N/A	18,400,000	Decommissioned since 2006/ongoing monitoring
Beaverlodge	Cameco Corp.	Saskatchewan	N/A	4,800,000	Decommissioned since 1982/ongoing monitoring
TOTAL			**14,127,450**	**159,466,760**	

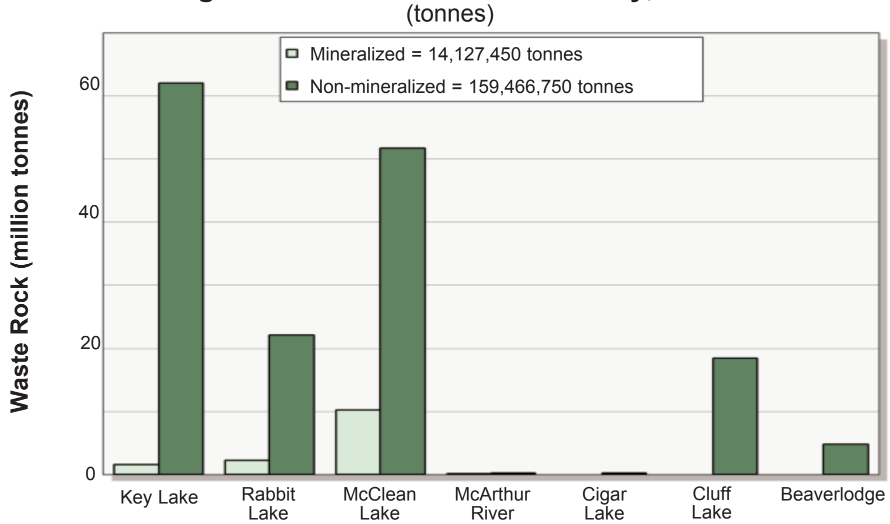
Notes: N/A Not available - mining predated waste segregation practices currently used, therefore all waste rock reported as non-mineralized.

[a] 2,735,000 tonnes of non-mineralized waste rock has been reclaimed.

[b] Decreases in waste rock inventories are due to milling or use as backfill, on road surfaces and for construction projects.

Figure 5.7: Waste Rock Inventory, 2010

(tonnes)



5.3.2 Waste Rock

Table 5.5 summarizes the total inventory of mineralized and non-mineralized waste rock from mine sites in Canada as of December 31, 2010. Waste rock data was not collected for mining operations in Ontario, the Northwest Territories, or at the Gunnar and Lorado sites in Saskatchewan as work at these sites predated current waste segregation practices. 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 accumulation rate can be deceptive and total inventory of waste rock is used to provide a more representative value.

The total inventory of waste rock for modern-day sites in Saskatchewan to the end of 2010 consisted of approximately 14 million tonnes of mineralized waste and 159 million tonnes of non-mineralized waste.

Figure 5.7 shows the mineralized and non-mineralized inventories for all operational sites in Canada as well as Cigar Lake, which is in the development stage and Cluff Lake and Beaverlodge sites, which have been decommissioned.

6.0 PROJECTIONS

Radioactive waste inventory in Canada has been projected to the end of 2010 and the end of 2050 for two of the three major waste groups including: nuclear fuel waste and L&ILRW. For uranium mining and milling waste, a brief qualitative assessment of future uranium mining and milling waste is provided in section 6.3. The year 2050 was selected as a reference because it approximately corresponds to the forecasted end of operations for the last constructed power reactors (Darlington Generating Station).

6.1 Nuclear Fuel Waste

Projection of nuclear fuel waste is provided to 2011 and 2050. This assumes that no new nuclear generating stations will be commissioned before the year 2050 and that all current operating reactors will have ceased operations by this time.

Projected nuclear fuel waste is summarized in Table 6.1. Projected waste quantities were provided by the utilities operating the power reactors and are based on the current operating plans for each reactor. End of operations for the operating power reactors range from year 2017 to 2050. Total lifetime inventory of nuclear fuel waste from these reactors is approximately 4.8 million bundles (19,370 m^3).

Projected nuclear fuel waste inventory to 2050 for the existing prototype/demonstration and research reactors owned by AECL is approximately 392 m^3.

Figure 6.1 shows the forecasted distribution of the nuclear fuel waste inventory in year 2050 by major producers: Ontario Power Generation, 88%; New Brunswick Power, 5%; Hydro-Québec, 5% and AECL, 2%. Figure 6.1 shows the estimated volume to the nearest 10 m³. Figure 6.2 compares estimated volumes (rounded to the nearest 10 m³) of nuclear fuel waste inventories to the end of 2010 with inventories projected to 2050.

Table 6.1: Projected Nuclear Fuel Waste Inventory to 2011 and 2050

Site Name	Source Company Name	End of Reactor Operations[a]	Nuclear Fuel Waste Inventory: To End of 2010 – Number of Fuel Bundles	To End of 2010 – Estimated Volume[c] (m^3)	Projected to End of 2011[b] – Number of Fuel Bundles	Projected to End of 2011[b] – Estimated Volume[c] (m^3)	Projected to the End of 2050[b] – Number of Fuel Bundles	Projected to the End of 2050[b] – Estimated Volume[c] (m^3)
POWER REACTORS								
Bruce A	Ontario Power Generation	2034-2037	416,243	1,665	426,400	1,710	920,600	3,680
Bruce B	Ontario Power Generation	2042-2045	533,079	2,132	556,000	2,220	1,314,000	5,260
Darlington	Ontario Power Generation	2050-2053	388,503	1,554	412,000	1,650	1,306,200	5,230
Pickering A and B	Ontario Power Generation	2017-2019	625,357	2,501	642,600	2,570	800,300	3,200
Gentilly-2	Hydro-Québec	2039	107,237	473	122,200	490	235,000	940
Point Lepreau	NB Power	2037-2042	116,070	498	121,800	500	259,700	1,060
Subtotal Power Reactors			**2,203,137**	**8,823**	**2,281,000**	**9,140**	**4,835,800**	**19,370**
PROTOTYPE/DEMONSTRATION/RESEARCH REACTORS								
Douglas Point	AECL	1984	22,256	89	22,256	89	22,256	89
Gentilly-1	AECL	1978	3,213	13	3,213	13	3,213	13
Chalk River Laboratories (items)[d]	AECL	2050	7,402	125	7,187	128	13,923	261
Chalk River Laboratories (bundles)	AECL	1987	4,886	20	4,886	20	4,886	20
Whiteshell Laboratories	AECL	1997	2,268	9	2,268	9	2,268	9
Subtotal Research Reactors[e]			**40,025**	**256**	**39,810**	**259**	**46,546**	**392**
TOTAL[a,e]			**2,243,162**	**9,079**	**2,321,000**	**9,400**	**4,882,000**	**19,800**

Notes: AECL = Atomic Energy of Canada Limited

[a] Assuming reburbishment at Gentilly-2 and all OPG and Bruce Power reactors with the exception of Pickering A. Point Lepreau is currently undergoing refurbishment and is scheduled to return online sometime in 2012. For the purpose of this report, the forecasted end of operations for Chalk River Laboratories is selected as 2050 to compare fuel inventories.

[b] Projected waste inventories rounded to nearest 100 bundles and 10 m³ for operating reactors. Total projected waste inventories rounded to nearest 1000 bundles and 100 m³. Inventories not expected to change have not been rounded off.

[c] Nuclear fuel waste volume calculated assuming a typical volume of 0.004 m³ for a CANDU fuel bundle, except for Chalk River Laboratories items.

[d] For research reactors, inventory is reported as the number of research rods, fuel assemblies, units or items.

[e] Includes CANDU fuel bundles as well as research rods, fuel assemblies, units and items.

Figure 6.1 : Nuclear Fuel Waste Inventories Projection, 2050
(estimated volume)

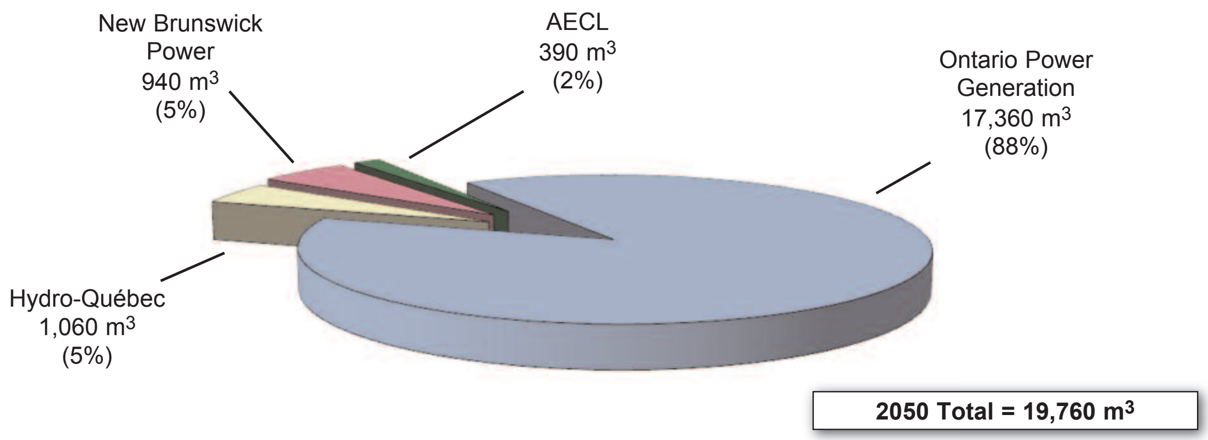
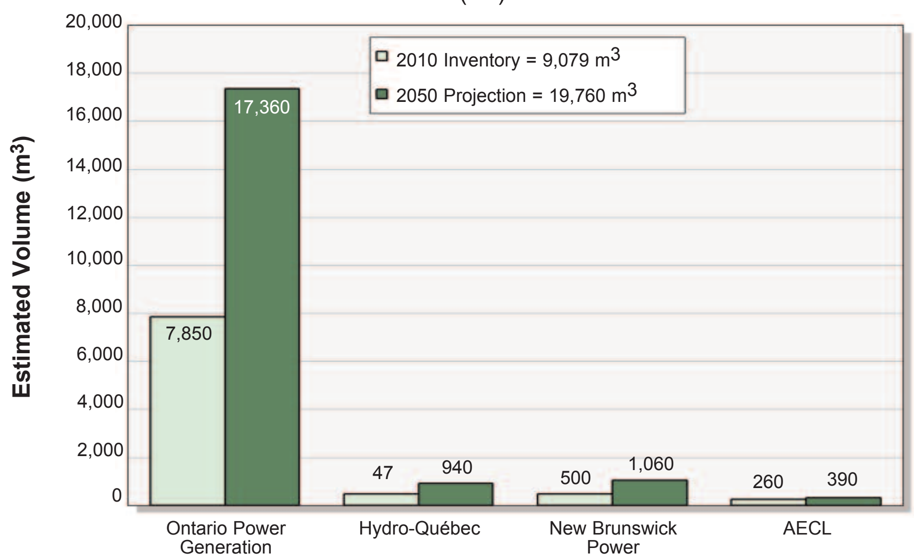


Figure 6.2 : Nuclear Fuel Waste Inventory, 2010 and Projection to 2050
(m^3)



6.2 Low- and Intermediate-Level Radioactive Waste

Projected inventories of LLRW and ILRW are summarized in Table 6.2. It is estimated that the 2010 inventories of 2.34 million m^3 and 32,900 m^3 will increase to approximately 2.59 million m^3 and 67,000 m^3 by 2050 for LLRW and ILRW, respectively. Projected inventories and the assumptions used to develop these projections are described in the following sections. Figures 6.3 and 6.4 provide a comparative status of total inventory to 2050 of LLRW and ILRW, respectively.

Table 6.2: Projected LLRW and ILRW Inventory to 2011 and 2050

Waste Source	LLRW[a]			ILRW[a]		
	Inventory to End of 2010 (m^3)	Projected Inventory to End of 2011 (m^3)	Projected Inventory to End of 2050[b] (m^3)	Inventory to End of 2010 (m^3)	Projected Inventory to End of 2011 (m^3)	Projected Inventory to End of 2050[b] (m^3)
A. ONGOING WASTE						
Operations						
Nuclear Fuel Cycle	90,648	94,800	147,000	13,093	13,300	30,000
Nuclear R&D	501,293	502,200	539,000	19,518	19,700	28,000
Radioisotope Production and Use	19,538	19,700	25,000	127	200	1,000
Subtotal	**611,479**	**616,700**	**711,000**	**32,738**	**33,200**	**58,000**
Decommissioning						
Nuclear Fuel Cycle	1,650	1,650	135,000	0	0	6,000
Nuclear R&D	3,462	3,600	25,000	168	200	3,000
Radioisotope Production and Use	0	0	0	0	0	0
Subtotal	**5,112**	**5,300**	**160,000**	**168**	**200**	**8,000**
Total Ongoing Waste	**616,592**	**622,000**	**871,000**	**32,906**	**33,400**	**67,000**
B. HISTORIC WASTE						
Port Hope	720,000	720,000	720,000	0	0	0
Welcome and Port Granby	893,000	893,000	893,000	0	0	0
Deloro Mine Site	38,000	38,000	38,000	0	0	0
Other Locations	71,000	71,000	71,000	0	0	0
Total Historic Waste	**1,721,000**	**1,721,000**	**1,723,000**	**0**	**0**	**0**
TOTAL	**2,338,000**	**2,343,000**	**2,594,000**	**32,906**	**33,400**	**67,000**

Notes: ***Historic Waste, Other Locations*** includes waste located at: various LLRWMO managed sites in the Greater Toronto Area, Chalk River Laboratories (Area D), Fort McMurray, Alberta and along the Northern Transportation Route.

a 2011 waste projections have been rounded to the nearest 100 m^3. Waste projections to 2050 and historic waste volumes have been rounded to the nearest 1000 m^3.

b Assuming all reactors except Pickering A will be refurbished.

6.2.1 Ongoing Waste

The total L&ILRW inventory projected to 2050 from ongoing operations and decommissioning will be about 0.9 million m^3.

6.2.1.1 Operations

Projection of L&ILRW 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 L&ILRW. It is also assumed that the 2010 waste accumulation rates will remain constant in the future except where otherwise forecasted by the producers (e.g. electric utilities).

Figure 6.3 : LLRW Inventories, 2010 and 2050

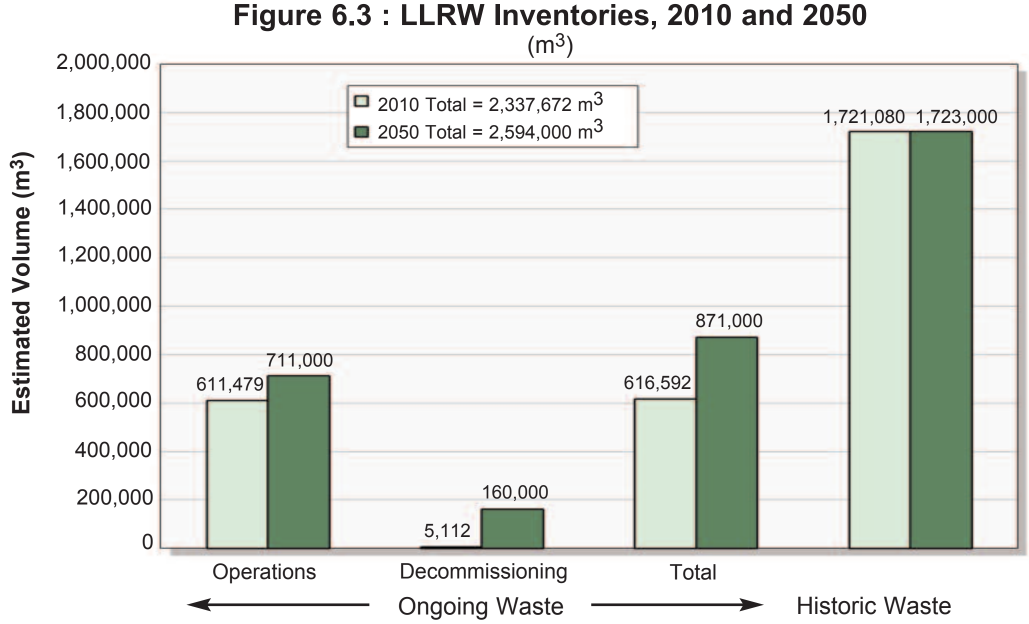
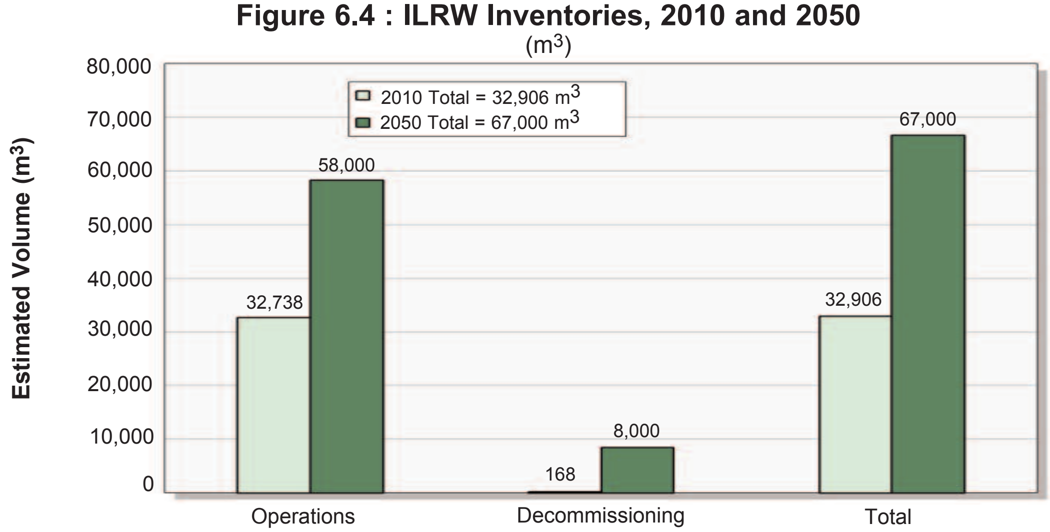


Figure 6.4 : ILRW Inventories, 2010 and 2050



The total projected inventory of waste to 2050 from operation and maintenance is 711,000 m^3 of LLRW and 58,000 m^3 of ILRW. Waste from operations will continue to be a major contributor to L&ILRW inventory until 2048 when Phase 3 decommissioning of the power reactors (Gentilly-1, Douglas Point and NPD) begins.

6.2.1.2 Decommissioning

Projected inventories of decommissioning waste 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. Decommissioning waste estimates for the nuclear fuel cycle were also obtained from each site's preliminary decommissioning plan. Projections of decommissioning waste to 2100 reflect the anticipated shutdown dates of the nuclear reactors as of December 31, 2010. Figure 6.5 shows the projected annual decommissioning waste volumes for the power reactors, prototype/demonstration power reactors and the Whiteshell and CRL nuclear facilities through to 2100. This timeline was selected to include complete Phase 3 decommissioning of all currently operating power reactors .

The following assumptions were used in projecting decommissioning waste inventory to year 2050:

- Decommissioning or major site refurbishment may be required at the uranium refining and conversion, and fuel fabrication facilities between the years 2020 and 2025, with the exception of the Blind River refinery, which is relatively new. These activities will result in the generation of approximately 102,000 m^3 of LLRW. This volume of waste has not been included in Figure 6.5.

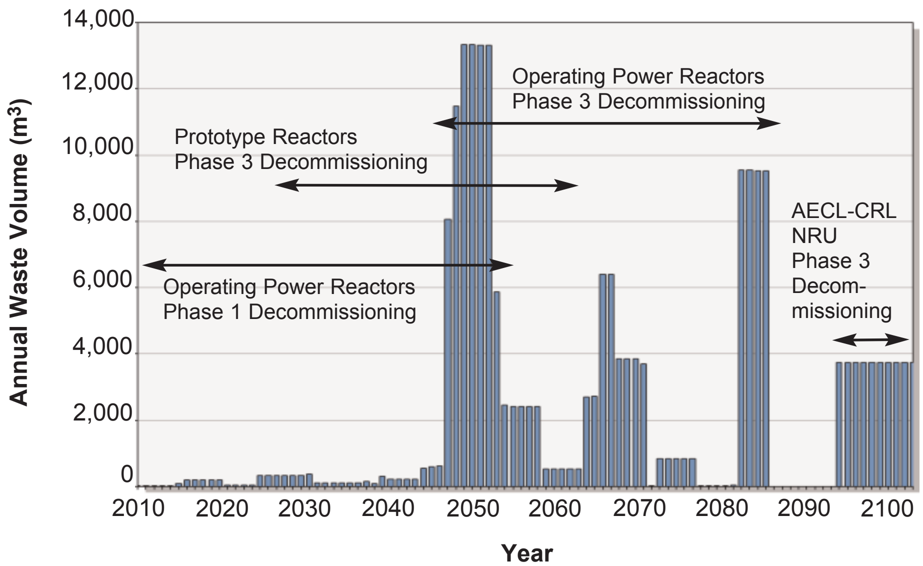
- The three partially decommissioned prototype power reactors will undergo Phase 3 decommissioning from year 2025 to 2060.

- Barring the decisions to extend the operating lives of currently operating power reactors, Phase 1 decommissioning of the operating power reactors will occur at various dates from 2014 through year 2045. Units 2 and 3 at the Pickering A nuclear generating station are currently shutdown and undergoing preparation for safe storage. Phase 1 decommissioning at each reactor will generate approximately 200 m^3 to 600 m^3 of waste.

- Decommissioning of the OPG waste management facilities is scheduled for 2061-2067.

The total projected inventory of decommissioning waste to year 2050 includes approximately 160,000 m^3 and 8,000 m^3 of low-level and intermediate-level radioactive waste, respectively.

Figure 6.5 : Annual Volume of Radioactive Waste from Decommissioning of Existing Nuclear Facilities to 2105



6.2.2 Historic Waste

A nominal accumulation rate of 50 m^3/year has been assumed to account for future discovery of historic waste for which AECL is responsible on behalf of the federal government. The inventory of LLRW in the Port Hope area is expected to remain unchanged at the current volume of 720,000 m^3.

The volume of waste managed by Cameco at its Port Granby site, as well as the waste managed by the MOE at the former Deloro Mine Site is expected to remain unchanged at the current volume of 438,200 m^3 and 38,000 m^3, respectively. The volume of waste managed by AECL at the Welcome Management Facility is 454,380 m^3.

The total volume of historic waste in year 2050 is estimated to be approximately 1.76 million m^3.

6.3 Uranium Mining and Milling Waste

The known resources of uranium ore 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 future uranium mining and milling waste.

6.3.1 Operating Sites

Future uranium production rates could increase depending on timing and market conditions. Ore grades from Cigar Lake will be higher and, as a result, will reduce the tailings production rates relative to uranium production. Cameco Corporation will continue to blend Key Lake special waste with high grade ore from McArthur River. At Rabbit Lake, mixing of tailings with waste rock or till prior to deposition is also considered. Due to these possibilities, it is difficult to forecast the final tailings mass from the operating mill sites.

6.3.2 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.

6.3.3 Development Sites

The Cigar Lake development site will become an operating site in the future, however the ore is to be milled at existing operating sites. Therefore, there will be no tailings accumulated at the site.

7.0 SUMMARY

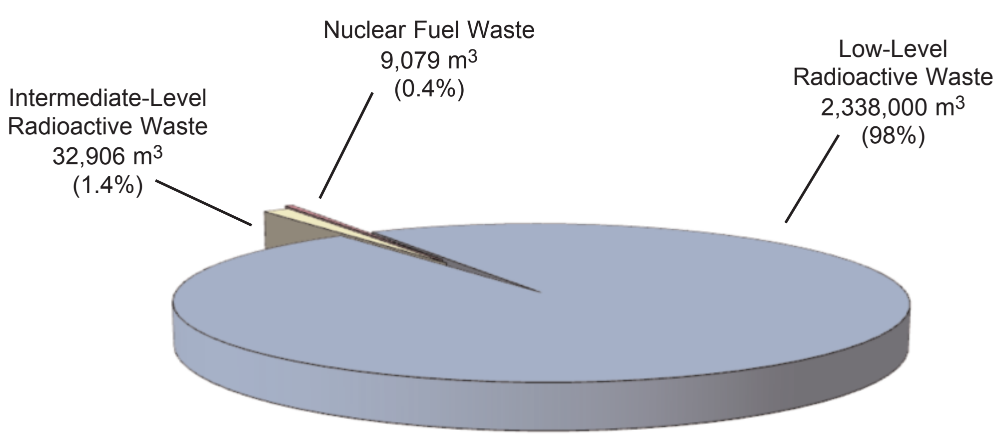
Radioactive waste has been produced in Canada since the early 1930s when the first radium mine began operating at Port Radium in the Northwest Territories. At present, radioactive waste is generated from: uranium mining, milling, refining and conversion; nuclear fuel fabrication; nuclear reactor operation for electricity generation; nuclear research; and radioisotope production and use.

Radioactive waste is grouped into three categories: nuclear fuel waste; low- and intermediate-level radioactive waste; and uranium mining and milling waste. The accumulated inventory of this waste to the end of 2010 and projections to the end of 2011 and 2050 are provided in Table 7.1. Figure 7.1 shows the summary of radioactive waste inventories to the end of 2010.

Table 7.1 : Summary of Current and Future Inventories

Waste Category	Waste Inventory to 2010 December	Waste Inventory Projected to End of 2011	Waste Inventory Projected to End of 2050
Nuclear Fuel Waste	9,079 m^3	9,400 m^3	19,800 m^3
Intermediate-Level Radioactive Waste	32,906 m^3	33,400 m^3	67,000 m^3
Low-Level Radioactive Waste	2,338,000 m^3	2,343,000 m^3	2,594,000 m^3
Uranium Mill Tailings	214 million tonnes	N/A	N/A
Waste Rock	174 million tonnes	N/A	N/A
Note: N/A - not available			

Figure 7.1 : Summary of Radioactive Waste Inventories, 2010
(estimated volume)



2010 Total = 2,379,985 m^3

8.0 SOURCES OF INFORMATION

A. General

Canadian Nuclear Safety Commission, 2010. *Annual Report* 2009-2010.

Government of Canada, 2008. *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October.

Intera Engineering Ltd., 2009. *Inventory of Radioactive Waste in Canada*, Report prepared for the Low-Level Radioactive Waste Management Office, December.

B. Nuclear Fuel Waste

Atomic Energy of Canada Limited, 2010a. *Chalk River Laboratories Annual Safety Review for 2009*. CRL-00583-ASR-2009, April.

Atomic Energy of Canada Limited, 2010b. *Whiteshell Laboratories Annual Safety Review for 2009*, WL-00583-ASR-2009, April.

Atomic Energy of Canada Limited, 2010c. *Douglas Point WMF Annual Compliance Report for 2009*, 22-00531-REPT-010, February.

Atomic Energy of Canada Limited, 2010d. *Gentilly-1 Waste Management Facility Annual Compliance Report for 2009*, 61-00521-REPT-006, February.

Atomic Energy of Canada Limited, 2010e. *NPD Waste Management Facility Annual Compliance Report for 2009*, 64-00521-REPT-006, February.

Hydro-Quebec, 2010. *Gestion des Installations de Stockage des Dechets Radioactifs Solides et du Combustible Nucleaire Irradie de la Centrale de Gentilly-2*, Rapport Quatrieme Trimestre, December.

New Brunswick Power Corporation, 2010a. *Fissionable Substance Report*, December.

Ontario Power Generation, 2010a. *Fissionable Substances Report*, December.

C. Low- and Intermediate-Level Radioactive Waste

Atomic Energy of Canada Limited, 2010a. *Chalk River Laboratories Annual Safety Review for 2009*. CRL-00583-ASR-2009, April.

Atomic Energy of Canada Limited, 2010b. *Whiteshell Laboratories Annual Safety Review for 2009*, WL-00583-ASR-2009, April.

Atomic Energy of Canada Limited, 2010c. *Douglas Point WMF Annual Compliance Report for 2009*, 22-00531-REPT-010, February.

Atomic Energy of Canada Limited, 2010d. *Gentilly-1 Waste Management Facility Annual Compliance Report for 2009*, 61-00521-REPT-006, February.

Atomic Energy of Canada Limited, 2010e. *NPD Waste Management Facility Annual Compliance Report for 2009*, 64-00521-REPT-006, February.

Hydro-Quebec, 2010. *Gestion des Installations de Stockage des Dechets Radioactifs Solides et du Combustible Nucleaire Irradie de la Centrale de Gentilly-2*, Rapport Quatrieme Trimestre, December.

New Brunswick Power Corporation, 2010b. *Point Lepreau Generating Station, Solid Radioactive Waste Management Facility Quarterly Report*, Fourth Quarter.

Ontario Power Generation, 2010b. *Western Waste Management Facility Quarterly Technical Report,* Fourth Quarter.

Ontario Power Generation, 2010c. *Nuclear Waste Management System Plan*.

D. Uranium Mine and Mill Waste

AREVA Resources Canada Inc., 2011b. *McClean Lake Operation 2010 Annual Report*, March.

AREVA Resources Canada Inc., 2004. *Cluff Lake Project 2003 Annual Report*, March.

Cameco Corp., 2011a. *Cigar Lake Project, Annual Report 2010*, March.

Cameco Corp., 2011c. *Key Lake Operation, Annual Report 2010*, March.

Cameco Corp., 2011d. *McArthur River Operation, Annual Report 2010*, March.

Cameco Corp., 2011e. *Rabbit Lake Operation, Annual Report 2010*, March.

Cameco Corp., 2010a. *Deilmann Tailings Management Facility, Annual Performance Report 2010*, June.

Cameco Corp., 2010b. *Annual Performance Report for Rabbit Lake In-pit Tailings Management Facility*, April.

Canada Nuclear Safety Commision, 2003. *Comprehensive Study Report - Cluff Lake Decommisioning Project*, December.

Rescan Consultants, 2011. *Results of 2007 Rayrock Long-term Monitoring Program - Final Report,* March.

SENES Consultants Limited (SENES) 2010. *Port Radium Long-Term Monitoring (Year 2) 2009 Inspection and Monitoring Activities,* January.

Appendix A
Policy Framework for Radioactive Waste

CANADA'S RADIOACTIVE WASTE POLICY FRAMEWORK

The elements of a comprehensive radioactive waste policy framework consist of a set of principles governing the institutional and financial arrangements for disposal of radioactive waste by waste producers and owners.

- 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, management and operation of disposal and other facilities required for their wastes. This recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste and uranium mine and mill tailing.