Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

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Government of Canada Gouvernement du Canada

Canada

Preface

Information in this Report covers the period up to March 31, 2011. However, given the timing of the earthquake and tsunami in Japan, the Report does not take into consideration actions taken by the CNSC with Class I Nuclear Facilities, mines and mills which include spent fuel bays and radioactive waste facilities. On March 22, 2011, under section 12(2) of the *General Safety and Control Regulations* (GNSCR), the CNSC requested all Class 1 licensed facilities in Canada to review initial lessons learned from the incident in Japan and to confirm that their overall safety cases remain strong. All licensees provided the requisite initial responses, identifying their proposed plans and schedules to meet the CNSC's request. Licensees concluded that their overall safety cases remain strong. To confirm their findings, the CNSC has performed a series of inspections at each station.

In addition, Canada will be participating in an Extraordinary Meeting of the Convention on Nuclear Safety in August 2012 on lessons learned from Fukushima. More information on the CNSC's response is available at nuclearsafety.gc.ca

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Executive Summary

1.0 Introduction

This report demonstrates how Canada continues to meet its obligations under the terms of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. A collaboration by government, industry and the regulatory body, this document focuses specifically on the progress of long-term management initiatives for spent fuel and radioactive waste in Canada, revisions and updates to Canada's *Third National Report* and comments and issues raised at the Third Review Meeting. Specifically, it includes additional information on:

- Canada's current priorities regarding long-term management
- the inventory of spent fuel and radioactive wastes current to the reporting period
- continued implementation and ongoing funding of the Nuclear Legacy Liability Program
- the regulatory approval process for Ontario Power Generation deep geological repository for its low- and intermediate-level waste

Information in this document is current to March 31, 2011.

2.0 Canada's key highlights and current priorities

- In June 2007, the Government of Canada selected the Adaptive Phased Management (APM) approach, recommended by the Nuclear Waste Management Organization (NWMO), for the long-term management of Canada's nuclear fuel waste. The NWMO is responsible for implementing this plan. In May 2010, the NWMO initiated the site selection process for the deep geological repository for spent fuel. (For more information about the NWMO, see sections G.17 and K.4.)

- The Government of Canada committed $520 million over five years to launch a long-term strategy for dealing with nuclear legacy liabilities at Atomic Energy of Canada Limited (AECL) sites, specifically Chalk River Laboratories (CRL), Whiteshell Laboratories and the three prototype reactors. The funding commitment initiated funds were spent to start the Nuclear Legacy Liabilities Program (NLLP) in 2006. The NLLP is now in its sixth year of implementation, with funding of $129 million in fiscal year 2011-12, which was initiated in April 2006 and is in the fifth year of the start-up phase. Planning is well advanced for the next three years of the program, which will commence in April 2011. (Program progress and achievements are summarized in section K.6.2.)

- In March 2011, OPG submitted the Environmental Impact Statement, Preliminary Safety Report and supporting reports to the Canadian Nuclear Safety Commission (CNSC) in support of its application for a site preparation and construction licence for a deep geology repository for its low- and intermediate–level radioactive waste. The Canadian Environmental Assessment Agency (CEA Agency) and the CNSC will establish a Joint Review Panel to review both the environmental assessment and the licence application in 2011. This Joint Review Panel, following public hearings, will prepare a report. Following the Government of Canada's Governor in Council's response to this report, the Panel will act as the Commission Tribunal and decide whether to issue the required licence. EA approval and a site preparation and construction licence are expected to be received in 2012–2013; earliest in-service is expected in 2018. (Further information can be found in section K.6.1.)

- Canada continues to manage and address historic waste as a priority. On October 16, 2009, the Commission Tribunal issued a licence to AECL for the Port Hope Project. The next step is to have the Port Granby Project come before the Commission Tribunal for a licensing decision. Both projects are nearing the end of the planning phase (Phase 1). (For further information, see section K.6.3.1 and annex 8.2.2.4.)

- Dalhousie University's SLOWPOKE-2 Reactor (DUSR) facility, part of Dalhousie's Trace Analysis Research Centre, was decommissioned in March 2011. The next stage of the licensing process is to consider an application for a licence to abandon. (For further information, see annex 7.8.)

3.0 Progress since the Third Review Meeting

During the peer review of Canada's *Third National Report* in 2009, contracting parties to the Third Review Meeting identified long-term waste management challenges and solutions. The following section (3.1) is an update on progress made for the long-term management of spent fuel and radioactive waste.

3.1 Canada continues progress for long-term management strategies by:

a. implementation of long-term management approaches for spent fuel
b. fostering relationships gained through stakeholder consultation
c. ensuring that there are adequate human resources to implement future work
d. increasing regulatory efforts necessary to support future industry initiatives
e. continuing the production of supporting regulatory documentation
f. validation of model predictions for waste rock and tailings
g. decommissioning of older waste rock sites and the development of new tailings management capacity
h. continued implementation and ongoing funding requirements for AECL CRL (Nuclear Legacy Liability Program)
i. finalization of the regulatory approval process for the low- and intermediate-level waste deep geological repository

3.1 (a) Implementation of long-term management approaches for spent fuel

Momentum has been sustained for implementing long-term management approaches for spent fuel since the NWMO received the mandate in 2007 to implement the Adaptive Phased Management (APM) Plan approved by the Government of Canada. The NWMO has been advancing work consistent with its five-year strategic plan. An important milestone was the development of a site selection process for the spent fuel deep geological repository through a collaborative process led in 2008 and 2009. A further milestone was reached in 2010 with the initiation of the site selection process and early engagement of communities to learn more about the APM approach for the long-term management of spent fuel. (See sections G.17 and K.4.)

3.1 (b) Fostering relationships gained through stakeholder consultation

The following are examples of how relationships have been fostered through stakeholder consultation and future steps to further develop these relationships.

Nuclear Waste Management Organization (NWMO)

In implementing the APM program, the NWMO has continued to engage organizations, communities, governments and Aboriginal peoples, with a diversity of interests, to invite guidance and confirmation of the appropriateness of its plans and activities at each stage. Over the last three years, the NWMO has sought input on strategic objectives, policy and communications documents and the collaborative development of the APM site selection process. More than 7,000 people were engaged in designing the site selection process in 2008 and 2009, and they contributed important and diverse perspectives through such activities as public information sessions, citizen panels, multi-party dialogues, Aboriginal dialogues and national surveys. A forum of municipal associations, the NWMO Elders Forum and its working group, Niigani, have provided the NWMO with important guidance for plan development, community engagement activities and communications material. A Youth Roundtable was convened to develop a basis for youth outreach. The NWMO met regularly with representatives and staff of the Government of Canada and of the governments of provinces where nuclear-related activities are carried out, to keep them informed of its plans and activities. Looking ahead to 2011 to 2015, engagement, education, outreach and capacity-building initiatives will be expanded. An important focus will be to build relationships with communities and regions potentially interested in, or affected by, the APM site selection process and the transportation of spent fuel.

Low-Level Radioactive Waste Management Office (LLRWMO)(AECL)

The LLRWMO's work under the direction of Natural Resources Canada (NRCan) entails extensive stakeholder relations and communications, negotiation and accommodation of public client needs, as well as thoughtful planning. In communities where small volumes of waste are present, the LLRWMO will continue to strive to clean up the waste and either remove it or manage it *in situ*, following NRCan's process of involving communities in the development of long-term solutions. The LLRWMO strives to maintain stakeholder confidence through open and transparent communications and engagement techniques.

Canadian Nuclear Safety Commission (CNSC)

The Canadian Nuclear Safety Commission (CNSC) is Canada's nuclear regulatory body. Part of its mandate is to disseminate information to all stakeholders. In discharging this obligation, the CNSC also established links in early 2007 with host communities of major nuclear facilities. To ensure the needs of future stakeholders are met, the CNSC proactively contacts communities likely to become involved in nuclear activities (such as mining and milling and waste management repositories) in the next decade.

Aboriginal consultation (CNSC)

Pursuant to section 35 of the *Constitution Act*, 1982, the Crown has a legal duty to consult with Aboriginal groups when its contemplated conduct may adversely impact established Aboriginal or treaty rights. The CNSC recognizes that Aboriginal peoples have concerns with regard to the nuclear sector and that it is important to seek opportunities to work together in ensuring the safe and effective regulation of nuclear energy and materials. The CNSC will continue to communicate "objective scientific, technical and regulatory information" about CNSC activities and the effects of the nuclear industry in Canada as per the objectives of the *Nuclear Safety and Control Act*.

The CNSC has established a team of experts in Aboriginal consultation. To ensure the CNSC upholds the honour of the Crown, this team identifies Aboriginal groups whose protected right may be adversely affected and proposes a plan to ensure that effective and meaningful consultation is carried out prior to making licensing decisions. This team provides policy and operational guidance to all CNSC divisions throughout the regulatory review process.

The CNSC strives to meet its commitment to excellence, in part through a good governance approach to effective and well-managed Aboriginal consultation processes when Aboriginal rights or interests could be impacted. CNSC staff meet with Aboriginal communities to build relationships which in turn foster the consultation process when licence applications undergo regulatory review. CNSC staff travel across Canada including Labrador, northern Quebec, Nunavut, Ontario, New Brunswick and northern Saskatchewan to share information with Aboriginal communities on its role as Canada's nuclear regulator, to listen to their concerns and to respond to their questions.

CNSC Participant Funding Program (PFP)

In February 2011, the CNSC launched its Participant Funding Program (PFP). The PFP was established to give the public, Aboriginal groups and other stakeholders the opportunity to apply for some funding to participate in aspects of environmental assessments or licensing actions. The objectives of the PFP are to enhance Aboriginal, public and stakeholders participation in relation to the CNSC's regulatory processes as well as to help stakeholders bring valuable information to the Commission's Tribunal through informed and topic-specific interventions.

3.1 (c) Ensuring that there are adequate human resources to implement future work

The following are examples of how organizations maintain a high level of expertise and ensure adequate human resources are available to implement future work.

Nuclear Waste Management Organization (NWMO)

The NWMO continues to strengthen the organization's skills and capabilities to implement APM, and further growth is planned. Over the last three years, the NWMO made the transition from a small organization into an implementing agency with a range of capabilities required to implement the APM program. On January 1, 2009, the NWMO became its own employer, with the necessary supporting infrastructure including finance, legal services and human resources. Staffing levels increased from 27 at the end of 2007 to 120 by year-end 2010. The NWMO continues to recruit staff in a wide range of disciplines.

Over the next five years, the organization will continue to ensure resource capacity and expertise are in place to provide the foundation for progressing through each phase of planning, design and site assessments. It is anticipated that some hiring of regionally based staff will be required to support communities engaged in the APM site selection process. In addition to maintaining in-house staff capability, the NWMO is developing specialist networks with universities and the consulting community within Canada. Joint research, development and demonstration programs are underway internationally. Planned research programs play an important role in enabling Canada to benefit from leading technological innovation, while, at the same time, securing institutional memory, knowledge transfer and the technical capacity of the workforce required to implement APM in future years. The development of a youth-engagement strategy further recognizes the intergenerational nature of this work.

Atomic Energy of Canada Limited (AECL)

AECL's Decommissioning & Waste Management (D&WM) organizational unit currently comprises approximately 440 full-time employees. D&WM has established a sound technical resource base that supports waste management, decommissioning and environmental remediation activities associated with legacy and operational wastes at AECL's sites, Canada's historic radioactive wastes and commercial waste. Staffing demands have increased during the past three years and are expected to continue due to the planned waste management, decommissioning and site remediation activities. Since the last reporting period, D&WM staff levels have increased by 25 percent. D&WM continues to emphasize workforce planning, staff development, succession management and knowledge management to meet its resource requirements for both the short and long term.

Low-Level Radioactive Waste Management Office (LLRWMO) (AECL)

Following NRCan's policy and funding priorities, the LLRWMO will continue to respond to Canada's needs for historic low-level radioactive waste (LLW) management on a project-by-project basis. To accomplish this goal, the LLRWMO relies on its staff's expert core capabilities, which add value to the work of private sector contractors engaged to help execute specific projects. As an advisor and responder to LLW issues and in recognition of logistical requirements of its reactive community programs, the LLRWMO sustains and adjusts resource strength to maintain corporate knowledge and ensure appropriate procedures are developed, maintained and followed. The LLRWMO also maintains the human resources required to operate ongoing monitoring, inspection and environmental remediation programs across Canada. This maintenance of expertise in various fields not only makes the LLRWMO a knowledgeable consumer of contracted services, but also permits the specialized and professional development of products and projects for clients and stakeholders.

Ontario Power Generation (OPG)

The Nuclear Waste Management Division of Ontario Power Generation (OPG) currently comprises approximately 300 full-time employees. Staffing demands have increased during the past years and are expected to keep rising due primarily to attrition as a result of retirements. With continued emphasis on succession management, workforce planning and staff development in the Nuclear Waste Management Division is positively positioned to meet its qualified staffing requirements for both the short and long term. (For information on OPG's initiatives, refer to section F.3.3.)

Canadian Nuclear Safety Commission (CNSC)

One of the CNSC's key strategic objectives for several years has been staff recruitment and retention. The CNSC has been successful in attracting qualified candidates and has recently reached its optimal employee complement. Therefore, the CNSC's efforts have shifted from recruitment to retention. To align with this change of focus, the CNSC has placed a strong emphasis on learning and the development of its workforce. (See section E.8.2.)

3.1 (d) Increasing regulatory efforts necessary to support future industry initiatives

Major Projects Management Office

The Government of Canada recently created the Major Projects Management Office (MPMO) within Natural Resources Canada (NRCan). The MPMO is a Government of Canada organization. Its role is to provide overarching project management and accountability for major resource projects in the federal regulatory review process and to facilitate improvements to the regulatory system for major resource projects. The MPMO, working collaboratively with federal departments and agencies, serves as a single window into the federal regulatory process and complements the technical discussions between proponents and regulators. The MPMO provides guidance to project proponents and other stakeholders, coordinates project agreements and timelines between federal departments and agencies, and tracks and monitors the progress of major resource projects throughout the federal regulatory review process.

The MPMO will monitor the federal regulatory review process for the OPG Deep Geologic Repository (DGR). A Project Agreement (PA) has been developed and approved for this project. A PA is an agreement between federal deputy ministers that outlines the process by which federal departments or agencies will carry out their particular roles or responsibilities during the federal regulatory review of a proposed major resource project. The PA includes a timeline and schedule for the completion of the regulatory review, with regular milestones to allow progress tracking.

Regulatory early involvement in the APM Project

As a best practice, the CNSC gets involved early in proposed new nuclear projects to ensure that licence applicants and affected communities have a comprehensive understanding of the CNSC's role in regulating Canada's nuclear sector. Future applicants are provided with CNSC information and guidance on the regulatory requirements and licensing process prior to the submission of a licence application and the initiation of the environmental assessment process. In 2009, the CNSC signed a service arrangement with the NWMO to provide regulatory guidance and support for implementing the NWMO's APM. The service arrangement identifies the terms under which the CNSC provides services to the NWMO prior to the submission of a licence application. Services include providing pre-project design reviews of APM deep geological repository concepts, identifying regulatory requirements for a geological repository and participating in public meetings to provide information on the CNSC's role. (See section K.5.)

3.1 (e) Continuing the production of supporting regulatory documentation

The CNSC has continued its production of support documentation, which leads to additional regulatory policies, standards and guides.

Regulatory Policy P-319, *Financial Guarantees*

In March 2011, the CNSC issued discussion paper DIS-11-01, *Implementation of Financial Guarantees for Licensees*. This document proposes a new financial guarantee policy which states: "It is the policy of the Canadian Nuclear Safety Commission (CNSC) that a financial guarantee be required of licensees for all facilities and activities licensed by the CNSC, unless in the opinion of the Commission Tribunal a financial guarantee is not required." In December 2011, the Commission Tribunal will consider the draft position paper for implementation. Should this policy be implemented, the CNSC will issue supporting regulatory documents which will advise licensees and applicants of CNSC expectations regarding financial guarantees. (For more details, refer to section F.4.3.)

3.1 (f) Validation of model predictions for waste rock and tailings

During an environmental assessment (EA) of a project, numerical modelling tools are used to predict the effects of mining-related activities on the environment, such as the long-term placement of waste rock and tailings. Formal EA follow-up programs are an important component of the environmental assessment process, as defined by the

Canadian Environmental Assessment Act. EA follow-up programs are tailored to verify the accuracy of EA predictions through the collection of monitoring data during the operational period.

The key components that control the release and transport of contaminants include the chemical and physical properties of the placed tailings or waste rock, and the site-specific hydrology and hydrogeology characteristics.

The data from focused monitoring programs provide a comparison of measured values to modelled predictions and will either validate the assumptions used in modelling, indicate a need for re-evaluation, or trigger adaptive measures, such as alternative mitigation measures or changes to operational procedures.

3.1 (g) Decommissioning of older waste rock sites and the development of new tailings management capacity

Over the last two decades, the Canadian approach to waste rock management has evolved to current best practices that include segregation, design for decommissioning and long-term performance models. Due to the large volumes of handled waste rock, the rock must be segregated while it is mined and then managed according to the long-term performance modelling to provide future environmental protection. Prior to mining, a waste rock segregation plan is developed based on *in situ* evaluation and waste rock characterization studies. During mining, qualified persons perform segregation by using radiometric methods, including probing of blast holes, scanning of blast cuttings, overhead truck scanning, hand scanning of the work faces with scintillation or Geiger counters, and geological interpretation. Recent years have seen advances in the use of field X-ray fluorescence analyzers to aid in segregating waste rock based on analyses of contaminants of potential concern.

Since the Third Review Meeting, Canada has made progress in validating model predictions of long-term performance by implementing follow-up programs to validate predictions made in the project environmental assessments. For example, post-placement characterization of segregated waste rock in open pits is conducted to validate contaminant source concentrations, and groundwater monitoring information from the operating period is evaluated to validate post-placement model predictions of contaminant transport. Canada has also made progress in developing long-term management plans for some older waste rock piles which predate good segregation methods. Long-term management plans at decommissioned sites have included sloping, revegetation, the design and implementation of engineered covers, and the installation of infiltration and groundwater monitoring systems.

As with waste rock management, tailings management practices for the current generation of uranium mills in Canada have also evolved. As reported in the Third Review Meeting, all three Saskatchewan uranium mills (Rabbit Lake, Key Lake and McClean Lake sites) have converted mined-out open pits into engineered tailings management facilities (TMFs). The understanding of long-term tailings properties has enabled the development and validation of long-term performance models of decommissioned tailings management facilities. At decommissioned sites, follow-up field measurements and post-closure modelling of decommissioned tailings areas are conducted in order to confirm tailings areas are performing as predicted in the original environmental assessments. Ongoing tailings evaluation programs are used at active sites during the operational period in order to optimize the tailings preparation and placement processes and validate predictions of tailings properties. Additionally, groundwater and contaminant transport models are developed and maintained for the tailings management areas.

The development of new capacity continues to be a current challenge with regard to tailings management. When new capacity is required, options such as the use of an existing pit for in-pit tailings disposal, expansion of an existing TMF, or the construction of a purpose-built TMF are considered, and, following a rigorous regulatory environmental review process, the optimal method is chosen for the site.

3.1 (h) Continued implementation and ongoing funding requirements for AECL CRL (Nuclear Legacy Liability Program)

Canada's "nuclear legacy liabilities" have resulted from 60 years of nuclear research and development carried out on behalf of the Government of Canada by the Natural Research Council (NRC) and AECL. These liabilities are largely located at AECL research sites and consist of shutdown research buildings (including several prototype and research reactors), a wide variety of buried and stored wastes, and contaminated lands. The shutdown buildings and contaminated lands need to be safely decommissioned, to meet federal regulatory requirements, and long-term solutions need to be developed and implemented to manage the wastes.

About 70 percent of the liabilities are located at AECL's CRL in Ontario. A further 20 percent are located at AECL's Whiteshell Laboratories site, in Manitoba, which is being decommissioned. The remaining 10 percent relate largely to three shutdown prototype reactors in Ontario and Quebec, which are in a storage-with-surveillance state. The inventory of legacy waste includes spent fuel, and intermediate- and low-level solid and liquid radioactive waste. Most of the waste is in an unconditioned form, and limited characterization information is available for the waste generated in past decades.

In 2006, the Government of Canada adopted a new long-term strategy to deal with the nuclear legacy liabilities over a 70-year period. The overall objective of the long-term strategy is to safely and cost-effectively reduce the liabilities and associated risks by applying sound waste management and environmental principles in the best interests of Canadians. The estimated cost to implement the strategy over 70 years is about $7 billion (current Canadian dollars).

Implementation of the long-term strategy was initiated in 2006 with a $520 million (Canadian dollars) commitment by the Government of Canada to fund the start-up phase of the Nuclear Legacy Liabilities Program (NLLP). The program is being implemented through a Memorandum of Understanding between NRCan and AECL whereby NRCan is responsible for policy direction and oversight, including control of funding, and AECL is responsible for carrying out the work and holds and administers the licences, facilities, land, materials and other asset responsibilities. The NLLP is now in its sixth year of implementation, with funding of $129 million in fiscal year 2011-12. (More information on the NLLP is available at nuclearlegacyprogram.ca)

3.1 (i) Finalization of the regulatory approval process for the low- and intermediate-level waste deep geological repository

Canada's *Third National Report* noted that OPG had initiated an environmental and regulatory approvals process to develop a long-term approach for the current and future low- and intermediate-level radioactive waste from its 20 CANDU reactors. To start construction, a site preparation and construction licence will be required from the CNSC, and this must be preceded by the approval of an environmental assessment. The CEA Agency and the CNSC are in the process of establishing a Joint Review Panel to review both the environmental assessment and the licence application. Following public hearings, the Joint Review Panel will prepare a report on the environmental assessment and that report will be submitted to the Government of Canada's Governor in Council. Once the Governor in Council has issued its response to the report, the members of the Joint Review Panel will act as a Commission Tribunal and decide whether to issue the required licence. Further information on OPG's DGR can be found in section K.6.1.

4.0 Conclusion

Spent fuel and radioactive waste in Canada are currently managed in storage facilities that are safe, secure and environmentally sound. Canada recognizes that enhanced long-term management approaches will be required for its spent fuel and radioactive waste. This *Fourth National Report* identifies several key initiatives that demonstrate Canada's commitment to identifying and implementing long-term management approaches that do not place an undue burden on future generations.

Section A – Introduction

A.1 Scope of the section

This section is a general introduction to the main themes of the report.

A.2 Introduction

The Government of Canada has jurisdiction over nuclear energy, and Natural Resources Canada (NRCan) is the department responsible for nuclear energy policy. The Government of Canada has long funded nuclear research and supported the development and use of nuclear energy and related applications. As a result of this investment:

- nuclear energy now supplies about 15 percent of Canada's electricity

- the nuclear industry is a significant contributor to the Canadian economy, currently generating several billion dollars in economic activity and accounting for more than 30,000 highly skilled jobs

- Canada is one of the world's largest suppliers of uranium, which continues to rank among the top 10 metal commodities in Canada for value of production

In May 2009, after in-depth review, the Government of Canada announced that it would restructure Atomic Energy of Canada Limited (AECL), guided by three policy objectives: i) to ensure safe, reliable and economic options to address Canada's energy and environmental needs; ii) to control costs to the Government while maximizing the return on the Government's investment in nuclear energy; and iii) to position Canada's nuclear industry and its workforce to seize domestic and global opportunities. In 2011, the Government announced that an agreement between AECL and SNC-Lavalin Group Inc. (SNC-Lavalin) for the sale of AECL's CANDU Reactor Division assets.

Radioactive waste has been produced in Canada since the early 1930s, when the first radium and uranium mine opened in Port Radium, Northwest Territories. Pitchblende ore was transported from the Port Radium mine to Port Hope, Ontario, where it was refined to produce radium for medical purposes and, later, uranium for nuclear fuel and military applications. Research and development on the application of nuclear energy to produce electricity began in the 1940s at CRL. At present, radioactive waste is generated in Canada from the various stages and uses associated with the nuclear fuel cycle:

- uranium mining and milling
- refining and conversion
- nuclear fuel fabrication
- nuclear reactor operations
- nuclear research
- radioisotope manufacture and use

The Government of Canada gives high priority to the safety of persons and the protection of the environment from the various operations of the nuclear industry and has put in place modern legislation that provides the basis for Canada's comprehensive and robust regulatory regime. Canada's nuclear regulatory body is the Canadian Nuclear Safety Commission (CNSC). In addition to NRCan and the CNSC, the major Government of Canada organizations involved in the Canadian nuclear industry include:

- **Health Canada (HC)**: HC recommends radiological protection standards and monitors occupational radiological exposures

- **Transport Canada (TC)**: TC develops and administers policies, regulations and services for the Canadian transportation system, including the transportation of dangerous goods.

- **Environment Canada (EC)**: EC contributes to sustainable development through pollution prevention, to protect the environment and human life and health from the risks associated with toxic substances. EC is responsible for the administration of the *Canadian Environmental Protection Act* (CEPA).

- **Canadian Environmental Assessment Agency (CEA Agency)**: The CEA Agency works to provide Canadians with high-quality environmental assessments that contribute to informed decision-making in support of sustainable development. The CEA Agency is responsible for the administration of the *Canadian Environmental Assessment Act* (CEA Act) and its regulations.

- **The Major Projects Management Office (MPMO)**: The MPMO provides overarching project management and accountability for major resource projects in the federal regulatory review process and for facilitating improvements to the regulatory system for major resource projects. The MPMO serves as the single point of entry into the federal regulatory process for all stakeholders. It also works collaboratively with other departments and agencies where the federal regulatory process for major resource projects can be improved, both in the short and long term.

Other federal and provincial departments are involved to a lesser extent. Annex 1 provides detailed descriptions of these departments.

The *Nuclear Energy Act* (NEA), the *Nuclear Safety and Control Act* (NSCA), the *Nuclear Fuel Waste Act* (NFWA) and the *Nuclear Liability Act* (NLA) are the centrepieces of Canada's legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation that ensures the safety of the nuclear industry and radioactive waste management in Canada. A detailed description of this legislative and regulatory framework is provided in annex 2.

A.3 Nuclear substances

Under the NSCA, the CNSC regulates nuclear substances in order to protect human health and the environment. The nuclear substances defined in the NSCA include any radioactive substance, plus deuterium, or any of their compounds as well as any substance that regulations define as being required for the production or use of nuclear energy.

Both radioactive waste and spent fuel contain nuclear substances and therefore are regulated in the same manner as any other nuclear substance. Section B.5 describes the policy on managing spent fuel and radioactive.

A.4 Canadian philosophy and approach to safety

Canada actively promotes and regulates safety within the nuclear sector. Canada's approach is based upon several factors, including the review of international standards, (e.g., International Atomic Energy Agency (IAEA) standards and guides), improvements to regulatory policies and standards (e.g., regulatory policy P-299, *Regulatory Fundamentals*). Canada considers the adoption of international recommendations, such as those regarding radiological dose limits to the public and workers in the International Commission on Radiological Protection (ICRP) publication, *Recommendations of the International Commission on Radiological Protection* (ICRP-60, 1990), as well as protection of the environment. For example, limits for controlled release of gaseous or liquid effluents or solid materials are adopted from complementary regulatory regimes (such as Ontario's Provincial Water Quality Objectives or Metal Mining Limits for Liquid Effluent Releases), or derived from specific licence conditions (such as the derived release limits). The CNSC may also adopt other standards, established by organizations such as the Canadian Standards Association (CSA), or the American Society of Mechanical Engineers (ASME).

The Commission Tribunal sets the standards and conditions; it is then the responsibility of the person in possession of the associated nuclear substance, or the operator of the associated facility, to ensure the safety. For example, it is the licensee's responsibility to demonstrate to the satisfaction of the regulatory body that a spent fuel facility or radioactive waste management facility can and will be operated safely throughout the lifetime of the facility. The regulatory regime is flexible about how licensees comply with regulatory requirement. The licensee must demonstrate how the design meets all applicable performance standards and will continue to do so throughout its design life.

A.5 Fundamental principles

The Canadian regulatory approach to the safety of spent fuel and radioactive waste management is based on three principles:

- lifecycle responsibility and licensing
- in-depth defence
- multiple barriers

A.6 Main safety issues

The two main safety issues that this report addresses are interim storage and long-term management of waste from past practices.

Currently, interim storage is being conducted in a safe manner. The Canadian nuclear industry and the Government of Canada are developing long-term waste management solutions that will protect health, safety, security and the environment. Key initiatives underway are described in section K of this report. Some of the most important challenges will be to bring these initiatives to fruition and develop and implement appropriate long-term solutions that have the public’s confidence.

The long-term management of waste from past practices has presented the federal and provincial governments with challenges to developing and implementing appropriate remedial strategies and long-term waste management solutions. Several initiatives have been completed or are underway to address theses sites, as described in sections H.6.1 and K.6.3.

A.7 Survey of the main themes

The main themes in this report are as follows:

- Canadian government departments and agencies and the nuclear industry have roles and responsibilities – confirmed in the 1996 *Radioactive Waste Policy Framework* – to ensure the safe management of spent fuel and radioactive waste.

- The primary responsibility for safety rests with the licensees. All licensees take their responsibility for safety seriously and are able to raise adequate revenue to support safe operations.

- The Canadian safety philosophy and requirements, applied through the regulatory process, ensure that the risk to the workers, the public and the environment that is associated with the operation of spent fuel management and radioactive waste management is kept as low as reasonably achievable (ALARA), social and economic factors taken into consideration.

- The Canadian regulatory body has sufficient independence, authority and resources to ensure compliance with and enforcement of regulatory safety requirements that pertain to the management of spent fuel and radioactive waste.

- Industry and various levels of government are engaged in a number of initiatives to develop and implement long-term solutions for spent fuel and radioactive waste, as well as cleanup of wastes from past practices such as uranium mining and processing.

Section B – Policies And Practices

B.1 Scope of the section

This section addresses Article 32 (Reporting) (1) of the Joint Convention and provides information on Canada's policies and practices concerning spent fuel and radioactive waste management.

B.2 Introduction

Under the current legislative and regulatory framework, spent fuel is considered to be another form of radioactive waste. As a result, legislation and policies on managing radioactive waste apply equally to spent fuel and other forms of radioactive waste.

B.3 Legislative instruments

Federal legislation that regulates and oversees the nuclear industry, including the management of radioactive waste and spent fuel, comprises the NSCA, NFWA, NLA, and the NEA (described in annex 2). The nuclear industry is also subject to the CEA Act, the CEPA and the *Fisheries Act*.

A number of Government of Canada departments are involved in administering these legislative instruments. Where multiple regulators are involved, the CNSC establishes joint regulatory groups to coordinate and optimize the regulatory effort.

In addition, the nuclear industry is subject to the provincial acts and regulations in force within the individual provinces and territories where nuclear-related activities are carried out. Where there is an overlap of jurisdictions and responsibilities, the CNSC takes the lead in efforts to harmonize the regulatory activities, including joint regulatory groups which involve provincial regulators.

B.4 National framework for radioactive waste management

The 1996 Government of Canada *Policy Framework for Radioactive Waste* sets the stage for institutional and financial arrangements to manage radioactive waste in a safe, comprehensive, environmentally sound, integrated and cost-effective manner. The *Policy Framework for Radioactive Waste* specifies that:

- the Government of Canada is responsible for developing policy and regulating and overseeing radioactive waste producers and owners so that they meet their operational and funding responsibilities in accordance with approved long-term waste management plans

- waste producers and owners are responsible, in accordance with the "polluter pays principle", for funding, organizing, managing and operating long-term waste management facilities and other facilities required for their waste

The policy framework recognizes that arrangements may be different for the four broad categories of radioactive waste found in Canada, namely spent fuel waste, low- and intermediate-level radioactive waste and uranium-mine waste rock and mill tailings.

The Canadian Institutional Framework is shown in figure B.1.

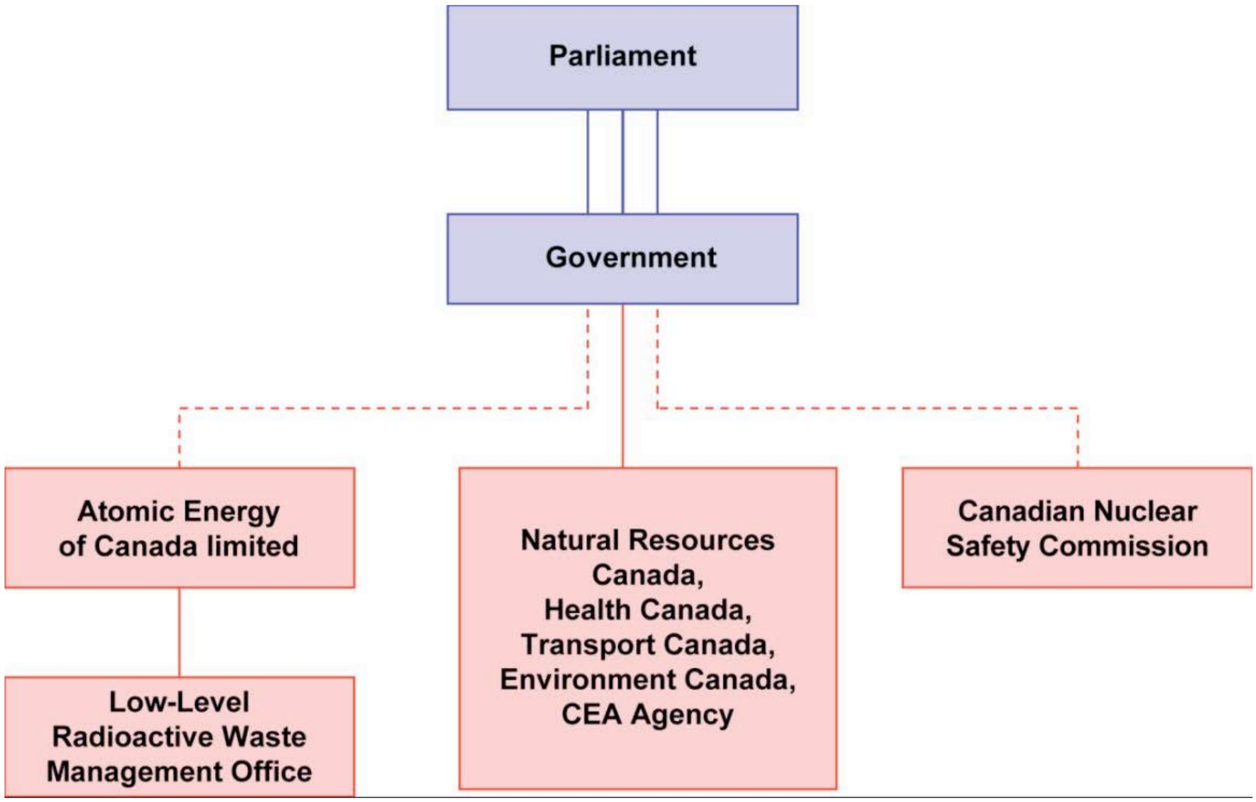

Figure B.1 – The Canadian Institutional Framework

NRCan is the lead Government department responsible for developing and implementing uranium, nuclear energy and radioactive waste management policies. It also administers the *Nuclear Fuel Waste Act* (NFWA) and has overall responsibility for the management of historic waste. The latter term refers to wastes that were managed in the past in a manner no longer considered acceptable, for which the current owner cannot be reasonably held responsible, and for which the Government of Canada has assumed responsibility for long-term management.

Several other federal departments have been assigned roles and responsibilities related to the safe management of spent fuel and radioactive waste, including Health Canada (HC), Environment Canada (EC) and the CEA Agency. (Additional information on all these departments and organizations, as shown in figure B.1, is provided in annex 1.)

AECL and the CNSC are connected to the Government with dashed lines to illustrate their arms-length relationships. They both report to Parliament through a Minister within the Government. AECL is a Crown corporation, owned entirely by the Government of Canada and run by a Board of Directors. AECL's mandate includes the management of the waste it generates from ongoing research, legacy radioactive waste and decommissioning liabilities on its properties, as well as for the waste it accepts for long-term management from non-utility radioactive waste producers across Canada on a fee-for-service basis. AECL also staffs and manages the Low-Level Radioactive Waste Management Office (LLRWMO), which is the national agent for the cleanup and management of Canada's historic waste. The LLRWMO is operated via a Memorandum of Understanding between NRCan and AECL, whereby NRCan provides the funding and policy direction for the LLRWMO.

Historic low-level waste is waste which was managed in the past in a manner that is no longer considered acceptable and for which the current owner cannot be reasonably held responsible; the Government of Canada has accepted responsibility for long-term management of this waste.

Legacy wastes (in the Canadian context) specifically date back to the Cold War and birth of nuclear technologies in Canada; these wastes are located at AECL sites. In addition, there is an initiative to remediate certain Cold War era mine and mill sites in northern Saskatchewan at the Gunnar mine and mill site (see appendix 8 for more information).

The CNSC is Canada's independent nuclear regulatory body. Its mission is to regulate the use of nuclear energy and materials to safeguard the health, safety and security of the public, protect the environment and implement Canada's international commitments on the peaceful use of nuclear energy. The CNSC's regulatory decision process is fully independent from the Government of Canada.

B.5 Regulatory policy on managing spent fuel and radioactive waste

The CNSC issued regulatory policy P-290, *Managing Radioactive Waste,* in July 2004, following extensive consultation with the public and industry stakeholders. The policy outlines the philosophy and six principles that govern the CNSC's regulation of radioactive waste. It is fully consistent with the federal *Policy Framework for Radioactive Waste.* The CNSC regulatory policy P-290 identifies the need for long-term management of radioactive and hazardous waste that arises from licensed activities.

The policy statement in regulatory policy P-290 defines radioactive waste as any form of waste material that contains a nuclear substance defined in the NSCA. This definition is sufficiently comprehensive to include spent fuel without any other special consideration. The policy indicates that, when making regulatory decisions concerning the management of radioactive waste, the CNSC will seek to achieve its objectives by considering certain key principles, in the context of the facts and circumstances of each case, as follows:

1. The generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices.

2. The management of radioactive waste is commensurate with its radiological, chemical and biological hazard to the health and safety of persons, to the environment and to national security.

3. The assessment of future impacts of radioactive waste on the health and safety of persons and environment encompasses the period of time when the maximum impact is predicted to occur.

4. The predicted impacts on the health and safety of persons and the environment from the management of radioactive waste are no greater than the impacts that are permissible in Canada at the time of the regulatory decision.

5. The measures needed to prevent unreasonable risk to present and future generations from the hazards of radioactive waste are developed, funded and implemented as soon as reasonably practicable.

6. The transborder effects on the health and safety of persons and the environment, which could result from the management of radioactive waste in Canada, are not greater than the effects experienced in Canada.

The differences between spent fuel and other forms of radioactive waste are addressed by the application of the second principle described above, indicating that wastes are expected to be managed according to their hazard.

The principles contained in regulatory policy P-290 are consistent with those recommended by the IAEA in Safety Series 111-F, *The Principles of Radioactive Waste Management*. The P-290 policy statement recognizes the regulatory body's commitment to optimizing regulatory effort, as indicated by the following statement:

"It is also the policy of the CNSC to consult and cooperate with provincial, national and international agencies to:

- "promote harmonized regulation and consistent national and international standards for the management of radioactive waste, and

- "achieve conformity with the measures of control and international obligations to which Canada has agreed concerning radioactive waste."

B.6 Regulatory guide G-320: *Assessing the Long Term Safety of Radioactive Waste Management*

Published in December 2006, regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*, helps licensees and applicants assess the long-term impact that radioactive waste storage and disposal methods have on the environment and the health and safety of people. Specifically, the guide addresses:

- assessment approaches, structures and methodologies
- level of detail of assessments
- confidence to be placed in assessment results
- application of radiological and non-radiological criteria
- definition of critical groups for impact assessments
- selection of timeframes for impact assessments
- setting of post-decommissioning objectives
- long-term care and maintenance considerations
- use of institutional controls

However, it does not address social acceptability or economic feasibility of long-term management methods or the assessment of facility operations. A copy of the guide is available at nuclearsafety.gc.ca

B.7 Classification of radioactive waste in Canada

Established in 1919, the Canadian Standards Association (CSA) is a not-for-profit organization composed of representatives from government, industry and consumer groups. Its primary product is safety and performance standards, including those for electrical, electronic and industrial equipment, boilers and pressure vessels, compressed gas handling appliances, and environmental protection and construction materials. The association also provides training materials and information products. CSA developed the CAN/CSA Z299 series of quality assurance standards, which are still used today and represent an alternative to the ISO 9000 series of quality standards.

As reported in the *Third National Report*, the CSA – in collaboration with industry, government and the CNSC – developed a standard that includes a radioactive waste classification system, CSA 293.3-08, which takes into account IAEA Safety Guide DS-390, *Radioactive Waste Classification,* and the needs of the Canadian industry. The standard was published in March 2008. The radioactive waste classification system described below recognizes four main classes of radioactive waste:

- high-level radioactive waste (see section B.7.1)
- intermediate-level radioactive waste (see section B.7.2)
- low-level radioactive waste (see section B.7.3)
- uranium mine and mill waste (see section B.7.4)

Sub-classes for low-level wastes are also identified to provide better guidance on the appropriate waste management needs.

Organization of classification system

The waste-classification system is organized according to the degree of containment and isolation required to ensure safety in the short and long term. It also takes into consideration the hazard potential of different types of radioactive waste.

A definitive numerical boundary between the various categories of radioactive waste (primarily low- and intermediate-level) cannot be provided, since activity limitations differ between individual radionuclides or radionuclide groups and will be dependent on both short- and long-term safety-management considerations. For example, a contact dose rate of 2 millisieverts per hour (mSv/h) has been used, in some cases, to distinguish between low-and intermediate-level radioactive waste.

The following sections provide an overview of the four main classes of radioactive waste in Canada:

B.7.1 High-level radioactive waste (HLW)

High-level radioactive waste (HLW) is used (irradiated) nuclear fuel that has been declared radioactive waste or waste that generates significant heat (typically more than two kW per cubic metre) via radioactive decay. In Canada, irradiated nuclear fuel or used nuclear fuel is a more accurate term for spent fuel, as discharged fuel is considered a waste material even when it is not fully spent. In spite of the name difference, the term “spent fuel” is meant in this report to be consistent with the terminology “spent fuel” of the Joint Convention.

Spent fuel is associated with penetrating radiation, which requires shielding. Furthermore, spent fuel contains significant quantities of long-lived radionuclides, meaning that long-term isolation is also required. Waste forms derived from spent fuel (e.g., nuclear fuel reprocessing wastes) can exhibit similar characteristics and may be considered HLW.

Placement in deep, stable geological formations is considered to be the preferred option for the long-term management of HLW.

B.7.2 Intermediate-level radioactive waste (ILW)

Intermediate-level radioactive waste (ILW) is waste that typically exhibits sufficient levels of penetrating radiation to warrant shielding during handling and interim storage. This type of radioactive waste generally requires little or no provision for heat dissipation during its handling, transportation and long-term management. However, because of its total radioactivity level, some ILW may have heat generation implications in the short term (e.g., refurbishment waste).

Identification of ILW

ILW generally contains long-lived radionuclides in concentrations that require isolation and containment for periods beyond several hundred years (e.g., beyond 300 to 500 years). IWL would also include alpha-bearing radioactive waste (wastes containing one or more alpha-emitting radionuclides, usually actinides) in quantities above the levels acceptable for near surface repositories.

ILW is sometimes subdivided into short-lived (ILW-SL) and long-lived (ILW-LL), depending on the quantity of long-lived radionuclides present.

B.7.3 Low-level radioactive waste (LLW)

Low-level radioactive waste (LLW) contains material with radionuclide content above established clearance levels and exemption quantities, and generally limited amounts of long-lived activity. LLW requires isolation and containment for up to a few hundred years. LLW generally does not require significant shielding during handling and interim storage.

Very-short-lived low-level radioactive waste (VSLLW)

Very-short-lived low-level radioactive waste (VSLLW) is waste that can be stored for decay for up to a few years and subsequently cleared for release. This classification includes radioactive waste containing only short half-life radionuclides, of the kind typically used for research and biomedical purposes. Examples of VSLLW are iridium-192 and technecium-99m sources and industrial and medical radioactive waste that contains similar short half-life radionuclides.

Generally, the main criterion for VSLLW is the half-life of the predominant radionuclides. In practice, the management of VSLLW should only be applied to radionuclides with a half-life of 100 days or less.

Very-low-level radioactive waste (VLLW)

Very-low-level radioactive waste (VLLW) has a low hazard potential, but is nevertheless above the criteria for exemption. Long-term waste management facilities for VLLW do not usually need a high degree of containment or isolation. A near surface repository with limited regulatory control is generally suitable. Typically, VLLW includes bulk material, such as low-activity soil and rubble, decommissioning wastes and some uranium-contaminated wastes.

B.7.4 Uranium mine and mill waste

Uranium mine waste rock and mill tailings are a specific type of radioactive waste generated during the mining and milling of uranium ore and the production of uranium concentrate. In addition to tailings, mining activities typically produce large quantities of mineralized and unmineralized waste rock excavated to access the ore body. The tailings and mineralized waste rock contain significant concentrations of long-lived radioactive elements, namely thorium-230 and radium-226.

B.8 Operational responsibilities for long-term management

While numerous government departments, agencies, hospitals, universities and industry members are involved in the management of radioactive waste, only a limited number of organizations are involved in long-term management. Figure B.2 shows the organizations responsible for the long-term management of spent fuel and radioactive waste in Canada.

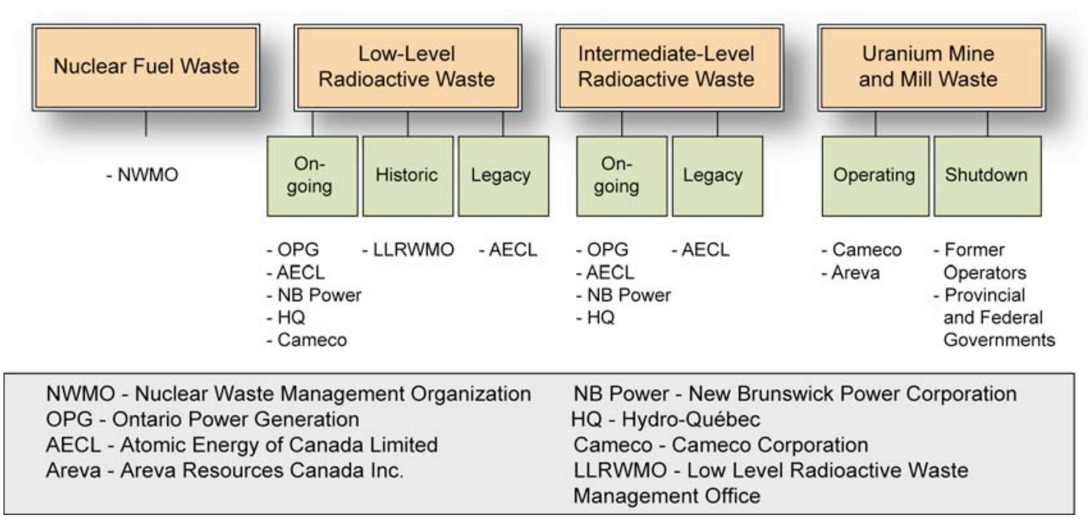

Figure B.2 – Organizations responsible for the long-term management of spent fuel and radioactive waste

The NWMO is responsible for implementing the Government of Canada's APM approach to the long-term management of spent fuel. (See sections G.17 and K.4.)

OPG, NB Power and Hydro-Québec (HQ) are responsible for the long-term management of low- and intermediate-level radioactive waste generated from nuclear reactor operations. This includes the spent fuel generated at their respective reactor sites until the NWMO is ready to accept the waste for management in facilities constructed under the APM approach. OPG is also responsible for the long-term management of low- and intermediate-level waste and spent fuel generated at the Bruce Power Nuclear Generating Station. (Refer to section K.6.1 for information on OPG's Deep Geologic Repository for the long-term management of its low- and intermediate-level waste.)

AECL is responsible for the long-term management of low- and intermediate-level radioactive waste generated by Whiteshell Laboratories, CRL and the three partially decommissioned prototype reactors (Gentilly-1, Nuclear Power Demonstration (NPD) and Douglas Point), as well as for the low- and intermediate-level waste it accepts from other

Canadian licensees on a fee-for-service basis. AECL is responsible for spent fuel, including research reactor fuel, until the NWMO is ready to accept the waste for management in facilities constructed using the APM approach, as well as for spent CANDU fuel sent to its laboratories for examination. (For information on AECL's long-term waste management strategy for its low- and intermediate-level waste, refer to section K.6.2.)

The AECL-LLRWMO manages historic waste on behalf of the Government of Canada. (See sections H.6.1, K.6.2 and K.6.3.)

Cameco and AREVA manage the only operating uranium mines and mills in Canada (see annex 6). Inactive uranium mines and mills sites are located in Ontario, the Northwest Territories and Saskatchewan, as described in annexes 7 and 8.

The term "inactive" is used to describe several different types of inventories, including:

- tailings sites that are currently being decommissioned (e.g., Cluff Lake)
- tailings sites at operating mill sites where closure activities are in progress (e.g., Rabbit Lake and Key Lake)
- tailings sites at former milling locations; these include recently decommissioned sites with engineered tailings containment systems, such as some of the Denison Mines and Rio Algom sites in the Elliot Lake area, as well as sites that date back to the earliest era of nuclear energy production in Canada, when tailings were deposited in lakes or low areas near lakes (e.g., Port Radium)

All of these inactive sites are either already licensed by the CNSC or in the process of becoming licensed. Thus, the site owners are responsible for monitoring and any future remedial work that may be required to protect human health and safety or the environment. Two former uranium mine tailings sites in Saskatchewan have yet to be fully decommissioned: the Gunnar and Lorado sites. The provincial government will decommission the sites, as described in annex 8.1.1.2.

B.9 Management practices for spent fuel

Spent fuel consists of irradiated fuel bundles removed from commercial, prototype and research nuclear reactors. Three provincial nuclear utilities, namely OPG, HQ and NB Power, own about 98 percent of the spent fuel in Canada. AECL owns the remaining two percent. Spent fuel waste includes nuclear fuel waste, as well as any research reactor fuel waste that is not in the form of a CANDU fuel bundle.

Canada does not have a long-term waste management facility for spent fuel. All spent fuel is currently held in interim wet or dry storage at the generating stations where it is produced. Spent fuel discharged from CANDU reactors is placed into special wet storage bays for several years, depending on site-specific needs, and is eventually transferred to an interim dry storage facility. Three designs of dry storage containers are used in Canada:

- AECL silos
- AECL MACSTOR
- OPG dry storage containers

(For a complete description of these dry storage containers, refer to annex 4.)

To address the long-term management of spent fuel, the three major waste owners – OPG, HQ and NB Power – established the NWMO in 2002 under the NFWA.

The NWMO's first mandate was to study options for the long-term management of spent fuel and recommend a management option to the Government of Canada by November 15, 2005. In 2005, the NWMO completed its study and recommended the APM approach to the Government of Canada, the end-point of which is a deep repository in an appropriate geological formation. On June 14, 2007, the Government adopted the NWMO's recommendation.

Following this decision, the NWMO assumed responsibility for implementing the APM. (For a full description of this long-term management plan for Canada's spent fuel, refer to sections G.17 and K.4.)

B.10 Management practices for low- and intermediate-level radioactive waste

In Canada, low- and intermediate-level radioactive waste refers to all forms of radioactive waste, except for spent fuel and waste derived from uranium and thorium mining and milling.

OPG, which owns 20 of Canada's 22 CANDU reactors, is responsible for approximately 77 percent of the low- and intermediate-level radioactive waste generated in Canada annually. AECL produces approximately 17 percent of the annual volume through its research and development activities at CRL and onsite decommissioning activities. AECL also accepts low- and intermediate-level radioactive waste from a number of small producers and users of radioactive materials for long-term management, which amounts to a further three percent of Canada's annual volume. The other two CANDU reactors (owned by NB Power and HQ) and Cameco Corporation's uranium processing and conversion facilities in Ontario generate the majority of the remaining waste. The owners of low- and intermediate-level radioactive waste all manage and operate storage facilities for their wastes. In addition, the two major waste owners, OPG and AECL, are pursuing long-term management solutions.

With regard to electricity generation, OPG's low- and intermediate-level radioactive waste from its CANDU reactors is safely stored in a central location at the Western Waste Management Facility at the Bruce nuclear site in Kincardine, Ontario. OPG entered into an agreement with the Municipality of Kincardine on October 13, 2004, to host a deep geological repository designed to hold current and future low- and intermediate-level radioactive waste from OPG and Bruce Power's 20 CANDU reactors. (More information on this initiative is provided in section K.6.1.) NB Power and HQ have their own facilities for the storage of low- and intermediate-level radioactive waste at their reactor sites.

Regarding research and development, AECL has waste storage facilities at its two laboratory sites – CRL and Whiteshell Laboratories, as well as at its three prototype reactor sites. Operational storage facilities include the Bulk Materials Landfill (BML) for dewatered sewage sludge, modular above ground storage structures (MAGS), shielded modular above ground storage (SMAGS) structures, concrete bunkers and tile holes. AECL also accepts low- and intermediate-level radioactive waste from small generators, such as hospitals, universities and small industries, on a fee-for-service basis.

As described in section K.6.2, the Government of Canada initiated the Nuclear Legacy Liabilities Program (NLLP) to deal with legacy radioactive waste and decommissioning liabilities at AECL sites. The program involves developing and constructing the infrastructure required to characterize, condition, treat, process, package and store legacy waste and implement long-term solutions. The low- and intermediate-level radioactive waste that AECL's ongoing operations generate, as well as that accepted from third party generators, will also be managed in these facilities. The NLLP is now in its sixth year of implementation, with funding of $129 million in fiscal year 2011-12. Program progress and achievements during the last three years of implementation are summarized in sections K.6.2.1 to K.6.2.3.

Radioactive waste from hospital nuclear medicine departments and universities and similar facilities contains only small amounts of radioactive materials with short half-lives. The radioactivity of this waste normally decays within hours, days or months. Institutions such as hospital nuclear medicine departments and universities have implemented delay-and-decay programs, after which waste can be treated using conventional means.

Canada has significant volumes of LLW, referred to as historic waste, which was once managed in the past in a manner that is no longer considered acceptable and for which the current owner cannot be reasonably held responsible. Canada's historic waste inventory consists largely of radium- and uranium-contaminated soils. The Government of Canada has accepted responsibility for the long-term management of this waste.

The bulk of Canada's historic LLW is located in the southern Ontario communities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 1.7 million cubic metres and relate to the historic operations of a radium and uranium refinery in the Municipality of Port Hope dating back to the 1930s. While the LLW materials under management do not pose an immediate unacceptable risk to human health and the environment, there is general consensus in the local community, as well as in professional and regulatory communities, that the *in situ* management systems presently implemented are not a suitable long-term solution.

In March 2001, the Government of Canada and the local municipalities agreed to community-developed proposals as potential solutions for the cleanup and long-term management of low-level radioactive wastes in the Port Hope area, thereby launching the Port Hope Area Initiative (PHAI). (The PHAI and other initiatives that deal with historic waste are described in section K.6.3.)

The LLRWMO continues to ensure the safe management of the LLW until the implementation of the PHAI is complete. At some sites, decontamination has proven to be technically and economically feasible. The management methods used included packaging the LLW in drums and consolidating the material into engineered, above ground containment cells on access-controlled sites. Regular inspection and monitoring verify the continued safety of these sites.

At this time, the LLRWMO is putting a strategy in place to address historic wastes in Canada's North. This contamination is located at several sites along what is known as the Northern Transportation Route, extending 2,200 km through lakes, rivers, and portages from Port Radium, Northwest Territories to Fort McMurray, Alberta. The LLRWMO is adapting methods of community engagement and technical approaches that have led to successful remediation projects in Canada's southern regions. Adjustments are being made to meet the realities of the North, including the challenges inherent in the need for understanding northern communities. Stakeholders are involved through community meetings, letters, individual emails and telephone calls. Engagement strategies are devised to accommodate various community needs, based on community input.

The success in the remediation of historic radioactive waste in communities across Canada has depended on building confidence with the involved communities in a deliberately incremental and careful process which has developed partnerships. Cultivating stakeholder involvement at an early stage was key in building the necessary confidence that would result in the implementation of cleanup solutions. It is important that partner organizations and stakeholders understand their roles and cooperate to solve problems (such as site preparation). To develop and maintain community confidence requires constant commitment, significant resources, and mutual effort and careful consideration of cultural sensitivities.

B.11 Management practices for uranium mine waste rock and mill tailings

Uranium mining and milling processes generate two major sources of radioactive waste: mine waste rock and mill tailings.

Over 200 million tonnes of uranium mill tailings have been generated in Canada since the mid-1950s. There are 25 tailings sites in Ontario, Saskatchewan and the Northwest Territories (figure B.3). Twenty-two of these sites no longer receive waste material. The three remaining operational tailings management facilities are located in Saskatchewan. The ore mined at McArthur River is transported to Key Lake for milling, as there are no tailings management areas at the McArthur Mine site. Both operational and inactive uranium tailings sites are the joint regulatory responsibility of the CNSC and the provinces and territories where the sites are located.

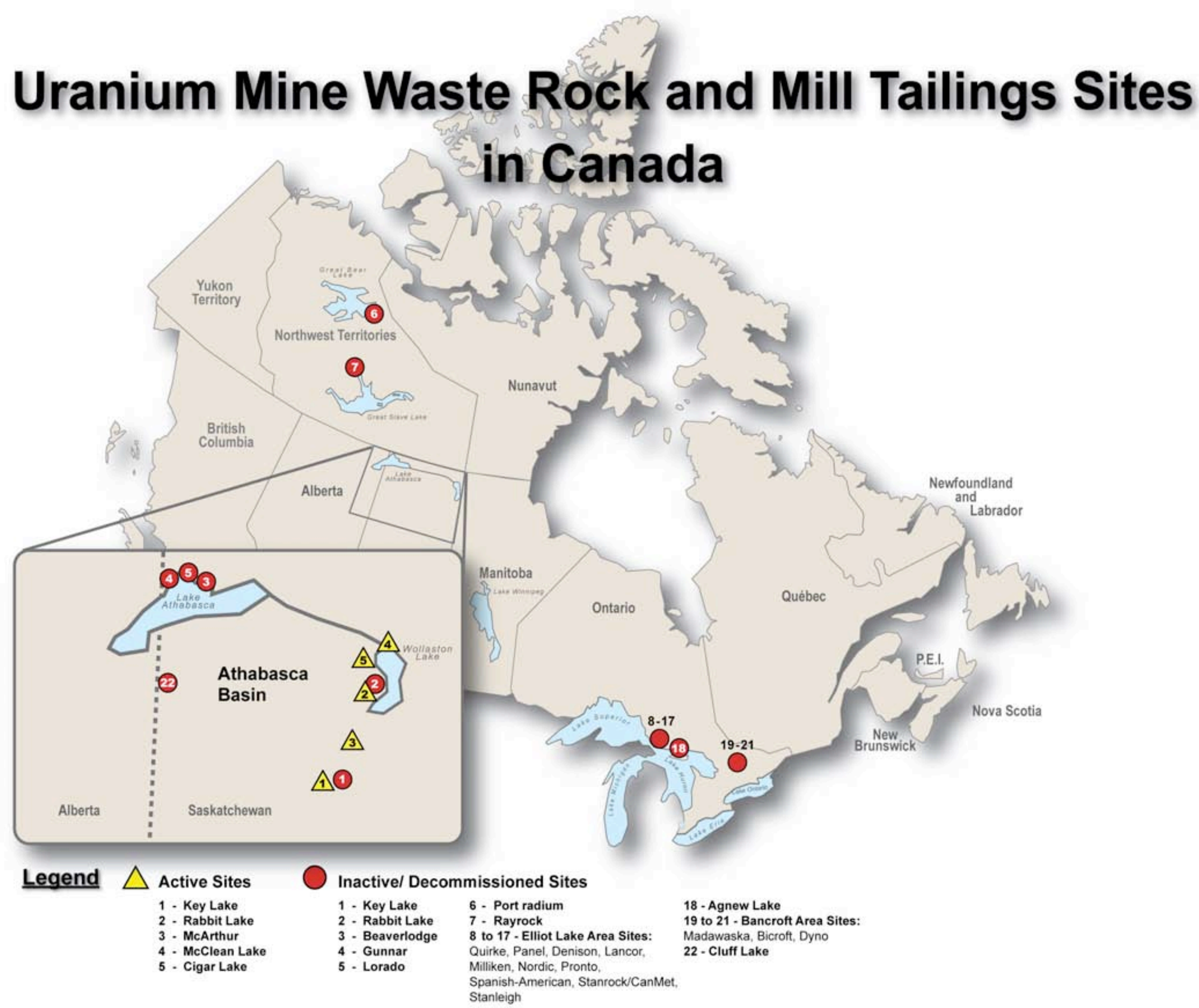

Figure B.3 – Location of operating, inactive/decommissioned sites

Historically, tailings were used as backfill in underground mines, deposited directly into lake basins or placed in low areas on the ground surface and confined by either permeable or water-retaining dams. Surface tailings could be left bare, covered with soil or flooded, and some bare or covered tailings may have been vegetated. In response to evolving regulatory requirements, the containment structures for surface tailings have become much more rigorously engineered for long-term storage and stability. Tailings management methods at operational facilities include chemically treating tailings to control their mineralogy prior to placing them in hydrostatically contained tailings management facilities, converted from mined-out open pits.

Contaminated industrial wastes are typically either recycled or landfilled at the site-specific tailings management facility. The quantities of contaminated industrial wastes are tracked and recorded; however, in the context of the overall site inventory of radioactive wastes, the actual amount of low specific activity material that would be contained in this volume is negligible and is effectively accounted for in the overall tailings quantity for each site.

In addition to the tailings produced from milling uranium ore, millions of cubic metres of waste rock are excavated to gain access to ore. At the Athabasca Basin open-pit sites, most of this waste rock is sandstone, which is environmentally benign and suitable for surface disposal. However, some of the waste rock contains either low-grade, uneconomic ore or significant concentrations of secondary minerals. If left exposed on the surface indefinitely, this "special waste rock" could generate acid or release contaminants at rates that could impact the local environment. The current method of managing special waste rock is to either blend it with high-grade ore for processing or isolate it from atmospheric conditions (e.g., locate it at the bottom of a flooded pit), thus keeping it in an environment similar to that from which it was mined and preventing oxidation reactions.

The inventory of nuclear substances in some inactive uranium tailings management areas can result in these areas being licensed as Class I nuclear facilities under the *Class I Nuclear Facilities Regulations*, pursuant to the NSCA. (Refer to section E.3.2.) This has implications for the licensing requirements and long-term management of such facilities. Those responsible for inactive tailings management areas with smaller inventories can be licensed for possession of nuclear substances. These inactive tailings disposal areas and facilities will remain under CNSC licence control in the absence of a suitable alternative. The Government of Saskatchewan, however, has developed such an alternative for decommissioned mining sites (not limited to uranium) on Crown land (see section H.10.3).

Current management practices for licensed facilities use a lifecycle planning process. A preliminary decommissioning plan and financial guarantees for decommissioning are integral to the licence approval process. All phases in the lifecycle of a facility are subject to the environmental assessment process.

Section C – Scope of Application

C.1 Scope of the section

This section addresses Article 3 (Scope of Application) of the Joint Convention. It provides Canada's position on reprocessing spent fuel, naturally occurring radioactive waste and military and defence programs.

C.2 Introduction

While neither the NSCA nor its associated regulations define radioactive waste, regulatory policy P-290, *Managing Radioactive Waste,* asserts that radioactive waste is "any liquid, gaseous or solid material that contains a nuclear substance, as defined in section 2 of the NSCA and for which the owner of the material foresees no further use and the owner had declared as waste. By definition, radioactive waste may contain non-radioactive constituents." Radioactive waste is therefore regulated in the same manner as all other materials that contain a nuclear substance. All radioactive waste, whether from a large nuclear facility or a small-scale user, is subject to the Joint Convention, with the exception of:

- reprocessed spent fuel
- naturally occurring radioactive materials
- radioactive waste generated by military and defence programs

C.3 Reprocessed spent fuel

Given Canada's large natural resource of uranium, the nuclear industry has not deemed it necessary to reprocess spent fuel at this time. Therefore, pursuant to Article 3(1) of the Joint Convention, Canada declares that reprocessing activities are not part of Canada's spent fuel management program and so are not included in this report. Note, however, that CRL did reprocess spent fuel in the 1940s to 60s to extract plutonium. The wastes from these activities are discussed in this report.

In accordance with Article 3(1), medical isotope production fuel is also excluded from the report because it is processed to extract isotopes, and so is outside the scope of the Joint Convention and protected from disclosure under Article 36.

C.4 Naturally occurring nuclear substances

Naturally occurring nuclear substances, other than those that are or have been associated with the development, production or use of nuclear energy, are exempt from the application of all provisions of the NSCA and its associated regulations, except:

- provisions that pertain to the transport of radioactive materials

- in the case of naturally occurring radioactive material listed in the schedule to the *Nuclear Non-proliferation Import and Export Control Regulations*, provisions that govern the import and export of radioactive materials

In accordance with Article 3(2) of the Joint Convention, only non-exempt naturally occurring radioactive substances are discussed in this report – namely radium-bearing wastes, resulting from the former radium industry, and tailings and waste rock from uranium mines and mills.

C.5 Department of National Defence programs

Although, under section 5 of the NSCA, the Department of National Defence's programs are not subject to the NSCA or its associated regulations, the Royal Military College of Canada (RMC) SLOWPOKE reactor is, because it is operated as a research reactor (see section H.3.6). Therefore, in accordance with Article 3(3), the RMC SLOWPOKE reactor is the only military or defence program to be addressed in this report.

C.6 Discharges

In accordance with Articles 3(4), 4, 7, 11, 14, 24 and 26 of the Joint Convention, the management facilities of spent fuel, radioactive waste and uranium mines and mills are regulated throughout their entire lifecycle – from site preparation and construction to operation, decommissioning and finally abandonment. At each licensing stage, operations must be carried out such that the dose to workers and the public is as low as reasonably achievable, given economic and social factors. Occupational and public radiological exposure limits derive from internationally accepted standards such as those of the ICRP.

In addition, an environmental monitoring program must be in place to ensure that all reasonable precautions are taken to protect the environment and control the release of radioactive and hazardous substances into the environment at each licensing stage. Limits on the controlled release of gaseous or liquid wastes or solid materials have been adopted from complementary regulatory regimes, such as Ontario's Provincial Water Quality Objectives or Metal Mining Limits for Liquid Effluent Releases, and derived from specific licence conditions, including the derived release limits.

For more information on discharges and ALARA, refer to section F.6. Radiological effluent discharge levels at licensed facilities are outlined in annexes 4 through 8.

Section D – Inventories and Lists

D.1 Scope of the section

This section addresses Article 32 (Reporting) (2) of the Joint Convention. It provides a list of the various spent fuel and radioactive waste management facilities in Canada and indicates the total inventory of each of the waste categories. Each licensee is required to develop and implement an accountability system, including the appropriate records. This system and associated records are subject to regulatory oversight. The requirements Safety Series 115 Part IV.17 are addressed in this section. Maps showing the location of radioactive waste management sites in Eastern, Central and Western Canada are attached in section D.4.

D.2 Inventory of spent fuel in Canada

D.2.1 Spent fuel wet storage inventory at nuclear reactor sites

Almost all nuclear generating stations and research reactor sites store spent fuel waste on site in irradiated fuel bays (wet storage), pending transfer to a dedicated spent fuel dry storage centre. Table D.1 inventories the number of spent fuel bundles in wet storage in Canada, and Table D.2 the spent fuel in dry storage.

Table D.1 – Inventory of spent fuel in wet storage in Canada as of December 31, 2010

Site	Number of fuel bundles in wet storage	Kilograms of uranium[4]
Bruce A and B Nuclear Generating Stations	735,060	14,071,675
Darlington Nuclear Generating Station	331,692	6,343,281
Gentilly-2 Nuclear Generating Station	31,197	594,124
Pickering A and B Nuclear Generating Station	406,365	8,063,824
Point Lepreau Nuclear Generating Station	40,758	782,674
McMaster Nuclear Reactor (MNR)	14[1]	12.8[4]
Chalk River Laboratories (CRL) – National Research Universal (NRU)	378[1]	2,233[2]

Table D.2 – Inventory of spent fuel in dry storage facilities in Canada as of December 31, 2010

Site	Number of fuel bundles in dry storage	Kilograms of uranium[4]
CRL Waste Management Area (WMA) G	4,886	65.395 [2]
CRL WMA B	7, 024[1]	32724[3]
Darlington Waste Management Facility	56,811	1,082,430
Douglas Point Waste Management Facility	22,256	299,827
Gentilly-1 Waste Management Facility	3,213	67,595
Gentilly-2 Waste Management Facility	87,000	1,651,603
Pickering Waste Management Facility	218,992	4,350,784
Point Lepreau Waste Management Facility	81,000	1,553,282
Western Waste Management Facility (located at Bruce Site)	214,262	4,085,034
Whiteshell Laboratories	2,268	21,540

[1] For CRL waste areas, inventory is reported as the number of irradiated fuel rods, fuel assemblies, units and items.
[2] Spent fuel material Includes irradiated natural and depleted uranium, thorium and plutonium.
[3] Area B includes natural, thorium rods fuel
[4] Reported as spent fuel (depleted or enriched fuel), unless otherwise noted.

D.3 Radioactive waste inventory – Radioactive waste management facilities

The table below (Table D.3) describes the low- and intermediate-level waste being stored, the waste management methods and the inventory of low- and intermediate-level waste in storage at each facility in Canada.

Table D.3 – Inventory of radioactive waste management for low-level radioactive waste (LLW) and intermediate-level radioactive waste (ILW) in Canada (as of December 31, 2010)

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2010			
				ILW		LLW	
				Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Western Waste Management Facility (WWMF)	OPG	Interim storage of low- and intermediate-level reactor waste generated from Bruce A and B, Darlington, Pickering A and B.	ILW: In-ground storage structures (trenches, tile holes, in-ground containers) and above ground storage structures (retube waste storage building, quadricells). LLW: Above ground storage structures (low-level storage buildings, steam generator storage buildings).	10,430[8]	56,398	73,690[8]	60
Pickering Waste Management Facility	OPG	Interim storage of intermediate-level reactor refurbishment waste from Pickering A.	ILW: Dry storage modules (DSMs).	2,210[8]	127,155	N/A	N/A
Gentilly-2	HQ	Operational reactor waste.	ILW: ASDR and IGDRS (concrete cells). LLW: ASDR and IGDRS (concrete cells).	310	3053	1060	5.3
Point Lepreau	NB Power	Operational waste. drums, filters, compactable.	LLRW: Concrete vault structures. ILRW: Concrete vault structures.	142.98	290.0	2,868.45	177.889

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2010			
				ILW		LLW	
				Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Chalk River Laboratories	AECL	Research reactor and isotope production waste as well as external waste.	ILRW: Tile holes and bunkers. LLRW: Sand trenches, low-level storage buildings, above ground stockpiles, MAGS, and the Bulk Materials Landfill. IL/LLWL: SMAGS	18,782[6]	N/A	118,066[6]	N/A
		Contaminated soils.	Luggers, 205-litre steel drums, B-25 containers in SMAGS, sand trenches, above ground stockpiles.	nil	nil	382,813	N/A
Whiteshell Laboratories	AECL	Research reactor waste and decommissioned reactor waste.	ILRW: In-ground concrete bunkers. LLRW: Above ground concrete bunkers.	863[6]	2942	19885[6]	333
Douglas Point Waste Management Facility	AECL	Contaminated soils.	LLRW: 205-litre drums.	nil	nil	66	N/A
Gentilly-1 Waste Management Facility	AECL	Contaminated soils.	LLRW: 205-litre drums.	nil	nil	1	N/A
Port Hope Conversion Facility	Cameco	Non-combustible process waste.	LLRW: 205-litre drums.	nil	nil	6000	N/A
Blind River Refinery	Cameco	Non-combustible process waste.	LLRW: 205-litre drums.	nil	nil	5400	N/A
Cameco Fuel Manufacturing	Cameco	Non-combustible process waste.	LLRW: 205-litre drums.	nil	nil	1300	N/A

Radioactive waste management or nuclear fuel cycle facility	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2010			
				ILW		LLW	
				Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
RWOS 1	OPG	Interim storage of low- and intermediate-level reactor waste generated from Douglas Point and Pickering A.	ILW: In-ground storage structures (trenches, tile holes). LLW: In-ground storage structures (trenches).	10[8]	12[7]	330[8]	<1[7]

[6] Volumes are based on method of storage and do not necessarily represent the actual breakdown of waste into intermediate and low-level.
[7] RWOS 1 activity estimated based on activity of waste stored.
[8] Rounded up to nearest 10 m^3.

Table D.4 describes the radioactive waste from past practices that is stored at each site and how it is managed.

Table D.4 – Management of low-level radioactive waste (LLW) from past practices

Site name or location	Licensee or responsible party	Description of stored waste	Storage method	LLW	
				Volume (m^3)	Activity (TBq)
Port Hope	AECL	Contaminated soils.	*In situ* and consolidated storage.	720,000	N/A
Welcome WMF	AECL	Contaminated soils.	Above ground mound.	454,380	N/A
Port Granby	Cameco	Waste and contaminated soils.	Trench burial.	438,200	N/A
Northern Transportation Route	AECL-LLRWMO	Contaminated soils.	*In situ* and consolidated storage.	10,000	N/A
Fort McMurray, Alberta	AECL-LLRWMO	Contaminated soils.	Above ground, consolidated mound.	43,000	N/A
Greater Toronto Area	AECL-LLRWMO Regional Municipality of Peel, Ontario	Radium-contaminated soils. Also, radium contamination fixed to structural elements in buildings.	*In situ* and consolidated storage. Above ground consolidated mound.	16,500	N/A
Deloro Mine Site	Ontario Ministry of the Environment (OMOE)	Contaminated soils and historical tailings.	*In situ* (fenced-in area).	38,000	6.3
Chalk River	AECL-LLRWMO	Packaged soils and artefacts.	Area “D”: Buildings and luggers.	1000	0.02

Table D.5 inventories the low- and intermediate-level radioactive waste resulting from decommissioning activities at Canadian facilities, as of December 31, 2010.

Table D.5 – Low- and intermediate-level radioactive waste (LLW and ILW) in Canada from decommissioning activities (as of December 31, 2010)

Site name or location	Company name or responsible party	Description of stored waste	Storage method	Onsite waste inventory as of December 31, 2010			
				ILW		LLW	
				Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Whiteshell Laboratories[9]	AECL	Decommissioning waste (Jan 1, 2005 to December 31, 2010).	ILRW: In-ground, concrete bunkers. LLRW: Above ground, concrete bunkers.	17	0.015	409	0.049
Chalk River Laboratories [9]	AECL	Decommissioning waste (Jan 1, 2005 to December 31, 2010).	ILRW: Tile holes and bunkers. LLRW: MAGS, SMAGS.	63	N/A	1,871	N/A
Douglas Point Waste Management Facility	AECL	Decommissioned reactor waste.	Reactor building.	61	6.9	82	70
Nuclear Power Demonstration Waste Management Facility[10]	AECL	Decommissioned reactor waste.	Reactor building.	nil	nil	31	97
Gentilly-1 Waste Management Facility	AECL	Decommissioned reactor waste.	Reactor building.	27	0.3	927	242

[9] Volumes are based on method of storage, and do not necessarily represent the actual breakdown of waste into low- and intermediate level radioactive waste.

[10] Volume does not include reactor components, such as shielding and heat transport systems, in the reactor buildings.

D.4 Uranium mining and milling waste

Uranium mining and milling generates two main forms of waste: tailings and waste rock. Historically, waste rock has been either stockpiled above ground or used as backfill in underground mines. Today, mineralized special waste rock is segregated and managed with due consideration given to the hazards associated with mineralization and particular contaminants. Tailings are managed in engineered tailings management facilities (TMFs). The unit of measure used in this report for uranium mine and mill wastes is tonne of dry mass, as this is the same unit used in the mining industry to track and report materials.

D.4.1 Operational mine and mill sites

Table D.6 details the uranium tailings and waste rock in storage at operational mine sites in Canada.

Table D.6 – Uranium tailings and waste rock at operational mine sites (as of December 31, 2010)

Operating tailings sites	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2010		
			Tailings	Waste rock	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Key Lake	Cameco	Deilmann tailings management facility.	4,082,300	1,585,580	62,033,000
Rabbit Lake	Cameco	Rabbit Lake in-pit tailings management facility.	7,438,860[11]	2,304,010	22,159,000
McClean Lake Operations	AREVA	In-pit tailings management facility stores tailings from McClean Lake.	1,826,000	10,200,000	51,700,000[12]
McArthur River	Cameco	No tailings on site. Ore is transported to Key Lake for milling.	nil	37,860	161,140
Cigar Lake	Cameco	No tailings on site. Not yet generating ore.	nil	nil	213,620

[11] Operational facility (see Table D.7 for inactive, onsite tailings management facilities)
[12]] Mining from 2008–2010 occurred below a set cut-off elevation where segregation of mineralized and non-mineralized waste was not implemented. All waste material was classified as mineralized waste for in-pit disposal although it was diluted with non-mineralized waste. Therefore, the non-mineralized total has not changed since reporting in 2007, while the mineralized total has increased.

D.4.2 Inventory of uranium mine and mill waste at inactive tailings sites

Table D.7 inventories waste rock and mill tailings at tailings sites that are no longer operational. As illustrated in Table D.6, there are operational tailings facilities at Key Lake and Rabbit Lake. "Inactive", in this context, refers to several different types of inventories described in section B.8. Note that waste rock inventory is generally not available for older sites such as Cluff Lake, Rabbit Lake and Key Lake, where operations predated current waste segregation practices.

Table D.7 – Uranium tailings and waste rock at decommissioned and inactive tailings sites (as of December 31, 2010)

Site name or location	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2007		
			Tailings	Waste rock	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Decommissioning Tailings Sites					
Cluff Lake	AREVA	Surface.	3,230,000	N/A[13]	18,400,000
Inactive Tailings Sites					
Key Lake	Cameco	Above ground tailings management facility.	3,590,000	N/A[13]	N/A
Rabbit Lake	Cameco	Above ground tailings management facility.	6,500,000	N/A[13]	N/A
Beaverlodge	Cameco	Above ground tailings and mine backfill.	5,800,000[14]	N/A	4,800,000
Gunnar	Saskatchewan Research Council	Above ground tailings.	4,400,000	N/A	N/A
Lorado	Saskatchewan Research Council	Above ground tailings.	360,000	N/A	N/A
Port Radium	Indian and Northern Affairs Canada	Above ground tailings in four areas.	907,000	N/A	N/A
Rayrock	Indian and Northern Affairs Canada	Above ground tailings in North and South tailings piles	71,000	N/A	N/A
Quirke 1 and 2	Rio Algom Ltd.	Flooded, above ground tailings.	46,000,000	N/A	N/A
Panel	Rio Algom Ltd.	Flooded, above ground tailings.	16,000,000	N/A	N/A
Denison	Denison Mines Inc.	Flooded, above ground tailings in two areas.	63,800,000	N/A	N/A

Site name or location	Company name or responsible party	Storage method	Onsite waste inventory as of December 31, 2007		
			Tailings	Waste rock	
			Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Spanish American	Rio Algom Ltd.	Flooded, above ground tailings.	450,000	N/A	N/A
Stanrock/Can-Met	Denison Mines Inc.	Above ground tailings.	5,750,000	N/A	N/A
Stanleigh	Rio Algom Ltd.	Flooded, above ground tailings.	19,953,000	N/A	N/A
Lacnor	Rio Algom Ltd.	Above ground tailings.	2,700,000	N/A	N/A
Nordic	Rio Algom Ltd.	Above ground tailings.	12,000,000	N/A	N/A
Milliken	Rio Algom Ltd.	Tailings management area.	150,000	N/A	N/A
Pronto	Rio Algom Ltd.	Above ground tailings.	2,100,000	N/A	N/A
Agnew Lake	Ontario Ministry of Northern Development and Mines	Lake-vegetated, above ground tailings.	510,000	N/A	N/A
Dyno	EWL Management Limited	Above ground tailings.	600,000	N/A	N/A
Bicroft	Barrick Gold Corp.	Above ground tailings in two areas	2,000,000	N/A	N/A
Madawaska	EWL Management Limited	Above ground tailings in two areas	4,000,000	N/A	N/A

[13] Not available. Note that much of the mining at these sites predated current waste segregation practices.
[14] Tailings volume no longer includes 4,300,000 tonnes that have been used as backfill.

Notes: N/A = not available

Figure D.1 – Map of radioactive waste management sites in Eastern Canada

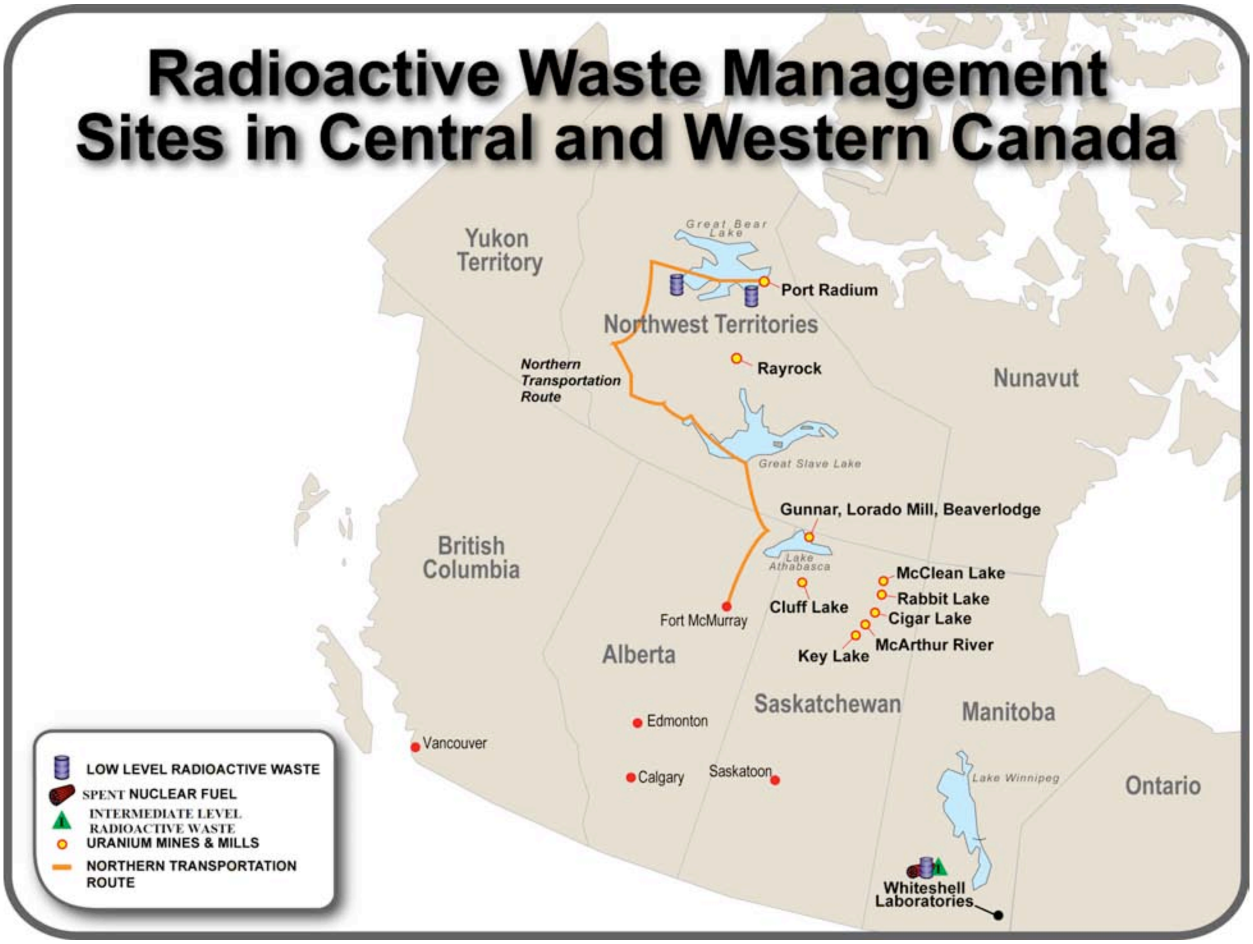

Figure D.2 – Map of radioactive waste management sites in Central and Western Canada

Section E – Legislative and Regulatory Systems

E.1 Scope of the section

This section addresses Articles 18 (Implementing Measures), 19 (Legislative and Regulatory Framework) and 20 (Regulatory Body), of the Joint Convention, as well as requirements set out in Articles 19 and 20 of the IAEA Safety Standard GS-R-1, *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety*. Specifically, this section describes Canada's legislative and regulatory framework, regulatory body and approach to licensing radioactive material.

The NSCA provides the regulatory body, the CNSC, with a mandate to establish and enforce national standards in the areas of public health, safety, and environmental protection. It also establishes a basis for implementing Canadian policy and Canada's obligations with respect to the non-proliferation of nuclear weapons. The NSCA sets out a formal system for review and appeal of decisions and orders made by the Commission Tribunal, designated officers and inspectors. It should be noted that the Commission Tribunal has legal authority to hear witnesses, take evidence and control its own proceedings. Additionally, the NSCA empowers the Commission Tribunal to require financial guarantees, to order remedial action in hazardous situations, and to require responsible parties to bear the costs of decontamination and other remedial measures.

E.2 Establishment of the Canadian legislative and regulatory framework

In Canada, matters that relate to nuclear activities and substances are under the jurisdiction of the Government of Canada. NRCan has been charged with setting Canada's nuclear policies, including those concerning radioactive wastes. The *Policy Framework for Radioactive Waste* establishes the roles and responsibilities of the Government of Canada and waste producers. In particular, the Government of Canada guides, oversees and regulates radioactive waste producers.

Section 9 of the NSCA states the objects of the NSCA and grants regulatory authority to the Commission Tribunal over the use of nuclear materials. The CNSC's responsibilities include issuing licences, making regulations and enforcing compliance.

A list of the various federal organizations and acts that relate directly to Canada's nuclear industry are provided in annexes 1 and 2. A detailed description of the regulatory body, its structure, operations and regulatory activities is provided in annex 3.

E.3 National safety requirements

The CNSC operates within a modern and robust legislative and regulatory framework. Figure E.1 depicts the main elements of Canada's nuclear regulatory framework. This framework consists of laws (acts) passed by the Parliament of Canada, which govern the regulation of Canada's nuclear industry, and instruments such as regulations, licences and documents that the CNSC uses to regulate the industry.

The *Nuclear Safety and Control Act* (NSCA) is the enabling legislation for the regulatory framework. Regulatory instruments fall into two broad categories: those that set out requirements and those that provide guidance on requirements. Requirements are legally binding and mandatory elements and include the regulations made under the NSCA, licences and orders. Regulatory documents also become legally binding requirements once they are referenced in licences. The NSCA, regulations, regulatory documents and licences are described in more detail in the sections below.

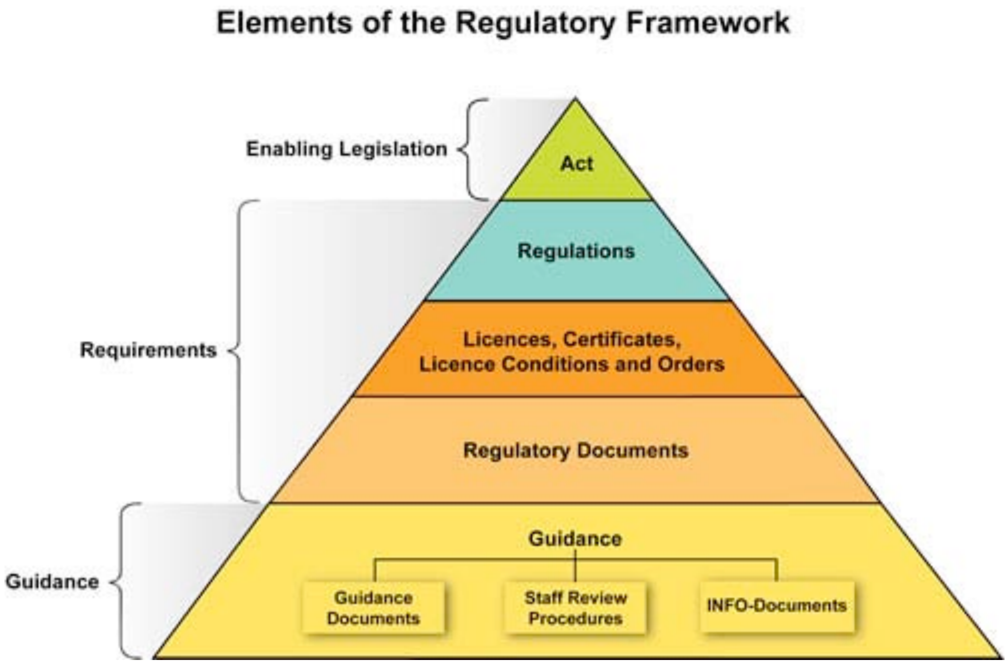

Figure E.1- Elements of the Canadian nuclear regulatory framework

E.3.1 *Nuclear Safety and Control Act* (NSCA)

In the Canadian parliamentary system, the federal Cabinet – on the advice and recommendation of the appropriate Minister – makes the decision to introduce government legislation into Parliament. The *Nuclear Safety and Control Act* (NSCA) was passed by Parliament on March 20, 1997, and became law in May 2000. This was the first major overhaul of Canada's nuclear regime since the *Atomic Energy Control Act* (AECA) and the creation of the Atomic Energy Control Board (AECB) in 1946. The NSCA provides legislative authority for all the nuclear industry developments since 1946. These developments include health and safety standards for nuclear energy workers, environmental protection measures, security regarding nuclear facilities, and public input into the licensing process. The NSCA can be viewed at: nuclearsafety.gc.ca

The NSCA established the CNSC as an independent regulatory body, responsible for regulating the use of nuclear material in Canada, including the nuclear fuel cycle. The CNSC comprises the Commission Tribunal, which makes licensing decisions, and the CNSC's staff organization, which prepares recommendations to the Commission Tribunal, exercises delegated licensing and authorization powers and assesses licensee compliance with the NSCA, the Act's associated regulations and licence conditions. The NSCA gives the CNSC the power to make regulations, as shown in section E.3.2 below.

The CNSC's regulatory framework consists of regulations, 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
- the import and export of controlled nuclear and dual-use substances, equipment and technology identified as proliferation risks

The CNSC's mandate includes the protection of the environment and the health and safety of workers, as well as members of the public. The CNSC discharges these responsibilities through cooperative arrangements with federal and provincial regulators in other fields, such as environmental protection and occupational health and safety.

According to the Parliamentary Directive issued to the CNSC in December 2007, the CNSC now readily takes into account the health of Canadians in regulating the production, possession and use of nuclear substances in order to ensure the necessary protection of the health of Canadians at times when a serious shortage of medical isotopes in Canada or around the world puts the health of Canadians at risk.

The NSCA incorporates stringent regulations to ensure that public health and safety are protected. For example, the NSCA includes:

- radiation dose limits that are consistent with International Commission on Radiological Protection (ICRP) recommendations
- regulations that govern the transport and packaging of nuclear materials
- specifications for enhanced security at nuclear facilities, including spent fuel dry storage and radioactive waste management facilities

The CNSC also has responsibilities under the *Nuclear Liability Act* (NLA). The regulatory body conducts environmental assessments under the CEA Act and implements Canada's bilateral agreement with the IAEA on nuclear safeguards verification. As a model of regulatory efficiency, the CNSC oversees the entire nuclear cycle and all aspects of nuclear safety in Canada.

E.3.2 Regulations issued under the NSCA

As illustrated in figure E.2, there are nine safety-related regulations issued under the NSCA:

1. *General Nuclear Safety and Control Regulations*
2. *Radiation Protection Regulations*
3. *Class I Nuclear Facilities Regulations*
4. *Class II Nuclear Facilities and Prescribed Equipment Regulations*
5. *Uranium Mines and Mills Regulations*
6. *Nuclear Substances and Radiation Devices Regulations*
7. *Packaging and Transport of Nuclear Substances Regulations*
8. *Nuclear Security Regulations*
9. *Nuclear Non-proliferation Import and Export Control Regulations*

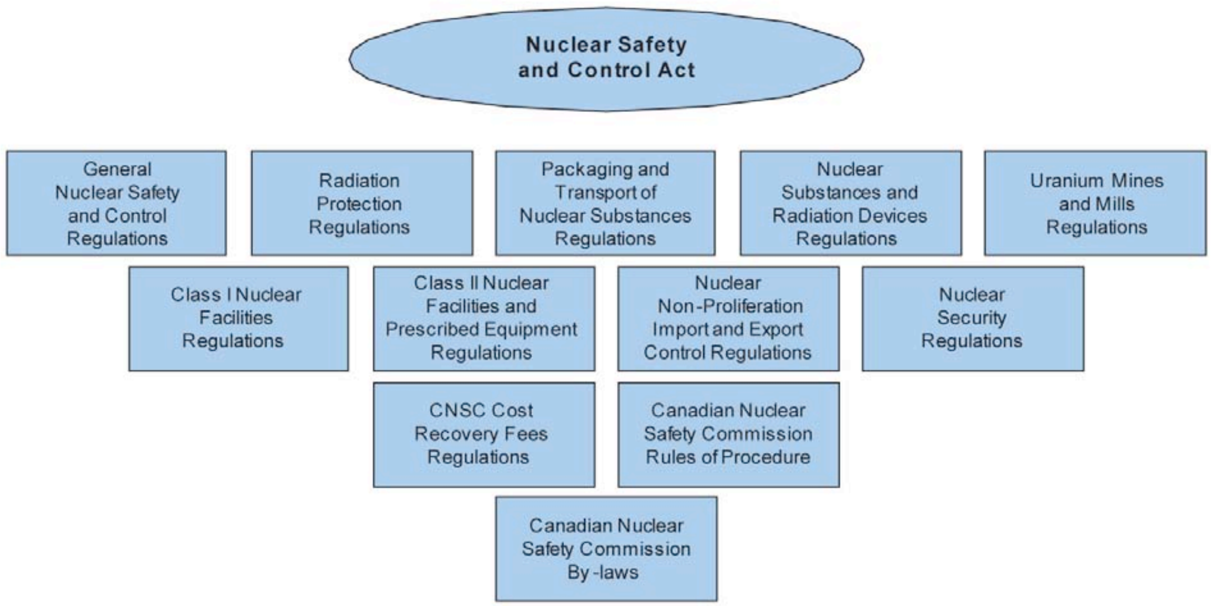

Figure E.2 – Regulations issued under the NSCA

In addition to the safety regulations, the CNSC's *Rules of Procedure* must also be followed. They apply to the public, licensees, the CNSC's staff and Commission Tribunal members and govern the conduct of Commission Tribunal proceedings.

The regulatory regime is flexible about how licensees comply with regulatory requirements. The regulations require licence applicants to submit information on the environmental effects of their use of both radioactive and non-radioactive hazardous substances. The CNSC then uses this information and consults other federal and provincial regulatory bodies to establish the operating parameters for a specific nuclear facility. Brief descriptions of the regulations are provided below. Note, however, that all of the regulations can be viewed in full at: nuclearsafety.gc.ca

General Nuclear Safety and Control Regulations (GNSCR): outline the information to be included in licence applications; the obligations of licensees and their workers; definitions of prescribed nuclear facilities, equipment and information; and reporting and record-keeping requirements. The GNSCR also detail the requirements for an application for a licence to abandon and obligations to provide information on any proposed financial guarantees. Note that these Regulations apply to all licensees, including licensees for management of spent fuel and radioactive waste and decommissioning activities. Naturally occurring nuclear substances that are not associated with the development, production or use of nuclear energy are exempt.

Radiation Protection Regulations (RPR): contain radiation protection requirements. They apply to all licensees and others who fall under the mandate of the CNSC. The RPR require the development of action levels, which are proposed by the licensee and subject to the regulatory body's approval. Action levels are not intended to be secondary legal limits, but rather checks for the proper operation of a licensee's radiation protection program.

The dose limits are based on the ICRP's recommendations in its publication *Recommendations of the International Commission on Radiological Protection* (ICRP-60, 1990) and apply to all organizations that fall within the CNSC's mandate. Nuclear energy workers, for instance, must not be exposed to more than 100 mSv over a five-year period or more than 50 mSv in a single year. The dose limit for pregnant nuclear energy workers is much lower at four mSv for the balance of the pregnancy once declared in writing. A member of the public must not be exposed to more than one mSv per year.

Pregnant Nuclear Energy Workers

In 1990, the ICRP published new dose guidelines of two mSv for pregnant nuclear energy workers. The CNSC initially planned to adopt this new recommendation. The new limit, which was 20 percent of the previous one, drew heavy criticism from members of both the industry and scientific community. It was widely believed that such a low dose would be very difficult to regulate and might restrict employment opportunities for female workers in Canada.

As is always the case when there are proposed changes to regulations, members of the public and industry were given the opportunity to review and comment on them. Public and industry response to the new proposed guidelines for occupational exposure for pregnant workers was made available in September 1992. Five major points were brought forward, of which two were given further consideration: (1) the reassignment of pregnant workers to non-radiation work will present major difficulties, and (2) the bioassay programs are not available to show compliance with the intake limit of 0.05 annual limit on intake (ALI) for pregnant nuclear energy workers. These concerns led to a second round of public consultation, which took place in October and November 1992. During the public consultation meetings, information on the risks to the embryo and fetus from radiation exposure and from natural causes was presented to the participants.

Participants raised three main concerns during this second round:

1. **Dose limits**: While participants generally agreed that it is appropriate to set the same dose limit for a fetus as for a member of general public, they deemed the proposed limit to be too low. Many believed that the risk estimates did not warrant a change to the original 10 mSv limit.

2. **Compliance**: Participants suggested that internal dosimetry would first need to be improved before they could demonstrate compliance with the proposed limit, and that contamination surveys, as opposed to a bioassay, could be used to comply with regulations.

3. **Other comments**: Many participants felt that the social and economic impacts of the proposed changes must be examined and believed that a mandatory declaration of pregnancy would be an invasion of workers' privacy.

The CNSC heard these concerns and adopted several participants' internal and external dosimetry suggestions. It also issued a document entitled *Revised Proposal for the Dose Limit for Pregnant Radiation Workers*, which increased the proposed dose limit from two to four mSv. This change to the proposed dose limit reflects social concerns raised during the consultative process and accepts that a mother may be willing to accept certain risks.

Though no longer consistent with the ICRP-60 recommendation that the public not be exposed to more than one mSv per year, the revised dose limit is consistent with the ICRP's conclusion that, in special circumstances, a higher dose could be allowed provided that the average over five years does not exceed one mSv per year. IAEA Safety Series No. 115 also states that, in special circumstances, a dose of up to five mSv in a single year is permissible provided that the average dose over five consecutive years does not exceed one mSv per year.

Provided that both the ICRP and IAEA agree that: (1) five mSv is not a significant conceptus dose, (2) it is reasonable to assume that a child would not be exposed to an additional dose until at least the age of five, and (3) there is scientific rationale to support a dose limit of five mSv, in special circumstances, a balance of pregnancy limit of five mSv would not pose a detectable risk to a conceptus. Therefore, the CNSC's adoption of a four mSv dose limit for the balance of pregnancy mitigates both social and scientific considerations of conceptus risk.

The final conclusions of the public consultation, based on the majority opinion of participants, was that the proposed limit of 2 mSv was too low. A value between the previous limit of 10 mSv and the ICRP's recommendation of 2 mSv was ultimately selected.

Class I Nuclear Facilities Regulations: detail the information licensees need to supply when applying for different types of Class I nuclear facility licences. Licences are available for each stage in the lifecycle of a facility, including site preparation, construction, operation, decommissioning and abandonment. The Regulations also address record keeping and the certification of reactor operators.

Note that under the NSCA, one of the definitions of a nuclear facility is "a facility for the disposal of a nuclear substance generated at another nuclear facility". A nuclear facility also includes, where applicable, the land on which such a facility is located, a building that forms part of the facility, equipment used in conjunction with the facility and any system for the management, storage or disposal of a nuclear substance. As defined under section 19(*a*) of the GNSCR, a facility that manages, stores or disposes of radioactive waste and whose resident inventory of radioactive nuclear substances is greater than 10^{15} Bq is a prescribed, Class 1 nuclear facility.

Class II Nuclear Facilities and Prescribed Equipment Regulations: specify the requirements for prescribed equipment, including low-energy accelerators, irradiators, radiation-therapy installations and equipment that contains only sealed sources.

Nuclear Substances and Radiation Devices Regulations **(NSRDR)**: apply to all nuclear substances, sealed sources and radiation devices used in Canada that are not included in Class II prescribed equipment. In order to harmonize Canada's regulatory approach for the exemption and clearance of radioactive material with international practices, the CNSC amended the NSRDR to consider the IAEA Basic Safety Standards, as well as the most recent guidance from the IAEA on the concepts of exemption, exclusion and clearance. The amendments, following extensive stakeholder input, were approved by the Governor in Council and subsequently published in the *Canada Gazette Part II*. The amended Regulations came into force on April 17, 2008. Further information on exemption and clearance levels is discussed below.

- **Exemption and clearance**: Some materials are excluded from the regulatory process because the associated radioactivity presents such a low risk that control by regulatory processes is not warranted. There are two such categories: (1) radioactive material that never enters the regulatory control regime, and (2) radioactive material that is released from regulatory control. Note that exempt and cleared waste materials may still be subject to other regulations (e.g., transportation regulations).

- **Exemption**: Radioactive materials in the first category are excluded from regulatory control by a process called exemption. Exempted waste is material that contains less than the exemption quantity as defined in section 1 of the NSRDR. Although still radioactive from a physical point of view, exempted material can be safely disposed of, by applying conventional techniques and systems, without specifically considering its radioactive properties.

- **Clearance**: The release of radioactive material from control, on the other hand, is called clearance. Clearance of radioactive material is a management tool, not a waste classification. There are two forms of clearance: unconditional and conditional clearance. Unconditional clearance levels are defined in the amended NSRDR.

Packaging and Transport of Nuclear Substances Regulations **(PTNSR)**: are based on the IAEA *Safety Standards Series No. TS-R-1, Regulations for the Safe Transport of Radioactive Material*, 1996 edition. The CNSC has been a major participant in the development of the IAEA regulations on the packaging and transport of nuclear materials and has communicated regularly with the federal transportation department – Transport Canada – and major Canadian shippers.

Nuclear Security Regulations **(NSR)**: were amended in November 2006 and now align Canadian nuclear facilities with the IAEA's internationally accepted recommendations. In developing the NSR, the CNSC gave due consideration to threats to Canada's security and included a number of new physical-protection requirements for security-sensitive areas, including:

- enhanced security screening of employees and contractors
- enhanced identification checks of personnel

- enhanced screening of persons and vehicles when entering or leaving a protected area
- heightened protection against forced vehicle penetration of protected areas
- enhanced intrusion detection for protected areas

Uranium Mines and Mills Regulations **(UMMR)**: detail the information needed for licence applications for uranium mines and mills, as well as code-of-practice and record-keeping requirements and licensee obligations. Licences are available for each stage of a facility's lifecycle, including site preparation, construction, operation, decommissioning and abandonment. UMMR apply to all uranium mines and mills, including management of mill tailings, but not to uranium prospecting or surface-exploration activities.

Nuclear Non-proliferation Import and Export Control Regulations **(NNIECR)**: govern the import and export of controlled nuclear substances, equipment and information.

Cost Recovery Regulations: enable the CNSC to recover the actual cost of regulating the nuclear industry equitably through licence fees.

E.3.3 Regulatory documents

The NSCA and its associated regulations provide the basis for regulatory expectations and decisions.

In 2007, the CNSC streamlined and improved its regulatory framework. The organization strengthened the roles and responsibilities of the Regulatory Policy Committee (RPC) to align the CNSC's regulatory framework with its overall strategic direction. In September 2007, the Commission Tribunal approved a revised regulatory framework for the development and approval of regulations and regulatory documents proposed by the RPC.

The following explanatory text is included in all regulatory documents:

- The CNSC develops regulatory documents under the authority of paragraphs 9(*b*) and 21(1)(*e*) of the NSCA.

- Regulatory documents clarify NSCA requirements and associated regulations, and are an integral part of the regulatory framework for nuclear activities in Canada.

- Each regulatory document aims to disseminate objective regulatory information to stakeholders, including licensees, applicants, public interest groups and the public, and promote consistency in the interpretation and implementation of regulatory requirements.

Additional information on the CNSC's regulatory documents program is available online at: nuclearsafety.gc.ca

As outlined in the CNSC regulatory policy P-299, *Regulatory Fundamentals*, the CNSC bases its regulatory requirements on industry, national and international standards and best practices, including those of the IAEA. Canada has actively helped the IAEA develop nuclear safety standards and create technical documents that outline more specific technical requirements and best practices for radioactive waste management and decommissioning.

Annex 3.6.1 includes a list of the CNSC's regulatory documents. Two of these documents are specific to spent fuel and radioactive waste. For uranium mine and mill waste, there is a draft regulatory guide that is currently undergoing public consultation. Other more generic regulatory documents that relate to action levels, decommissioning, environmental protection and public-information programs may also apply to waste management facilities. The CNSC's regulatory documents for radioactive waste and decommissioning are described below. A complete list of regulatory documents is available at: nuclearsafety.gc.ca

Regulatory policy P-290, *Managing Radioactive Waste*: The CNSC issued this document in July 2004, following extensive consultation with the public, the nuclear industry and other stakeholders. The policy identifies the need for long-term management of radioactive waste and non-radioactive hazardous waste arising from licensed activities. P-290 is discussed in section B.5.

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*: In December 2006, the CNSC published this regulatory guide to assist licensees and applicants to assess the long-term storage and disposal of radioactive waste. The guide (discussed in section B.6) was developed using provincial, federal and international documents, following a consultation with the nuclear industry in Canada.

Regulatory guide G-219, *Decommissioning Planning for Licensed Activities*: This document provides guidance on the preparation of plans for the decommissioning of activities licensed by the CNSC. G-219 is described in section F.8.

Regulatory policy P-319, *Financial Guarantees*: In March 2011, the CNSC issued discussion paper DIS-11-01, *Implementation of Financial Guarantees for Licensees*. This document proposes a new financial guarantee policy which states: “It is the policy of the Canadian Nuclear Safety Commission (CNSC) that a financial guarantee be required of licensees for all facilities and activities licensed by the CNSC, unless in the opinion of the Commission Tribunal a financial guarantee is not required.” In December 2011, the Commission Tribunal will consider the draft position paper for implementation. Should this policy be implemented, the CNSC will issue supporting regulatory documents which will advise licensees and applicants of CNSC expectations regarding financial guarantees. (For more details, refer to section F.4.3.)

Regulatory document RD/GD-370, *Management of Uranium Mine Waste Rock and Mill Tailings* (draft): This document sets out the requirements of the CNSC for the sound management of mine waste rock and mill tailings resulting from site preparation, construction, operation and decommissioning of new uranium mine or mill projects in Canada, to ensure the protection of the environment and the health and safety of people. This regulatory document also provides guidance to applicants regarding CNSC’s expectations for new mining projects throughout Canada on the management of waste rock and tailings generated by uranium mining and milling operations.

E.4 Comprehensive licensing system for spent fuel and radioactive waste management activities

E.4.1 Licensing procedure

Canada maintains the philosophy that a licensee is responsible for the safe operation of its own facilities. Licensees make safety-related decisions routinely; therefore they must have a robust set of programs and processes in place to ensure adequate protection of the environment and the health and safety of workers and the public. The CNSC performs regulatory oversight and verifies that licensees and operators comply with regulations.

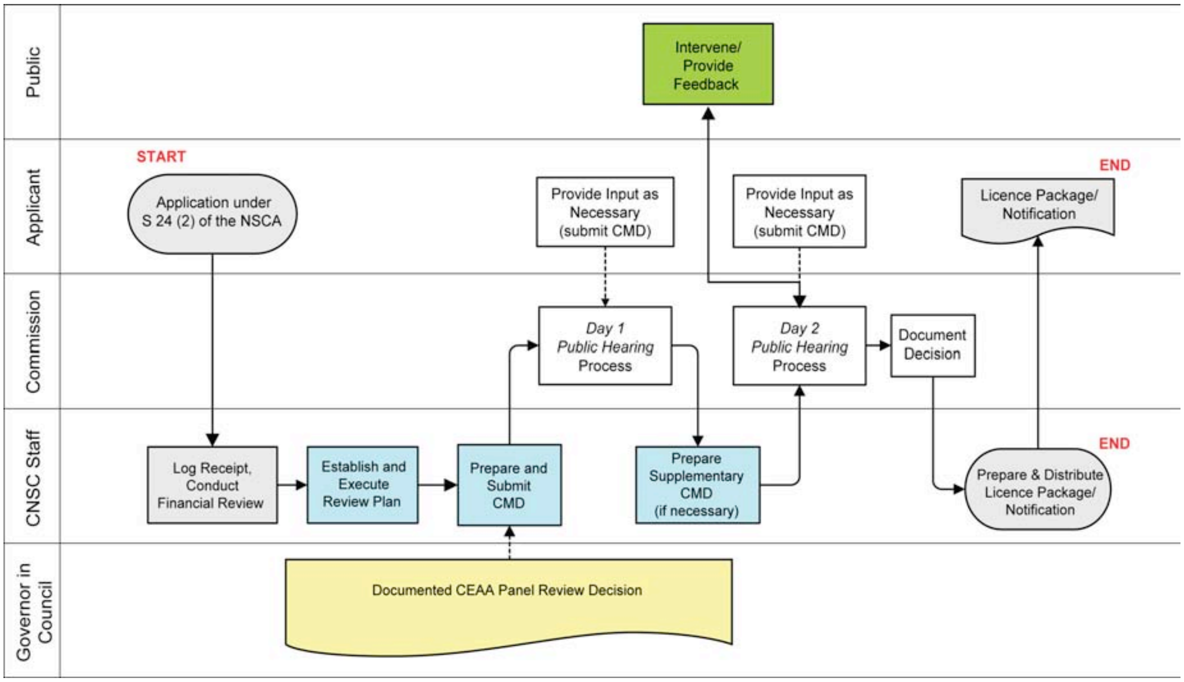

Figure E.3 – The licensing process

Figure E.3 illustrates how an applicant can obtain a licence under the NSCA. First, the applicant must submit either an application for a licence (or letter of intent) or a notification of intent for a project to the CNSC. The applicant must meet general performance criteria, provide information and develop programs in accordance with the NSCA and regulations to be considered. CNSC staff publish regulatory documents, including policies, guides, standards and notices, which help licensees meet regulatory requirements. Licensees are obligated to adhere to terms and conditions of a licence, such as references to standards and decommissioning planning and financial guarantee requirements.

An application for a CNSC licence, including renewals or amendments, may be subject to other legislation and regulations. For example, an environmental assessment (EA) under the CEA Act may be required to analyze potential environmental, physical and socio-economic impacts. Note that there are opportunities throughout the EA process for public consultations. The range of stakeholder consultations is determined by possible environmental impacts and the size and complexity of the project.

Only after a positive decision is made on the EA (if one is required) may the Commission Tribunal proceed with making a licensing decision. The Commission Tribunal holds public hearings to consider licence applications for major facilities (see section E.4.3). Under section 37 of the NSCA, the Commission Tribunal can delegate the responsibility for issuing certain types of licences – other than Class I licences and licences for uranium mines and mills – to persons who have been identified as designated officers (DOs), as defined under the legislation. This can include issuing various types of licences, such as licences for radioactive waste management facilities that are not defined as Class I nuclear facilities. When a DO is delegated this responsibility, no public hearing occurs, unless the DO refers the decision back to the Commission Tribunal, using a risk-based approach. In this case, the Commission Tribunal will evaluate the need to conduct a public hearing, as part of its decision-making process.

The CNSC administers its licensing system in cooperation with other federal and provincial government departments and agencies that work in areas such as health, the environment, transportation and labour.

Once a licence is issued, CNSC staff are responsible for administering the Commission Tribunal's decision, including the requirement to develop and implement a compliance verification program (see section E.6.3) to ensure that licensees continue to meet their legislative and licence obligations.

E.4.2 Licence application assessment process

Early communication with the CNSC can help applicants develop a good understanding of the licensing process, regulatory requirements for spent fuel and radioactive waste management facilities and information to be submitted in support of a licence. Early communication also enables the CNSC to develop a regulatory review, which ensures that qualified staff are available to carry out the application review.

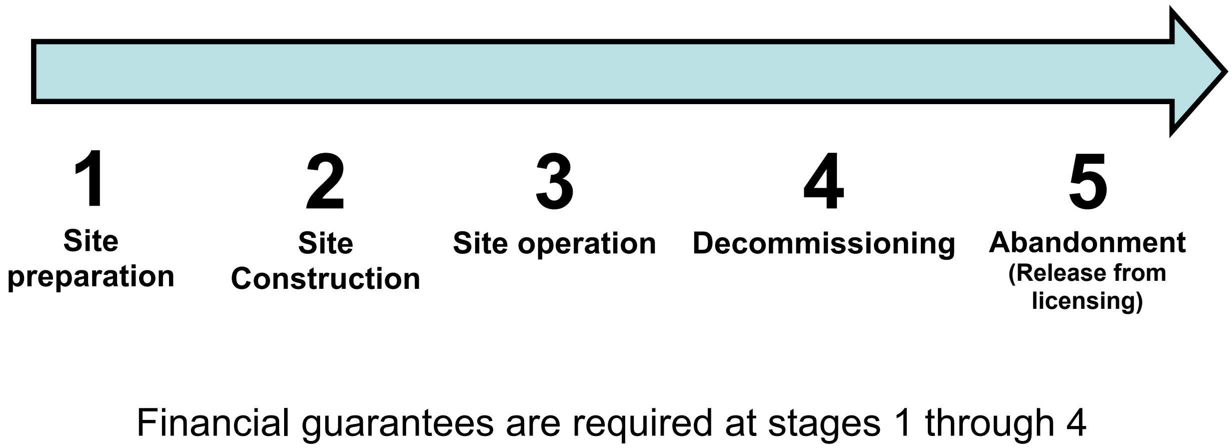

Figure E.4 – The lifecycle of the CNSC's licensing approach (step-wise approach/early planning)

The management of spent fuel, radioactive waste management and uranium mine/mill waste is regulated during their entire lifecycle – from site preparation, construction and operation to decommissioning and, finally, abandonment. Each phase requires a separate licence.

E.4.2.1 Licence application

For a new licence, the regulations require applicants to submit comprehensive information on their policies and programs, the design and components of the proposed facility, the manner in which the facility is expected to operate, facility operating manuals and procedures and any potential impacts on the site or surrounding environment. The design must be such that emissions from the facility meet strict limits under normal operating and upset conditions, as applicants are required to identify the manner by which a facility may fail to operate correctly, predict the potential consequences of such a failure and establish specific engineering measures to mitigate the consequences to tolerable levels. Those engineering measures may include, but are not limited to, multiple barriers to prevent the escape of noxious material. Many analyses of potential accidents are complex, covering a very wide range of possible occurrences.

CNSC staff rigorously review all submissions, using existing legislation and the best codes of practice and experience available in Canada and around the world, to ensure regulatory requirements are met. The expertise of the CNSC's staff covers a broad range of engineering and scientific disciplines. Considerable effort is also spent reviewing the analyses to ensure that predictions are based on well-established scientific evidence and that defences meet defined standards of performance and reliability.

In addition to reviewing the information described above, section 24(4) of the NSCA places the onus on the CNSC to ensure that "the applicant:

- "is qualified to carry on the activity that the licence will authorize the licensee to carry on, and

- "will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed."

The comprehensive assessment that takes place during the licensing process may result in defining additional programs and criteria, as a condition(s) of the licence. Once satisfied that all of the requirements of the NSCA and its associated regulations are met, and the applicant's documentation is complete and acceptable, CNSC staff prepare a licence recommendation for submission to the Commission Tribunal – or a DO – for a decision. The recommended licence may include any necessary conditions that were identified as required during the assessment, including the documentation references submitted in support of the application. By referring to the applicant's documentation, the licence legally binds the applicant to comply with its own procedures and programs, and makes them subject to the CNSC's compliance, verification and enforcement program.

Licences may also contain other terms and conditions, such as references to standards, with which licensees must comply. For example, licensees may be required to observe occupational and public radiological exposure limits derived (or adopted) from internationally accepted standards, such as those of the ICRP. Limits for controlled release of gaseous or liquid effluents or solid materials are adopted from complementary regulatory regimes, such as Ontario's Provincial Water Quality Objectives or Metal Mining Limits for Liquid Effluent Releases, or derived from specific licence conditions, such as the derived release limits. Other standards, established by organizations such as the CSA and the American Society of Mechanical Engineers (ASME), may also be adopted by the CNSC.

E.4.2.2 Joint regulatory review process

Although the nuclear sector is subject to federal jurisdiction through the NSCA, the CNSC utilizes a harmonized or joint review approach with other federal, provincial or territorial departments in such areas as health, environment, transport and labour. The CNSC would expect nuclear facilities to comply with all applicable federal and provincial regulations.

In recognition of this dual jurisdiction, the CNSC has established a joint regulatory process. As a lead agency, the CNSC invites other federal and provincial regulatory agencies to participate in the licensing process, when their areas of responsibility could impact the proposed nuclear facility. Those that choose to participate become members of a site-specific Joint Regulatory Group.

This procedure ensures that the legitimate concerns of federal, provincial and territorial agencies are considered in the regulatory process and are reflected, as appropriate, in the licence in the form of site-specific requirements. For example, the CNSC and the Saskatchewan departments of Environment and Labour have an administrative agreement that optimizes the participation of the Ministry of Environment (MoE) and the Ministry of Advanced Education, Employment and Labour (Labour) in the administration of the CNSC's regulatory regime. The involvement of Labour and the MoE in the regulation of Saskatchewan's uranium mines and mills helps to better

- protect the health, safety and security of Canadians and their environment
- harmonize the CNSC, MoE and Labour regulatory requirements and regulatory activities

E.4.2.3 Example of a new licence issued by the Commission Tribunal

The following is an example of a licence that the Commission Tribunal issued after the last report was published. Following the public hearing process in March 2009, the CNSC approved the *Draft Environmental Assessment Guidelines for the Proposed Decommissioning of the SLOWPOKE-2 Reactor Facility* in accordance with the requirements of the *Canadian Environmental Assessment Act* (CEA Act). In January 2011, a hearing was held for Dalhousie University's application to the CNSC for a decommissioning licence. This licence was granted and is currently valid from January 14, 2011 to December 31, 2015. Concurrently, the Commission Tribunal revoked the previous non-power operating licence for the Dalhousie University SLOWPOKE-2 reactor facility.

E.4.2.4 Licence periods

Typical licence terms for radioactive waste management facilities vary from five to ten years.

In 2002, the CNSC introduced flexible licence terms to allow for more risk-informed regulation of spent fuel and radioactive waste management facilities. The CNSC may consider adjusting licence terms based on licensee performance, facility risks, and compliance and verification findings. Short licence periods will continue to be an option in case of unsatisfactory licensee performance or other considerations. However, along with the assignment of longer licence terms, the Commission Tribunal has requested mid-term or status updates, to allow the Commission Tribunal and the public to stay informed about the facilities' operations and performance. In some cases, such as Rio Algom's waste management facility operating licence, licences have been issued for indefinite terms on the condition that status reports be provided at five-year intervals.

CNSC staff recommend licence periods using a set of consistent factors. These factors include: facility-related hazards, the development and implementation of safety programs (see section E.5.3), the implementation of an effective monitoring and maintenance program, licensee experience and performance, *Cost Recovery Fees Regulations* and the facility's planning cycle.

Regardless of the specifics of the licence term, or the schedule of mid-term or status reports, CNSC staff have an obligation to inform the Commission Tribunal of any significant event at a nuclear facility licensed by the CNSC. Should such an event occur, all operational issues must be included in an emergency notification report to be presented to the Commission Tribunal.

E.4.2.5 Licence renewals

Applications for licence renewal or amendment require the CNSC to revisit the original documentation and assessment in light of licensee performance and compliance history (see section E.6.1). The CNSC bases its review on performance history, risk and expert judgment, and may add, modify or remove licence conditions.

Since the last report, the CNSC renewed the nuclear research and test establishment decommissioning licence for AECL's Whiteshell Laboratories (WL). This licence, issued in December 2008, allows AECL to decommission and undertake residual operations at WL, located in Pinawa, Manitoba. The licence was renewed for a 10-year term on the condition that an interim status report be submitted after the third and seventh year of the licence term.

E.4.2.6 Licence amendments

Amendments to spent fuel, radioactive waste management and uranium mine and mill licences can modify existing licence conditions, add new licensing requirements or approve revisions to the facility design, its operations or licensee programs referenced in the licence. Examples of documents to review before reaching a decision include: operating policies and principles (OP&P), station-shift complement, radiation protection requirements and emergency plans. DOs, when delegated by the Commission Tribunal, can typically amend waste nuclear substance licences.

E.4.3 Information and participation of the public

E.4.3.1 Public hearings

As discussed in the CNSC licensing procedure (see section E.4.1), the NSCA requires that a public hearing be held before a major licensing decision is made or whenever it is in the public interest to do so. Public hearing proceedings give non-nuclear organizations and interested members of the public a reasonable opportunity to comment on matters before the Commission Tribunal. The CNSC *Rules of Procedure* (Rules) apply to these proceedings and set out the requirements for, among others, the notification of public hearings and publication of decisions from public hearings.

In accordance with the Rules, a public hearing may take place on a single day or on two non-consecutive days. Most major decisions are made following a two-day public hearing process. Day One and Day Two may be several months apart (the usual timeframe is 60 days), to allow stakeholders enough time to review the application and recommendations. The CNSC's licensing process is described in annex 3.

E.4.3.2 Streamlining

Since the last reporting period, panels of the Commission Tribunal also conducted hearings to increase the efficiency of its operations and maintain the forum's effectiveness. The CNSC President established several panels of one or more members last year to exercise Commission Tribunal functions. Under the NSCA, not all Commission Tribunal members must be in attendance at a Commission Tribunal activity. A smaller panel of members can exercise certain powers. The Commission Tribunal's use of panels is in line with the practices of other Canadian administrative tribunals.

E.4.3.3 Abridged hearings

The Commission Tribunal is required to make all decisions with respect to applications to amend licences that it has previously issued (i.e., for Class I nuclear facilities and uranium mines and mills). Many of these applications regard minor changes and updates that are of low safety significance to a facility's operations and reference documentation. The Commission Tribunal therefore decided, in accordance with Part 2 of the Rules, that in such cases it may be neither efficient nor in the public interest to hold full public hearings.

The Commission Tribunal must also decide on approvals and other requested changes to – or deviations from – licence requirements when the authority to make such decisions has not been previously delegated to CNSC staff or the changes or deviations are akin to a licence amendment. An abridged hearing process may also be used, when appropriate, for such approvals, changes or deviations.

To consider Class I and uranium mines and mills licence amendments that pose relatively low risk as fairly, informally and expeditiously as possible, the Commission Tribunal may, in accordance with Rule 3 of the Rules, hold hearings over an abridged timeframe and with a reduced notice period and limited opportunity, if any, for interventions. For example, on January 24, 2007, the Commission Tribunal used an abridged hearing process to accept the Environmental Impact Statement for the proposed Port Hope long-term low-level radioactive waste-management project.

E.4.3.4 Outreach activities

The CNSC's outreach program is described in annex 3.11.

Public hearings and meetings are fundamental to the CNSC's outreach activities. The Commission Tribunal publishes *Records of Proceedings, including Reasons for Decision* to explain the basis for its licensing decisions. This document, along with other information about the Commission Tribunal's proceedings and decisions, is publicly available at: nuclearsafety.gc.ca. The Commission Tribunal also posts the complete transcripts of all public proceedings within days of a hearing or meeting, a best practice confirmed through benchmarking analysis.

Although most hearings are held in Ottawa, an increasing number of affected communities use videoconferencing as a cost-effective way to participate. The Commission Tribunal offers teleconference and videoconference services to facilitate access to public hearings and meetings. Since the last reporting period, and as part of the CNSC's ongoing efforts to provide easier access to the Commission Tribunal's proceedings and enhance the visibility of the CNSC, the public can now view live Webcasts of all public hearings and meetings through the organization's external Web site. Archived Webcasts of past proceedings are also available online for three months following the proceedings. Note that in an effort to encourage public participation, the Commission Tribunal periodically holds licensing hearings relating to large, complex facilities in the local communities.

In 2008–2009, the Commission Tribunal conducted 20 hearings, with a total of 221 intervenors participating through written and oral submissions. In 2009–2010, it conducted and documented 10 hearings, where it duly considered submissions from applicants and input from CNSC staff and stakeholders. A total of 187 intervenors participated through written and oral submissions. In 2010–2011, the Commission Tribunal conducted 10 hearings. A total of 428 intervenors participated through written and oral submissions.

E.5 A system of prohibition of the operation of spent fuel or radioactive waste without a licence

Under section 26 of the NSCA, no person may possess, package, transport, manage, store or dispose of a nuclear substance, except in accordance with a licence issued by the CNSC or when exempted by the regulations. Since all radioactive waste contains nuclear substances, radioactive waste is subject to the NSCA and associated regulations.

E.6 System of institutional control, regulatory inspection, and documenting and reporting

E.6.1 General description of the Compliance Program

As stated in section E.4.1, only the Commission Tribunal or a designated officer can issue licences to operate spent fuel and waste management facilities.

Section 30 of the NSCA authorizes the CNSC staff who are designated inspectors to carry out inspections and verify licensee compliance with regulatory requirements, including licence conditions. Licensees must have an approved set of programs and processes in place that adequately protect the environment and human health and safety.

The CNSC's regulatory policy *Compliance* (P-211) is implemented through a corporate-wide Compliance Program, the output of which is integral to the operating licence renewal process and which integrates all three compliance elements:

- promotion to encourage compliance
- verification activities to confirm that licensees are complying with safety provisions
- reactive control measures to enforce compliance

The CNSC rigorously enforces its regulatory requirement through a variety of measures such as inspections, reviews, audits and assessments. The CNSC's staff:

- apply regulatory requirements in a manner that is fair, predictable and consistent
- use rules, sanctions and processes that are securely founded in law and graded according to the seriousness of the violation, the compliance history of the licensee and the actions of the licensee once the violation is discovered
- establish and maintain a compliance verification program based upon the level of risk that the radioactive material or activity presents to human health, its authorized use and the environment
- ensure that its compliance activities are conducted by trained and qualified staff
- develop and implement a compliance promotion strategy and a compliance-enforcement strategy

E.6.2 Compliance promotion

The Compliance Program aims to inform the regulated community of the rationale behind the regulatory regime, disseminate information to regulated areas about regulatory requirements and standards, and design realistic and achievable requirements and standards. Promotional activities include communication and consultation.

The most common communication and consultation activity used to promote compliance consists of regularly scheduled meetings with the licensee, at which ongoing activities and developments, licensing and compliance issues, safety performance, outstanding commitments and emerging issues are discussed. Generally, compliance verification activities also result in follow-up meetings. The frequency of planned meetings varies by licensee, facility and risk level.

E.6.3 Compliance verification

To verify compliance with regulatory requirements and licence conditions, the CNSC:

- evaluates a licensee's operations and activities
- reviews, verifies and evaluates licensee supplied information
- ensures that administrative controls are in place
- evaluates a licensee's remedial action and any actions taken to avoid future incidents

Programs cited in the licence or previously assessed during the licence application review process are evaluated. The CNSC checks that a licensee's activities meet acceptance criteria derived from:

- legal requirements
- the CNSC policies, standards, or guides that clarify how the Commission Tribunal intends to apply the legal requirements
- licensee-supplied information that expressly states the licensee's intentions to meet the legal requirements in performing the licensed activity
- the CNSC staff's expert judgment, including knowledge of industry best practices

CNSC staff assess licensee programs and their implementation according to the following four ratings:

FS Fully satisfactory
SA Satisfactory
BE Below expectations
UA Unacceptable

The following categories are used to summarize all assessment and inspection results, as well as group licensee programs and performance in several safety areas being evaluated for licensing purposes. A standard list of programs or topics has been developed for each type of facility and may include:

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards
- packaging and transport

Compliance verification results are used in licence renewals and mid-term reports.

E.6.3.1 Regulatory inspections

Type II inspections

Type II – or routine – inspections provide an overall perspective of the status of a facility in the area examined and note any obvious deficiencies or abnormalities. These may be planned or unscheduled inspections, but are usually conducted according to written check sheets, which allow an inspector to record his or her observations and recommendations for follow-up action. Check sheets are dated, signed and kept on file.

Type I inspections

Type I evaluations are usually done according to inspection guides prepared for that specific occasion. The results are recorded and sent to the licensee for follow-up action, as necessary, and kept on file. When planned, the inspections are coordinated with the licensee and meetings are scheduled. When unscheduled inspections arise, follow-up meetings may not always be possible due to scheduling conflicts among the licensee's contacts.

Type I audits are always planned to a high degree of detail, with acceptance criteria spelled out in advance. The licensee is notified in advance of the audit and its subject area. Entrance meetings, daily briefings of audit results and exit meetings are included in audit plans. Staff who conduct the audit are chosen for their expertise in the area being assessed. They could include specialists from head office, project officers on site or from head office, or a combination of the two. The audit results are recorded in a CNSC report to the licensee and follow-up actions are recorded and assigned dates for completion.

E.6.3.2 Regulatory reporting

CNSC staff also assess the contents of submitted operating reports. Licensees are required to submit operating reports to the CNSC according to licence conditions. The frequency of these submissions varies by licensee, facility and risk level, but generally ranges from quarterly to annually. The analysis of safety-significant events is another component in the safety performance evaluation of a facility. The objective of these analyses is not for the CNSC staff to duplicate reviews done by licensees, but to ensure that licensees have adequate processes in place to take corrective actions when needed and integrate lessons learned from past events into day-to-day operation.

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Figure E.5 – Compliance verification

E.6.4 Compliance enforcement

The CNSC uses a gradual approach to enforcement, commensurate with the risk or regulatory significance of the violation. The enforcement tools available to the CNSC are:

- discussion
- verbal or written notice
- warning
- increased regulatory scrutiny
- issuance of an order
- licensing action (e.g., amendment or suspension of part of a licence)
- revocation of personal certification
- prosecution
- revocation or suspension of a licence

Depending on the effectiveness of the initial action, subsequent enforcement measures of increasing severity may be invoked.

E.7 Considerations taken into account in deciding whether or not to regulate nuclear substances as radioactive waste

Section E.3.1 indicates that the CNSC is authorized, under the NSCA, to regulate nuclear substances so as to protect human health and the environment. The CNSC regulatory policy P-290, *Managing Radioactive Waste,* defines radioactive waste as any waste containing a nuclear substance, leaving no room for regulatory doubt, and promotes the following key principles with respect to radioactive waste:

- The generation of radioactive waste should be minimized to the extent practicable.

- Radioactive waste should be managed in a manner that is commensurate with its radiological, chemical and biological hazards.

(For a full description of regulatory policy P-290, refer to section B.5.)

E.8 Establishment of the regulatory body

E.8.1 Funding the CNSC

The CNSC is a departmental corporation, listed in Schedules II and V of the *Financial Administration Act.* The NSCA stipulates that the CNSC report to the Parliament of Canada through a member of the Privy Council for Canada who is designated by the Governor in Council. Currently, this designate is the Minister of Natural Resources Canada. The Commission Tribunal requires the involvement and support of the Minister for special initiatives such as amendments to regulations and requests for funding.

The CNSC's operations are funded primarily from fees collected from industry (licensees), pursuant to the CNSC *Cost Recovery Fees Regulations*, and secondarily through an annual appropriation from Parliament. The CNSC has a revenue spending authority that allows it to spend the revenues collected to fund the cost of activities that are cost recoverable as per the Regulations. This authority provides a sustainable and timely funding regime to address rapid changes in the regulatory oversight workload associated with the Canadian nuclear industry.

E.8.2 Maintaining competent personnel

The CNSC has been successful in attracting qualified candidates and has reached its optimal employee complement. Between April 1, 2008 and March 31, 2011, the CNSC hired approximately 370 people, which represents an increase of roughly 23 percent. Over the last year, the CNSC's efforts have shifted from recruitment to retention and development of its current workforce.

In support of this direction, the CNSC has developed a Strategic HR Plan for 2010 to 2013 which outlines the priorities and strategies that will allow the CNSC to support the retention and development of its workforce. This strategy emphasizes knowledge management, succession planning, human resources planning, and learning, and raises the CNSC's profile to become an employer of choice.

Given the importance of employee development, the CNSC continues to encourage learning and development opportunities for managers and employees. The implementation of mandatory individual learning plans ensures that employees prepare for future careers with the CNSC, while building the skills required for their current roles. In addition to the more than 100 in-house courses offered each year, the CNSC encourages employees to attend external training courses, as well as to consider assignments, independent study and on-the-job training.

The CNSC is placing particular emphasis on developing and implementing a comprehensive Inspector Training and Qualification Program.

New employees and managers at the CNSC are further supported by a recently revised orientation program, which includes a comprehensive orientation manual, a two-day in-class orientation session, three on-line orientation modules (general orientation, introduction to radiation protection, and health and safety) and monthly lunch-and-learn sessions on a variety of topics related to the CNSC and its mandate.

The CNSC also continues to contribute to the CANTEACH and University Network of Excellence in Nuclear Engineering (UNENE) programs. (See section F.3.2.)

E.8.2.1 Aboriginal consultation

As an agent of the Government of Canada and as Canada's nuclear regulator, the CNSC recognizes and understands the importance of consulting and building relationships with Canada's Aboriginal peoples. The CNSC ensures that all its licensing decisions under the *Nuclear Safety and Control Act* and environmental assessment decisions under the *Canadian Environmental Assessment Act* uphold the honour of the Crown and consider Aboriginal peoples' potential or established Aboriginal or treaty rights pursuant to section 35 of the *Constitution Act*, 1982 (together, the "Aboriginal Interests").

The CNSC is also mindful of its role as a statutory administrative tribunal exercising quasi-judicial powers, which confers on it the duty to fairly treat all participants in its proceedings. When developing and implementing consultation processes, the CNSC takes into account the guiding principles that have emerged from Canada's case law and best consultation practices as outlined in *Aboriginal Consultation and Accommodation – Updated Interim Guidelines for Federal Officials to Fulfill the Legal Duty to Consult* (2011).

Insofar as its statutory functions allow, the CNSC supports a whole-of-government approach to Aboriginal consultation, with an aim to coordinating consultative efforts, where feasible, with other federal, provincial, and/or territorial regulatory departments and agencies through a one-window approach, with respect to environmental assessment and licensing activities.

Further information is available on the CNSC Web site at: nuclearsafety.gc.ca/eng/lawsregs/dutytoconsult

E.8.2.2 Management system

The CNSC is formally committed to aligning its management system in accordance with the requirements and guidance set out in both the IAEA's Safety Standard for integrated management systems *The Management System for Facilities and Activities* (GS-R-3) and also the Government of Canada's framework for excellence known as the Management Accountability Framework. To help drive and coordinate the continual strengthening of the management system, the Internal Quality Management Division has been given the responsibility of managing all priority improvement initiatives and ensuring corporate-wide alignment and integration throughout the CNSC.

A stronger, more robust management system allows the CNSC to deliver on key goals and objectives across all areas (safety, health, environment, quality, finance, human resources, security, etc.) in a balanced, harmonious and optimal manner. In defining and applying a common set of principles, practices and/or processes across the entire organization the management system provides the CNSC with overarching and uniform management structure by:

- coherently and consistently bringing together and managing all of the organization's regulatory business requirements
- mapping out and managing processes as part of a larger single integrated system to minimize both gaps in direction/guidance and duplication of effort
- clarifying roles, responsibilities and authorities across all areas and all levels
- providing a consistent robust platform for enabling continual improvements

As the top-tier document, the CNSC *Management System Manual* summarizes the integrated management system and provides a strong base for aligning process documentation in the form of processes, procedures, criteria, forms and guides. These lower-tiered documents are developed on a priority basis and are driven by the need for additional guidance and direction for staff, management and/or licensees and other key stakeholders. This practical approach helps the CNSC to continually strengthen its management system such that it is complete, documented and implemented.

E.8.2.3 IRRS mission to Canada

In 2005, the CNSC requested an IAEA Integrated Regulatory Review Services (IRRS) mission to Canada. The CNSC's initial preparation for the mission was a self-assessment covering three modules that focused on the regulation of nuclear power plants:

- general requirements
- regulatory activities
- management system

In the fall of 2007, following a review of IRRS missions conducted in other countries, the CNSC chose to broaden the scope of its planned mission to also include the regulation of nuclear substances, medical and research facilities, waste management facilities, research reactors, and fuel cycle facilities including uranium mines and mills. In 2008, a complementary self-assessment was conducted for the regulatory activities of the Directorate of Nuclear Cycle and Facilities Regulation and the Directorate of Nuclear Substance Regulation. The results of this complementary self-assessment confirmed the direction of the previously identified improvement initiatives, but recommended that they be better coordinated with clearer priorities and shorter-term deliverables.

The need to improve the coordination and to strengthen the implementation of important improvement initiatives led to the development of the Harmonized Plan for Improvement Initiatives (referred to herein as the Harmonized Plan). The Harmonized Plan builds upon initiatives previously identified through prior assessments, audits and evaluations and is refreshed on an ongoing basis. The initial version of the Harmonized Plan was considered to be the corrective action plan addressing remaining outstanding actions from the 2006 self-assessment and those identified in the 2009 IRRS peer review.

The scope of the 2009 IRRS mission included all activities and facilities licensed by the CNSC, with the exception of import and export licences. All activities and facilities within scope were assessed with respect to the eight IRRS modules:

- Module I Legislative and Governmental Responsibilities
- Module II Responsibilities and Functions of the Regulatory Body
- Module III Organization of the Regulatory Body
- Module IV Authorization
- Module V Review and Assessment
- Module VI Inspection and Enforcement
- Module VII Regulations and Guides
- Module VIII Management System

Three technical areas were identified as out of scope for the IRRS mission to Canada: security, emergency preparedness, and safeguards.

The thematic areas (specific facilities, activities or program areas) for the IRRS mission to Canada were the following:

- regulation of nuclear power plant operations
- regulation of nuclear power plant refurbishment
- licensing of new nuclear power plants
- regulation of uranium mining
- radiation protection programs
- environmental protection programs
- implementation of IAEA *Code of Conduct on Safety and Security of Radioactive Sources* (2004)
- implementation of IAEA *Code of Conduct on Safety of Research Reactors* (2004)

Three policy issues were also addressed during the mission:

- research for safety and regulatory purposes
- roles and responsibilities of technical services in support of regulatory decision-makers
- new builds: regulatory transition from pre-operational to operational phases

The peer review team consisted of 21 members, representing 13 countries. The review was completed in June 2009, with the final report issued in November 2009.

The mission report provided a comprehensive summary of the IRRS assessment and identified 19 good practices, 14 recommendations and 18 suggestions that collectively provided excellent feedback to the CNSC and have helped inform the CNSC's ongoing improvement initiatives under the direction of the Harmonized Plan. As of April 2011, improvement initiatives addressing 27 of the combined 32 recommendations and suggestions were completed, with the remaining five initiatives scheduled for completion by the third quarter of 2011–2012.

In response to one of the IRRS's recommendation, CNSC conducted an analysis of how to modernize the current regulatory framework with respect to the requirements for spent fuel and radioactive waste. In addition, the analysis also proposed a plan for new or updated regulations or regulatory guides. This analysis, including a proposed plan for new or updated regulations or regulatory guides was completed in March 2010.

The CNSC has proposed to focus, for the next five years, on the following documents to modernize the regulatory framework with respect to spent fuel and radioactive waste:

- an information document on the licensing of geological repositories
- a regulatory guide for the siting of a geological repository
- a regulatory guide for the post-closure of a geological repository
- a regulatory guide for radioactive waste management programs
- a revision of regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management*

CNSC staff are also conducting an analysis to determine whether or not there is a need to develop radioactive waste and decommissioning regulations. Completion of the needs analysis is planned for 2012.

Preparations for the IRRS follow-up mission are well underway. Scheduled for late November 2011, the scope of the mission will be to verify that the CNSC continues to perform well in areas identified as good practices and that significant progress has been made in addressing the recommendations and suggestions identified during the 2009 IRRS mission.

E.9 Supporting the separation of roles

E.9.1 Separation of the CNSC and organizations that promote and utilize nuclear energy

The NSCA is distinct and comprehensive legislation for the regulation of nuclear activities and the separation of functions of the regulatory body from organizations that promote or use nuclear energy. The CNSC's mandate (see section E.3.1) focuses clearly on the health and safety of persons and the protection of the environment, and does not extend to economic matters.

Section 19 of the NSCA authorizes "the Governor in Council [to], by order, issue to the Commission directives of general application on broad policy matters with respect to the objects of the Commission." However, any political directives given to agencies – such as the CNSC – must be of a general nature and cannot fetter the Commission Tribunal's decision-making authority in specific cases. In addition, all directives must be published in the *Canada Gazette* and put before each House of Parliament.

E.9.2 Values and ethics

The CNSC has a firmly entrenched values and ethics regime, which serves to strengthen and support governance and ethical leadership. The CNSC issued a statement of values in 2000 and established the Values and Ethics Strategy in 2005. This program identifies the values, ethical practices, the advisory structure and the training required to support ethical decision-making. It includes provisions for the disclosure of wrongdoing in the workplace and the protection of employees from reprisal.

In consultation with staff, the Office of Audit and Ethics (OAE) drafted the CNSC Values and Ethics Code in 2010. The Code is a CNSC adaptation of the Values and Ethics Code for the Public Sector that the Treasury Board of Canada prepared as a template for most departments and agencies in compliance with the *Public Servants Disclosure Protection Act*. The Code was approved by CNSC Management Committee on March 31, 2011, and it is expected to be implemented in September 2011.

The OAE continues to post scenarios of ethical dilemmas on the CNSC's Intranet. These have become popular as they feature real cases encountered by the staff. A new policy on conflict of interest and post-employment will be developed in 2011. It aims to expand the directives on the divestment of assets and the establishment of blind trusts, post-employment, outside and political activities. In addition, the new policy will spell out the conflict of interest arising within staff members' multiple assigned duties to address the increase in organizational partnerships between the private, academic and non-profit sectors.

Section F – Other General Safety Provisions

F.1 Scope of the section

This section addresses Articles 21 (Responsibility of the Licence Holder) to 26 (Decommissioning) of the Joint Convention. It provides information about the steps Canada takes to meet its obligations for general safety at the national and facility levels. This section addresses requirements of several IAEA standards. These include:

Article 21 – Responsibility of the Licence Holder – IAEA Safety Standard GS-R-1
Article 22 – Human and Financial Resources – IAEA Safety Standard GS-R-1
Article 23 – Quality Assurance – IAEA Safety Standards GS-R-1, WS-R-1 and Safety Series 50-C/SG-Q
Article 24 – Operational Radiation Protection – IAEA Safety Standard 115
Article 25 – Emergency Preparedness – IAEA Safety Standard GS-R-2
Article 26 – Decommissioning – IAEA Safety Standard WS-R-2 and Safety Guide WS-G-2.4

F.2 Responsibility of the licence holder

Each licensee in Canada has the prime responsibility for the safety of its spent fuel and radioactive waste management facilities. This responsibility includes providing adequate human and financial resources to support the safe management of the spent fuel and radioactive waste management facility over its lifespan.

F.3 Human resources

Adequate human resources are defined as the employment of enough qualified staff to carry out all normal activities without undue stress or delay, including the supervision of work done by external contractors. Section 44(1)(*k*) of the NSCA provides the legislative basis for the qualification, training and examination of staff. Sections 12(1)(*a*) and 12(1)(*b*) of the *General Nuclear Safety and Control Regulations* specify that the licensee must ensure the presence of a sufficient number of trained, qualified workers.

As in the case of many countries with mature nuclear programs, the nuclear sector and the CNSC have both faced challenges in recent years recruiting experienced staff, partly due to an aging Canadian population. The sections below outline initiatives the parties have taken to develop sufficient human resources to ensure the long-term sustainability of the workforce.

F.3.1 University Network of Excellence in Nuclear Engineering

The University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of Canadian universities, nuclear power utilities, and research and regulatory agencies working to support and develop nuclear education and research and development capability in Canadian universities. UNENE was established in July 2002. Its purpose is to assure a sustainable supply of qualified nuclear engineers and scientists that can meet the current and future needs of the national nuclear sector. It accomplishes this through university education and university-based education, and by encouraging young people to choose a career in the nuclear sector. More information is available online at unene.ca

The alliance consists of 10 universities and several industrial partners (CANDU Owners Group, OPG, Bruce Power, AECL, the CNSC and Nuclear Safety Solutions).

Funding provided by all industry partners, the Natural Sciences and Engineering Research Council (NSERC) and the CNSC has been committed towards the support of engineering programs and of education and research in nuclear engineering at the following universities:

- Queen’s University
- University of Toronto
- McMaster University
- University of Waterloo
- University of Western Ontario

- Royal Military College of Canada
- University of Ontario Institute of Technology

The funds will create six research chairs, and sponsor up to 100 students in Masters and Ph.D level programs. In addition, the Nuclear Waste Management Organization (NWMO) has committed funding to an NSERC research chair in nuclear fuel and waste containers research at the University of Western Ontario.

F.3.2 CANTEACH

The CANTEACH program was established by AECL, OPG, the CANDU Owners Group, Bruce Power, McMaster University, École Polytechnique and the Canadian Nuclear Society to meet succession planning requirements. The aim of CANTEACH is to develop, maintain and electronically disseminate a comprehensive set of education and training documents. The CNSC and other industry members are also contributing information to the program. More information is available online at canteach.candu.org/catalog.html#the CNSC

F.3.3 Ontario Power Generation

The Nuclear Waste Management Division (NWMD) of Ontario Power Generation (OPG) currently comprises approximately 300 full-time employees. Staffing demand has increased over the past three years and is expected to continue increasing, primarily due to attrition from retirements. From 2005 to June 2008, OPG recruited 36 positions (2005), 27 positions (2006), 72 positions (2007) and 41 positions (January to June 2008). The 2007 increase in recruitment was primarily due to staffing of the new facilities at Darlington Waste Management Facility, combined with attrition at the other nuclear waste facilities. Staff for the skilled and semi-skilled trades has been recruited from within OPG with an increasing emphasis on the external labour marketplace. Technical and engineering positions have been primarily from external sources, with a mixture of experienced candidates and approximately five new university graduates per year, hired through the University Graduate Training Program.

The NWMD has introduced – or is in the process of introducing – the following recruitment and retention strategies:

- succession management: assessment of leadership capabilities and succession replacement planning for all leadership positions

- participation in the OPG New Grad Internship program where development students are recruited for a 12–18 month assignment in various organizational disciplines

- advance hiring: critical positions in the organization are identified in its succession-management program

- bench strength assessment with recommendations to advance, hire or develop new grads in advance of forecasted attrition

- Development and Co-op Student Program: recruitment each semester of university or college students in technical and business streams for work terms; a number of these co-op students are hired upon graduation in the OPG Grad Training Program

- participation in workforce planning within OPG to ensure adequate recruitment in advance of staffing needs: concentration on the skilled operator and maintenance positions with an induction process to provide core skills training; the NWMD's staffing demand is satisfied by the internal selection and placement processes

- semi-skilled labour: direct hire from community impact areas

With continued emphasis on succession management, workforce planning and staff development, the NWMD is positively positioned to meet its qualified staffing requirements for both the short and long term.

F.3.4 Nuclear Waste Management Organization

Following the Government of Canada's selection of the Adaptive Phased Management (APM) approach in 2007, the NWMO began its evolution from a small study-based group to a sustainable corporation with full responsibility for implementing the plan. Work was undertaken to enhance the organization's long-term viability and improve its capacity to recruit and retain personnel. Investments were made to ensure resource capacity, expertise and sound administrative and management policies and practices to provide a foundation for fulfilling the mandate.

On January 1, 2009, the NWMO became its own employer, with the necessary supporting infrastructure including finance, legal services and human resources. Staffing levels increased from 27 at the end of 2007 to 81 a year later, with further increases to 120 by year-end 2010. Implementing a long-term management plan for spent fuel requires an understanding of the many social issues and concerns associated with this issue. The NWMO's has reinforced its workforce with the addition of specialists in the fields of social research; public, government and Aboriginal engagement; communications; and new media. The NWMO technical research program focuses on spent fuel storage and repository engineering, geosciences and safety assessment. Research also helped to shape development of the site preparation process and continues to support its implementation. Specialized professionals with extensive experience in the nuclear and mining industries have been hired in the areas of geoscience, safety assessment, repository engineering and regulatory affairs. The largest staff additions resulted from an agreement between the NWMO and OPG to transfer to the NWMO all the willing OPG personnel who had been working on both NWMO programs and the OPG's Deep Geologic Repository Project for Low and Intermediate Level Waste. A significant benefit of this arrangement was the acquisition of the experience base of an established nuclear waste management and repository team.

NWMO employees are highly skilled professionals who regularly participate in specialized development and training to complement their technical, professional and academic backgrounds. All new staff are required to complete core business needs training. The NWMO continues to recruit staff in all key skill areas. The organization has also developed succession plans to ensure a sustainable senior management team is in place for the future.

The NWMO's research capability is supported through contracts with more than a dozen Canadian universities. The organization works with an extended group of consultants, practitioners and academics from across Canada and internationally to ensure that APM benefits from the best available research and experience. The NWMO also has contacts with many international organizations and has exchange agreements with national radioactive waste management organizations in Sweden, Finland, Switzerland and France to ensure that best international practices are incorporated in all its activities.

F.4 Financial resources

F.4.1 General

Canada generally applies the "polluter pays" principle, by which the Government of Canada has clearly indicated that waste owners are financially responsible for the management of their radioactive waste, and has set in place mechanisms to ensure that this financial responsibility does not fall to the Canadian public. This position was reaffirmed in the 1996 Government of Canada *Policy Framework for Radioactive Waste* (refer to section B). In 2002, under the *Nuclear Fuel Waste Act*, the owners of spent fuel were specifically required to establish segregated funds to fully finance long-term waste management activities.

F.4.2 Historic waste

In instances where remedial actions are required at uranium mine and mill tailings facilities, but where the owner no longer exists, the federal and provincial governments ensure that the sites are safely decommissioned. In Ontario, home of the former Elliot Lake uranium mining complex, the Governments of Canada and Ontario entered into a Memorandum of Agreement in 1996 that outlined their respective roles in the management of abandoned uranium mine and mill tailings. Under the agreement, the costs associated with any necessary remediation at an abandoned site will be split between the two governments on a 50/50 basis. To date, these arrangements have not been necessary, as all Ontario sites have owners that are complying with their responsibilities.

In September 2006, the Governments of Canada and Saskatchewan entered into a Memorandum of Agreement to share the estimated $24.6 million cost of remediating the Gunnar uranium mine and mill site, as well as numerous small satellite uranium mine sites in northern Saskatchewan. Private sector companies that no longer exist operated these sites during the Cold War from the 1950s until the early 1960s. When the sites were closed, no regulatory framework was in place to ensure appropriate containment and treatment of the waste, which has led to environmental impacts to local soils and lakes. Phase 1 (environmental assessment and licensing) of the project to remediate these sites began on June 15, 2007. The environmental impact study for the project was submitted for review to the CNSC in January 2011. An additional site, the Lorado uranium mill, is being remediated under a separate agreement between the Government of Saskatchewan and EnCana Corporation, the successor to the original owner and operator, Lorado Uranium Mines Ltd.

F.4.3 Financial guarantees

Licensees of spent fuel and radioactive waste management facilities and uranium mines and mills must provide guarantees that adequate financial resources are available for decommissioning of these facilities and managing the resulting radioactive wastes, including spent fuel.

Section 24(5) of the NSCA provides the legislative basis for this requirement. Section 3(1)(*l*) of the GNSCR stipulates that "an application for a licence must contain a description of any proposed financial guarantee related to the activity for which a licence application is submitted." Regulatory guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities,* covers the provision of financial guarantees for decommissioning activities. Regulatory guide G-219, *Decommissioning Planning for Licensed Activities,* provides guidance on the preparation of plans for the decommissioning of activities licensed by the CNSC. These guides can be viewed at nuclearsafety.gc.ca

Also, since the last reporting period, CNSC staff participated in the development of a Nuclear Energy Agency (NEA) document on cost estimation for decommissioning. The document, published in early 2010, provides an international overview of cost elements, estimation practices and reporting requirements.

Financial guarantees must be sufficient to fund all approved decommissioning activities. These activities include not only dismantling, decontamination and closure, but also any post-decommissioning monitoring or institutional control measures that may be required, as well as subsequent long-term management or disposal of all wastes, including spent fuel. To ensure that licensees are required to cover the costs of spent fuel only once, the money in the trust funds set up under the *Nuclear Fuel Waste Act* is considered part of the licensee's total financial guarantee to the CNSC.

The CNSC must be assured that it (or its agents) can access adequate funding measures upon demand, if a licensee is not available to fulfill its obligations for decommissioning. Measures to fund decommissioning may involve various types of financial guarantees. Acceptable guarantees include: cash, letters of credit, surety bonds, insurance, and legally binding commitments from a government (either federal or provincial). The acceptability of any of the above measures will be determined ultimately by the CNSC according to the following general criteria:

- **Liquidity**: The proposed funding measures should be such that the financial vehicle can be drawn upon only with the approval of the CNSC, and that payout for decommissioning purposes is not prevented, unduly delayed or compromised for any reason.

- **Certainty of value**: Licensees should select funding, security instruments and arrangements that provide full assurance of their value.

- **Adequacy of value**: Funding measures should be sufficient, at all or predetermined points in time, to fund the decommissioning plans for which they are intended.

- **Continuity**: The required funding measures for decommissioning should be maintained on a continuing basis. This may require periodic renewals, revisions, and replacements of securities provided or issued for fixed terms. For example, during a licence renewal, the preliminary decommissioning plan may be revised and the financial guarantee updated accordingly. Where necessary, to ensure that there is continuity of coverage, funding measures should include provisions for advance notice of termination or intent to not renew.

Since 2000, the CNSC has concentrated on financial guarantees for large complex facilities and has required all major licensees with Class 1 operating facilities and uranium mines and mills to have financial guarantees in place. Since the last reporting period, CNSC staff have developed a new discussion paper on the implementation of financial guarantees for licensees. The paper outlines the CNSC's plans to broaden the financial guarantee program over the next two years to require all sites and activities licensed by the CNSC to have financial guarantees. The financial guarantee policy was issued for public comment in February 2011.

International opinion (IAEA, NEA) has evolved substantively over the last several years in this area. In March 2011, in keeping with current international opinion, the CNSC issued discussion paper DIS-11-01, *Implementation of Financial Guarantees for Licensees*. This document proposes a new financial guarantee policy which states: "It is the policy of the Canadian Nuclear Safety Commission (CNSC) that a financial guarantee be required of licensees for all facilities and activities licensed by the CNSC, unless in the opinion of the Commission Tribunal a financial guarantee is not required." In December 2011, the Commission Tribunal will consider the draft position paper for implementation.

Should this policy be implemented, the CNSC will issue supporting regulatory documents which will advise licensees and applicants of CNSC expectations regarding financial guarantees.

F.5 Quality assurance

F.5.1 QA program requirements

NSCA regulations require licensees to prepare and implement quality assurance (QA) programs for nuclear facilities. The licensees of spent fuel and radioactive waste management facilities submit their overall QA programs to the CNSC before they start their planned activity. The organization responsible for a facility must establish and implement a QA program for the items and services that the facility supplies. The overall QA program may cover the licensed spent fuel and radioactive waste management activities for more than one site. After a licence is granted, the involved organization must demonstrate the effectiveness of the QA programs.

The requirements for the management of safe operation for nuclear power plants and power reactors research facilities are in a transition from that of a Quality Assurance Program as per the CSA N286 Series of QA Standards to that of a management system as per CSA Standard N286-05, *Management system requirements for nuclear power plants*. The requirements for a management system emphasize overall safe operations versus specific controls and requirements for safety-related systems and equipment. This standard applies to spent fuel and waste management facilities activities at nuclear power plants.

The QA programs for uranium mines and mills facilities must comply with the QA expectations of the NSCA and UMMR. The application for a licence must provide the QA programs that are being reviewed by CNSC staff. The specific waste management activities are preformed under accepted QA programs. Reviews conducted by CNSC staff during a licence application and QA program changes concentrate on an applicable QA program that satisfies CNSC-accepted QA requirements and on its ability to:

- consistently define roles and responsibilities for the facility
- implement the QA program in a structured manner
- demonstrate control changes and program interactions
- self-assess and take corrective action

F.5.2 QA program assessment

To assess licensee QA programs' effectiveness, CNSC staff examine the results from the licensees' internal reviews and assessments. They also perform detailed reviews of the documents that communicate the QA program requirements to licensee personnel. After the QA program is accepted, the CNSC plans and carries out compliance audits, to ensure that the licensee complies with its provisions. When deficiencies are detected, the CNSC produces detailed reports of the audit findings and forwards them to the licensee for response and corrective actions. Based on the safety significance of the audit findings, the CNSC may decide an enforcement action is appropriate. Section E.6.4 provides further information on the CNSC's compliance enforcement.

F.6 Operational radiation protection

F.6.1 Requirements for doses so they are consistent with ALARA

Operations at Canada's spent fuel and radioactive waste management facilities must be carried out to ensure that doses to workers, the public and the environment are as low as reasonably achievable, economic and social factors taken into account (the ALARA principle). This approach is legislatively supported through the NSCA and the *Radiation Protection Regulations* (RPR). Doses are minimized through practices such as:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual circumstances
- ascertaining of the quantity and concentration of any nuclear substance released as a result of a licensed activity

In October 2004, the CNSC issued, in support of this requirement, regulatory guide G-129 rev 1, *Guidelines on How to Meet the Requirements to Keep All Exposures As Low As Reasonably Achievable*.

F.6.2 Derived release limits

Some nuclear facilities release small quantities of gaseous radioactive material in a controlled manner into the atmosphere (e.g., incineration of radioactive waste) and into adjoining water bodies as liquid effluents (e.g., treated waste water). Radioactive material released from nuclear facilities into the environment through gaseous and liquid effluents can result in radiation doses to members of the public, through one or more of the following ways:

- direct irradiation
- inhalation of contaminated air
- ingestion of contaminated food or water

Doses received by members of the public through routine releases from nuclear facilities are very low – almost always too low to measure directly. Therefore, to ensure that the public dose limit is not exceeded, the RPR limits the amount of radioactive material released in effluents from nuclear facilities. These effluent limits are derived from the public dose limit, and are referred to as "derived release limits" (DRLs). The nuclear sector sets operating targets or administrative limits that are typically a small percentage of the derived release limits. These targets are based on the ALARA principle and are unique to each facility, depending on the factors that exist at each site.

When approving DRLs for nuclear facilities, the CNSC considers the environmental pathways through which radioactive material could reach the most exposed members of the public – also known as the "critical group" – after being released from the facility. Members of the critical group are those individuals expected to receive the highest dose of radiation because of their age, diet, lifestyle and location.

Figure F.1 – Effluent monitoring

F.6.3 Action levels

Licensees are required, through the RPR, to establish “action levels”. An action level is a specific level that, if reached, may indicate a loss of control of part of the radiation protection program. When an action level is reached, the following actions must be taken:

- notify the CNSC
- investigate to establish the cause
- take action to restore the effectiveness of the radiation protection program

Regulatory guide G-228*, Developing and Using Action Levels,* has been published by the CNSC to help licensees develop action levels in accordance with section 6 of the RPR.

F.6.4 Dosimetry

The CNSC requires that every licensee ascertain and record the magnitude of exposure to workers by direct measurement or monitoring or, in cases where this is not possible, by estimation. If a nuclear energy worker has a reasonable probability of receiving an effective dose of greater than 5 mSv, the licensee is required to use a licensed dosimetry service. Dosimetry services are also licensed by the CNSC under the RPR. Requirements for licensing are found in S-106 rev.1, *Technical and Quality Assurance Requirements for Dosimetry Services* (March 2006).

F.6.5 Preventing unplanned releases

The nuclear sector uses several means to reduce the risk of unplanned effluent releases of radioactive material into the environment: multiple barriers, reliable components and systems, competent staff and the detection and correction of failures.

Due to the robust design of storage facilities housing high-risk materials such as spent fuel, the potential for a significant release is present mainly when materials are handled. Such operations are closely monitored by licensee staff who would be available in the unlikely event of an accidental release. The process of transferring waste from the point of origin to a storage site is subject to stringent control and is only done in the safest possible manner. Some of these controls involve transporting the spent fuel at extremely low speeds and prohibiting the transfer of spent fuel during periods of rain or snow.

In the event of an uncontrolled release into the environment, competent licensee staff is available for an initial mop-up exercise, preventing further spread of radioactive contaminants. If necessary, the stored waste may be retrieved and held more securely. Depending on the magnitude and seriousness of the release, emergency procedures and emergency preparedness plans may be activated.

F.6.6 Protection of the environment

Regulatory policy P-223, *Protection of the Environment*, describes the philosophy, principles and fundamental factors that guide the Commission Tribunal as it regulates the production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information. These are regulated in order to prevent unreasonable risk to the environment, in a manner consistent with Canadian environmental policies, acts and regulations, and with Canada's international obligations. This policy applies to all regulatory decisions made by the Commission Tribunal or CNSC staff. P-223 applies to all types of CNSC licences, including decommissioning.

Regulatory standard S-296, *Developing Environmental Protection Policies, Programs and Procedures at Class 1 Nuclear Facilities and Uranium Mines and Mills*, sets out the environmental protection policies, programs and procedures that licensees must implement at uranium mines and mills and Class I nuclear facilities – which include spent fuel and radioactive waste management facilities – when required by the applicable licence or other legally enforceable instrument.

The requirements of an environmental management system (EMS) include the following tasks:

- Establish, implement and maintain an EMS that meets the requirements set by the Canadian Standards Association's ISO 14001:2004, *Environmental Management Systems – Requirements with Guidance for Use*. Certification to ISO 14001 by an authorized registrar or other independent third party is not considered by the CNSC as meeting the requirements of this standard. The CNSC, in exercising its responsibilities as outlined in the NSCA, will evaluate all licensees' programs in relation to the requirements of this standard.

- Ensure that the scope of the EMS is consistent with the definitions of "environment", "environmental effect" and "pollution prevention", as provided in the S-296 glossary.

- Conduct internal audits (clause 4.5.5 of ISO 14001:2004) at planned intervals so that all elements of the EMS are audited on at least a five-year cycle.

- Conduct a management review (clause 4.6 of ISO 14001:2004) annually.

The supporting regulatory guide G-296, *Developing Environmental Protection Policies, Programs and Procedures at Class 1 Nuclear Facilities and Uranium Mines and Mills*, was released along with S-296. The purpose of this regulatory document is to help applicants seeking a licence for Class I nuclear facilities and uranium mines and mills (other than a licence to abandon) to develop and implement environmental protection policies, programs and procedures in accordance with the NSCA and its associated regulations. G-296 outlines the scope of an EMS, recognizing that the complexity of the EMS documentation should be appropriate for the nature and scale of the environmental effects that may result from licensed activities. ISO 14001, with a few additional CNSC-specific requirements, is the basis for the CNSC regulatory standard S-296 and may be incorporated in a licence as a legal requirement. For all licences, the information provided in G-296, along with ISO 14001 and ISO 14004, can be used to develop an EMS that will meet the CNSC requirements for policies, programs and procedures in environmental protection.

In a manner that is appropriate for the facility type and phase of licensing, the EMS should include the proposed measures to control the release of nuclear substances, hazardous substances, or both, into the environment, and the measures that will be taken to mitigate the effects.

In terms of releases, the EMS should be commensurate with overall regulatory requirements, the specific information provided on the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics.

In terms of wastes, the EMS should be commensurate with overall regulatory requirements and the specific information provided on the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activity to be licensed. This includes waste that may be stored, managed, processed or disposed of at the site of the activity to be licensed, and the proposed method(s) for managing and disposing of that waste. For uranium mines and mills, there is a further requirement to address management of the anticipated liquid and solid waste streams within the mine or mill, including:

- the ingress of fresh water and any diversion or control of uncontaminated surface and groundwater
- the anticipated quantities, composition and characteristics of backfill
- the proposed waste management system

As a further consideration, the EMS should address environmental emergency preparedness and respond by proposing measures:

- to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment
- to protect the health and safety of persons

Reporting requirements for certain emergency situations should also be included in the EMS. Lastly, additional elements relating to worker training or qualifications, and the environmental protection obligations of workers should be included. Training programs should enable workers to meet their obligations with respect to environmental protection.

F.6.6.1 Monitoring and measurement

Licensees should establish procedures to measure, monitor and evaluate environmental performance relative to the performance indicators and targets they have set to achieve their environmental objectives. Measurement and evaluation are the best way to verify whether the controls placed on contaminants are effective. For licensees to achieve their performance targets it is important that the overall monitoring process include continual feedback mechanisms. Such mechanisms enable licensees to take appropriate action when necessary. Monitoring should be conducted on a spatial and temporal scale and reflect the environmental effects predicted in an environmental assessment.

Effluent monitoring should be the primary indicator of performance in terms of releases to air, surface waters, groundwater and soil. Effluent monitoring addresses both the nature and quantity of releases of nuclear and hazardous substances (including wastes). Monitoring schedules should be controlled administratively to help prevent situations that might lead to unreasonable risk for the environment. Targets should be designed that will prompt investigations – and thus lead to preventive measures – when situations are abnormal.

As part of a Code of Practice for Uranium Mines and Mills, certain performance targets (action levels) must be developed to protect the environment. These should address how releases at the source are managed. All facilities require action levels for the radiation protection program. Although specific to radiation protection, regulatory guides G-218, *Preparing Codes of Practice to Control Radiation Doses at Uranium Mines and Mills*, and G-228, *Developing and Using Action Levels,* provide useful generic guidance on the principles underlying action levels. These principles, along with ALARA (as outlined in regulatory guide G-129 (revision 1), *Guidelines on How to Meet the Requirements to Keep All Exposures As Low As Reasonably Achievable* should be used to develop targets for environmental performance.

Class I nuclear facilities do not require a Code of Practice for environmental protection. However, licensees of Class I nuclear facilities should ensure their operations can control releases that are potentially harmful. The development of administrative controls typically requires modelling of environmental pathways, in order to derive release targets that can be interpreted in terms of levels in environmental media. These levels are chosen to protect the environment as a whole, with adequate safety margins. The *Canadian Environmental Quality Guidelines* provide practical guidance on levels that are thought to be sufficiently protective. Alternatively, levels can be derived from assessments performed under the CEA Act, the CEPA, or the NSCA.

Facilities that may potentially expose the public to releases are also expected to develop derived release limits (DRLs), historically referred to as derived emission limits (DELs). Facilities calculate DRLs through multimedia pathways modelling; DRLs represent estimates of releases that could result in doses to the public that equal the prescribed public limit (for effective dose of 1 mSv) or equivalent dose limits. If not referenced in the EMS as part of licensing documentation, DRLs may be incorporated separately as a licence condition.

F.6.6.2 Environmental Monitoring (CSA Revised Standard N288.4)

With the promulgation of the NSCA in 2000, protection of the environment (as opposed to the previous human-focused legislation) from both radionuclides and hazardous substances also became the responsibility of the CNSC. As mentioned in the previous reporting period, CSA document N-288 issued in 1990 had several identified gaps; therefore, it was recognized that a revised environmental monitoring standard/guide was required.

In June 2010, a revised version of N288.4 was developed by CNSC staff by working with the CSA. This current document addresses radiological, conventional (i.e., hazardous substances) and physical stressors and pathways for both human and non-human biota. In February 2011, the CNSC met with affected licensees through a CSA meeting to provide them with the items the licensees needed to implement, as set out in the action plan that the CNSC developed. In March 2011, the affected licensees met again to discuss a timeline associated with each item identified in the action plan. The CNSC is currently waiting for the outcome of this meeting to follow up with licensees.

F.6.7 Canadian Nuclear Safety Commission activities

To verify compliance with the requirements of a licence and regulations, CNSC staff:

- review documentation and operational reports submitted by licensees
- conduct radiation protection evaluations
- conduct evaluations of licensee environmental-protection programs and other programs as required

A detailed description of the compliance verification program is provided in section E.6.3.

F.7 Nuclear emergency management

Nuclear emergency preparedness and response in Canada is a multi-jurisdictional responsibility shared by all levels of government and the licensees. In emergency situations, licensees are responsible for protecting health, safety, security and the environment by preventing or mitigating the effects of accidental releases of nuclear or hazardous substances. Licensees must also respect Canada's international commitments on the peaceful use of nuclear energy. The provinces and territories have primary responsibility to implement measures for civil protection and offsite nuclear emergency preparedness and response, including designating municipalities to carry out nuclear emergency planning within their jurisdictions.

The Government of Canada is responsible, through the Federal Nuclear Emergency Plan (FNEP), for coordinating federal actions that support provinces and territories during a nuclear or radiological emergency, as well as to respond to emergencies that have international implications. The FNEP outlines the Government of Canada's role in such situations, how it must be organized and its capability to respond to a nuclear emergency. Health Canada, as the lead department, is responsible for coordinating the federal nuclear emergency response of more than 14 departments and six federal agencies, including the CNSC. These organizations each have distinct roles and responsibilities, thus making a structured framework essential. The FNEP provides this structure.

The CNSC employed a collaborative approach in developing its Nuclear Emergency Management (NEM) Policy, regulatory policy P-325, *Nuclear Emergency Management*, and upgraded programs. The CNSC developed the policy in partnership with external stakeholders and included extensive consultations with licensees, the public, and provincial, territorial, municipal and federal government organizations involved in emergency management.

The CNSC NEM Policy provides the foundation for all of the CNSC emergency management activities. Specifically, it outlines responses consistent with the risks at hand, clarifies roles and responsibilities, and helps maintain the current capacity while taking future requirements into consideration. In addition to developing the policy, it has also identified key elements of an improved nuclear emergency management program. As part of this emergency management program, the CNSC maintains thorough emergency plans and procedures which are routinely reviewed and updated as required.

The CNSC Emergency Operations Centre (EOC) has been modernized in recent years to increase its reliability and functionality and to enhance its backup resources, including the installation of an emergency power generator at the CNSC headquarters site to ensure an uninterrupted response by the CNSC in the event of a power outage. In addition, CNSC Emergency Management Programs Division staff have conducted extensive training with their emergency response organization as well as with other federal departments on their roles, responsibilities, procedures and emergency response to radiological and nuclear-related events, and have reactivated the federal–provincial–territorial committee on radiological/nuclear emergencies.

The CNSC requires licence applicants to assess the impacts of their proposed activities on health, safety, security and the environment, and to propose measures to prevent or mitigate the effects of accidental releases of nuclear or hazardous substances. Once the CNSC has reviewed and accepted these measures and has issued a licence, the measures become binding upon the licensee. Due to the variety of risk among radioactive waste facilities in Canada, some facilities require detailed emergency preparedness and response plans coordinated with mutual aid organizations, while others may require internal emergency procedures only.

The CNSC maintains its regulatory role and responsibilities through direct oversight of the licensees' response actions and provides technical and advisory support to the provincial, territorial and federal authorities through the FNEP. These responsibilities encompass a wide range of contingency and response measures to prevent, correct or mitigate accidents, spills, abnormal situations and emergencies.

In Ontario, 20 of Canada's 22 reactors and the largest nuclear waste management facility are located. In 2004, the Government of Ontario named its first Commissioner of Emergency Management in 2004. The Commissioner's role is to:

- oversee Ontario's emergency planning and preparedness
- monitor emergency situations in other jurisdictions to ensure the entire province is prepared for similar situations
- work in partnership with the Government of Canada on the co-location of an emergency management centre
- lead the development of regulations to implement emergency management across key government ministries
- assist in reviewing the current provincial *Emergency Management Act* and related legislation and regulations

Quebec has only one reactor, which is located at Gentilly near Trois-Rivières on the St. Lawrence River. The Organisation de la sécurite civile du Québec (OSCQ) has led the emergency management effort for all hazards, including offsite nuclear emergencies. OSCQ has a plan in place, the Plan des mesures d'urgence nucléaire externe de la centrale nucléaire de Gentilly-2 (PMUNE-G2). This plan is in accordance with several of Quebec's provincial acts of legislation, such as la *Loi sur la sécurité civile* (L.R.Q., c. S-2.3), the *Loi sur la Santé publique* (L.R.Q., c. S-2-2) and others, which define the responsibilities of the government agency with specific objectives for minimizing consequences, protecting the public and providing support to the municipality.

New Brunswick also has only one reactor, located near Point Lepreau. The New Brunswick Emergency Measures Organization (NB EMO) coordinates emergency preparedness for New Brunswick's provincial and municipal governments. NB EMO works at the provincial and municipal levels through district coordinators to ensure that the province and its communities have appropriate and tested emergency plans. In addition, New Brunswick has invested significantly in provincial communications infrastructure to improve connectivity and harmonization with federal and provincial intervening organizations during a nuclear emergency.

Saskatchewan has several uranium mines in the northern part of the province. The Saskatchewan Emergency Management Organization (SaskEMO) is the provincial government's lead agency for emergency management. SaskEMO coordinates overall provincial emergency planning, training and response operations for the safety of residents and the protection of property and the environment before, during and after an emergency. Corrections and Public Safety, through SaskEMO, is the provincial government's lead agency for emergency management. Corrections and Public Safety is responsible for *The Emergency Planning Act* (November 1, 1989) which contains provisions for emergency planning, emergency powers and disaster relief. SaskEMO supports community preparedness by encouraging the formation of local government emergency measures organizations, assisting in the development of location emergency plans and providing onsite consultation to municipal officials during government-declared states of emergency. SaskEMO also supports provincial preparedness by maintaining the provincial government emergency plan and related contingencies, coordinating provincial government resources during a state of emergency, assisting government departments, Crown corporations and agencies with emergency planning, and coordinating with Government of Canada emergency preparedness programs within Saskatchewan.

In Nova Scotia, many shipments containing radioactive substances pass through the dock at the Port of Halifax. The *Emergency Measures Act* is Nova Scotia's emergency-management and emergency-powers legislation. It establishes the rules for managing emergencies in Nova Scotia and requires municipal governments to have emergency plans. The Nova Scotia Emergency Measures Organization (NS EMO) is the lead agency to ensure the safety and security of residents of Nova Scotia, their property and the environment by providing for a prompt and coordinated provincial and municipal response to an emergency. This is accomplished through cooperative and consultative planning before emergencies occur and by coordinating the provision of provincial resources to assist with the response. The NS EMO facilitates and coordinates communication and emergency planning efforts between all levels of government.

F.7.1 The CNSC's assessment of licensees' emergency management programs

Applicants, including those for spent fuel and radioactive waste management facilities, must submit their emergency plans as part of their licence application. CNSC staff then review and evaluate those plans, according to regulatory criteria and guidance documents. Once the CNSC has issued a licence, CNSC staff regularly review and perform audits of the licensees' emergency plans.

F.7.2 Types of nuclear emergencies

With respect to nuclear accident mitigation, emergency planning includes both onsite and offsite consequences, as described below:

- Onsite nuclear emergencies are those that occur within the physical boundaries of a nuclear facility licensed by the CNSC. The operators of those nuclear facilities are responsible for onsite emergency planning, preparedness and response.

- Offsite nuclear emergencies are events that occur outside licensed facilities, but may originate from, or be associated with, a licensed facility or activity, and may even originate outside Canada. Events of this type require intervention from provincial, territorial or municipal authorities operating outside of the licensed facility or activity and likely require support from the licensee and the Government of Canada's Federal Nuclear Emergency Plan (FNEP).

F.7.3 Government of Canada responsibilities

In the event of a nuclear emergency affecting Canada or Canadians abroad, the Government of Canada is responsible for:

- coordinating the federal response and providing support to provinces
- liaising with the international community
- liaising with diplomatic missions in Canada
- assisting Canadians abroad
- coordinating the national response to a nuclear emergency occurring in a foreign country and affecting Canadians
- managing third-party nuclear liabilities

As much as possible, the Government of Canada's emergency planning, preparedness and response is based on the "all-hazards" approach. However, because of the inherent technical nature and complexity of nuclear emergencies, hazard-specific planning, preparedness and response arrangements are required. These special arrangements, which are one component of the larger federal emergency management framework, constitute the FNEP. The FNEP describes the Government of Canada's preparedness for nuclear emergencies and how it would coordinate the federal response.

Within the FNEP's common administrative framework, the development and implementation of emergency preparedness and response plans for the offsite consequences of nuclear emergencies are primarily a provincial/territorial responsibility. However, there are also direct inputs from the local government, the nuclear facility and Government of Canada departments and agencies (including the CNSC). This allows jurisdictions and organizations with various emergency-management responsibilities to act in a cooperative, complementary and coordinated manner.

The Government of Canada is responsible for managing a nuclear civil liability regime that addresses civil liability and compensation for injury and damage arising from nuclear incidents. This regime is established under the *Nuclear Liability Act* (NLA), and the CNSC designates certain nuclear facilities as coming within its scope. Typically, these are facilities where there is a risk of criticality. An operator of such an installation is absolutely and exclusively liable for any civil damages caused by an incident at that installation and carries mandatory insurance. In the event of a serious incident, the NLA provides special compensation measures that may be imposed by government to replace the normal court process. NRCan is the lead department for ensuring the process of compensation is well coordinated and administered in Canada.

F.7.4 International arrangements

Canada has signed and ratified the following three international emergency response conventions:

Canada–U.S. Joint Radiological Emergency Response Plan **(1996)**: This plan focuses on emergency response measures of a radiological nature, rather than generic civil emergency measures. It is the basis for cooperative measures to deal with peacetime radiological events involving Canada, the United States or both countries. Cooperative measures contained in the FNEP are consistent with this plan.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency **(1986)**: This international assistance agreement, which was developed under the auspices of the IAEA, promotes cooperation between signatories and facilitates prompt assistance in the event of a nuclear accident or radiological emergency. Its purpose is to minimize the consequences of such an accident; practical steps include taking measures to protect life, property and the environment. The agreement sets out how assistance is requested, provided, directed, controlled and terminated.

Convention on Early Notification of a Nuclear Accident **(1987)**: This international convention, which was developed under the auspices of the IAEA, defines when and how the IAEA would notify the signatories associated with an international event that could have an impact in their respective countries.

F.8 Decommissioning

In accordance with regulatory guide G-219, *Decommissioning Planning for Licensed Activities*, the CNSC requires Class I facilities and uranium mines and mills licensees to keep decommissioning plans up to date throughout the lifecycle of a licensed activity. The CNSC also requires licensees to prepare a preliminary decommissioning plan and detailed decommissioning plan for approval.

The preliminary decommissioning plan must be filed with the CNSC as early as possible in the lifecycle of the activity or facility. In the case of nuclear facilities, specific requirements for decommissioning planning are set out in the CNSC regulations for uranium mines and mills and for Class I and Class II nuclear facilities.

The preliminary plan documents the preferred decommissioning strategy and objectives at the end of decommissioning. The plan should be sufficiently detailed to assure that the proposed approach is technically and financially feasible. It must also be in the interests of health, safety, security and protection of the environment. The plan defines areas to be decommissioned and the general structure and sequence of the principal decommissioning work packages envisioned.

The applicable regulations and regulatory guide can be viewed on the CNSC Web site at: nuclearsafety.gc.ca

Decommissioning activities are listed in annex 7. Decommissioning waste generated in the last reporting period is listed in section D.

Since the last reporting period, CNSC staff continued to participate in the development of an IAEA Safety Guide on the safety assessment for the decommissioning of facilities that use radioactive material. The IAEA published the safety guide in December 2008. CNSC staff have also contributed to the development of a related IAEA project on the use of safety assessment in the planning and implementation of decommissioning of facilities that use radioactive material. Additionally, CNSC staff participated in the development of a CSA document, N294-09, *Decommissioning of facilities containing nuclear substances*. This document was published in July 2009.

F.8.1 Qualified staff and adequate financial resources

Section 24(5) of the NSCA legislates that licensees of nuclear facilities must guarantee that adequate financing and human resources will be available for the decommissioning of facilities and the management of resulting radioactive wastes, including spent fuel. Section 3(1)(*l*) of the GNSCR states: "An application for a licence shall contain a description of any proposed financial guarantee relating to the activity to be licensed." Section F.4.3 describes the financial guarantees applicable to the decommissioning process. Section 44(1)(*k*) of the NSCA provides the legislative basis for the qualification, training and examination of personnel. Sections 12(1)(*a*) and 12(1)(*b*) of the GNSCR specify that the licensee must ensure the presence of a sufficient number of trained qualified workers.

F.8.2 Operational radiation protection, discharges, unplanned and uncontrolled releases

During decommissioning, the licensee is required to maintain a radiation protection program that takes under consideration the ALARA principle, derived release limits, dose limits and actions levels, measures to prevent or mitigate the effects of unplanned releases, and the protection of the environment.

F.8.3 Emergency preparedness

For nuclear emergency management, an emergency response plan is required during the decommissioning phase. The plan is based on the risk associated with the facility at the time of decommissioning.

F.8.4 Records

As part of the decommissioning planning process, records are reviewed. Relevant aspects are incorporated into the documentation required for formal approval of both preliminary and final decommissioning plans. A preliminary plan serves as the basis for the decommissioning financial guarantees provided by the licensee. The CNSC requires that it be in place prior to the start of construction and operations. A detailed decommissioning plan must be developed while operations approach completion. This serves as the basis for environmental assessments and subsequent licensing of the decommissioning activities. The detailed plan must include a description of the records and information that will be permanently retained and of the reports that are to be submitted to the CNSC.

The licensee must retain specified records and information, typically through the corporate office, as the need for onsite staff diminishes. Reports submitted to regulatory agencies will be retained in accordance with the respective agencies' procedures.

For example, the *Class 1 Nuclear Facility Regulations* require that every licensee who operates a nuclear facility keep a record of the following:

- operating and maintenance procedures
- the results of the commissioning program
- the results of the inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the nuclear facility
- the status of each worker's qualifications, re-qualification and training

Also, every licensee who decommissions a Class 1 nuclear facility must keep a record of the following:

- the progress achieved in meeting the schedule
- the implementation and results of the decommissioning
- the manner in which, and the location at which, any nuclear or hazardous waste is managed, stored, disposed of or transferred
- the name and quantity of any radioactive nuclear substances, hazardous substances and radiation that remain at the nuclear facility after completion of the decommissioning
- the status of each worker's qualifications, re-qualifications and training

These Regulations can be viewed at the CNSC's Web site at: nuclearsafety.gc.ca

Section G – Safety of Spent Fuel Management

G.1 Scope of the section

This section addresses Article 4 (General Safety Requirements) to Article 10 (Disposal of Spent Fuel). It provides a comprehensive description of spent fuel management in Canada. At every stage of spent fuel management, there are effective defences against potential hazards. These defences protect individuals, society and the environment from the harmful effects of ionizing radiation.

In addition to describing facilities and their normal operation, this section discusses the steps and controls in place to prevent accidents with radiological consequences and to mitigate the consequences should such accidents occur. The information contained in this section demonstrates that the requirements of the following applicable IAEA Safety Standards have been addressed:

Article 4 – General Safety Requirements – IAEA Safety Requirements NS-R-1, WS-R-1 and WS-R-2
Article 6 – Siting of Proposed Facilities – IAEA Safety Requirement NS-R-3
Article 7 – Design and Construction of Facilities – IAEA Safety Requirements NS-R-1 and WS-R-1
Article 8 – Assessment of Safety of Facilities – IAEA Safety Requirements NS-R-1, WS-R-1 and Safety Series 115
Article 9 – Operation of Facilities – IAEA Safety Standards NS-R-1, WS-R-1WS-R-2 and Safety Series 115
Article 10 – Disposal of Spent Fuel – IAEA Safety Standard WS-R-1

G.2 Nuclear power plants

In Canada, spent fuel is stored in wet and dry states at the locations where it is produced. When the fuel first exits a power reactor, it is placed in water-filled bays. Water cools the fuel and shields the radiation. After several years in the bays – six to 10 years, depending on site-specific needs and organizational administrative controls – and when the associated heat generation has diminished, the spent fuel can be transferred to an onsite dry storage facility. These dry storage facilities are large, reinforced concrete cylinders or containers. Each nuclear power plant in Canada has enough storage space to store all the spent fuel produced during the operating life of the station. A 600 MW CANDU nuclear reactor produces approximately 20 cubic metres of spent fuel per year.

G.3 CANDU fuel

All CANDU fuel bundles are fabricated from natural uranium oxide pellets, contained in a zirconium-alloy (zircaloy-4) tube (cladding). There are normally 30 uranium oxide pellets per element. The maximum nominal bundle diameter is 102 mm, with an overall bundle length of 495 mm. The weight of a nominal bundle is 23.6 kg, of which 21.3 kg is uranium oxide. Approximately 19.2 kg can be attributed to the uranium (without the oxygen component). These numbers are averages and may vary depending on the type and age of the CANDU bundle. Each year, 4,500 to 5,400 fuel bundles per reactor are added to the wet storage bays, based on 80 percent to 95 percent full power reactor operation.

G.4 Research reactors

G.4.1 General

In support of the international regime, Canada contributed its expertise and perspective to the development of two IAEA documents, the *Code of Conduct on the Safety of Research Reactors* and *Safety Requirements for Research Reactors.* These documents will help strengthen the regulatory framework governing the safe operation of research reactors in Canada.

As of March 2011, there were seven operating research reactors in Canada. Four of these are SLOWPOKE-2 reactors, designed by AECL. These are located across Canada, one in Ontario at the Royal Military College of Canada, one in Quebec at the École Polytechnique, one in Alberta at the University of Alberta, and one in Saskatchewan managed by the Saskatchewan Research Council.

A fifth SLOWPOKE, at Dalhousie University in Nova Scotia has been decommissioned. The used highly enriched uranium (HEU) fuel has been removed and is in temporary storage at the AECL Chalk River Facility. It will eventually be sent to Savannah River in the United States.

Of the three remaining research reactors, one includes a 5-MW pool-type reactor at McMaster University while the last two reactors, namely National Research Universal and Zero Energy Deuterium-2, are located at AECL CRL. In the past, research reactors have typically used HEU for the fuel cores, but within the last decade some of them have been converted to low-enriched uranium (LEU) fuel. This conversion to an LEU operation is in line with the United States Department of Energy's Reduced Enrichment for Research Test Reactors Program. The program aims to convert all HEU research reactors to LEU fuel. The HEU fuel used in Canadian reactors comes from the United States.

G.4.2 Nuclear fuel waste from research reactors

Two of the four SLOWPOKE 2 reactors in Canada use LEU (below 20 percent uranium-235); the others use HEU. All SLOWPOKE 2 cores are preassembled and cannot be modified by the licensee. The cores last many years, with the addition of beryllium reflector shims compensating for reactivity decreases in fuel. Once the addition of the shims can no longer compensate for the decreased reactivity of the spent fuel (usually after 20 to 30 years, depending on usage), the complete core is removed and the spent fuel is sent either to AECL CRL for waste management storage or to the United States. The fuel may also be removed if the facility is being decommissioned or converted to an LEU core.

The waste and spent fuel for CRL reactors is stored on site. The spent fuel from NRU is stored in fuel storage pools until it can be transferred to Waste Management Area B, which is described in annex 4. The ZED-2 reactor is operated occasionally and is mainly used for prototype testing of fuel to determine fuel characteristics.

The McMaster Nuclear Reactor (MNR) was recently fully converted to LEU. Some of the LEU comes from France. All MNR used HEU fuel was sent to Savannah River in the United States.

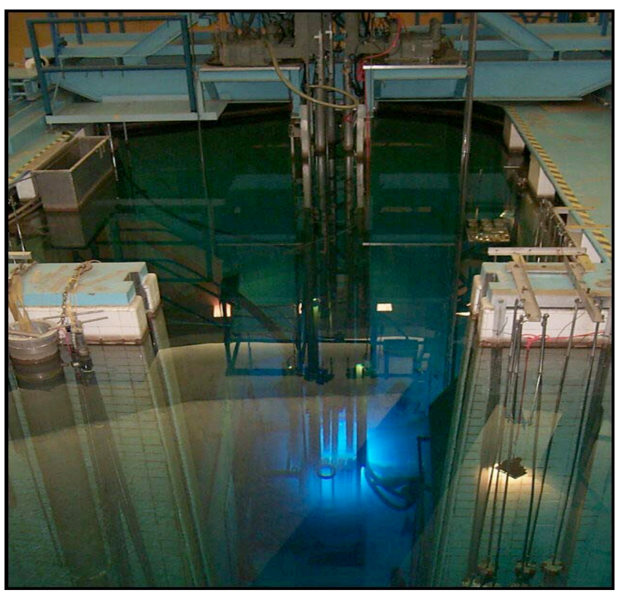

Figure G.1 – McMaster Nuclear Reactor

G.5 Medical isotope production fuel

This type of fuel is not included in the report because, once spent, the fuel is reprocessed for extraction of medical isotopes and is therefore outside the scope of the Joint Convention, according to Article 3(1).

G.6 Storage of spent fuel

In Canada, all spent fuel is stored at the site where it was produced, with the following exceptions:

- small quantities that are transported to research facilities for experimental or examination purposes, and which are stored at those facilities

- the fuel from the Nuclear Power Demonstration (NPD) reactor, which is stored at the nearby AECL CRL site

All Canadian power reactors were constructed with onsite spent fuel storage bays or water pools. Spent fuel is stored in either storage bays or in dry storage facilities at the location where it was produced. The only exception is the spent fuel produced at the now-closed NPD nuclear facility. The spent fuel from this facility was transferred to AECL CRL, where it was placed in a dry storage facility. Refer to section D.4 for maps of the locations.

Secondary or auxiliary bays have also been constructed at Pickering A, Bruce A and Bruce B for additional storage. Since 1990, dry storage technology has been chosen for additional onsite interim storage. In addition, the spent fuel from the earlier decommissioned prototype reactors is stored on site in dry storage facilities. The research reactor fuels are stored in dry storage facilities in tile holes and in silos at the CRL and WL waste management facilities.

The engineered structures, canisters, MACSTOR and OPG dry storage containers were originally designed for a 50-year lifetime. The actual life of the structures could be much longer. These structures are vigorously monitored; in the event of a structure failure, the spent fuel can be retrieved and transferred to a new structure.

Dry storage facilities are licensed for a limited period. Licences issued by the CNSC are generally valid for a five- to 10-year period. At the time of licence renewal, the CNSC examines the operational performance of the dry storage facility to determine whether it can continue to operate safely for another licensing term – again, typically for a five-year period. This situation may continue until a long-term management facility becomes available.

G.7 Spent fuel management methods and requirements for spent fuel storage

The fuel cycle in Canada is a once-through process (currently, there is no reprocessing or intent to reprocess spent fuel for recycling of its uranium and plutonium content). The development and selection of an approach for long-term management of spent fuel is discussed in section G.17.

Spent fuel handling and storage facilities are required to provide the following:

- containment
- shielding
- dissipation of decay heat
- prevention of criticality
- assurance of fuel integrity for the required time of storage
- allowance for loading, handling and retrieval
- mechanical protection during handling and storage
- allowance for safeguards and security provisions
- physical stability and resistance to extreme site conditions

The CSA has developed a standard consisting of best practices for the safe site preparation (siting), design, construction, commissioning, operation and decommissioning of facilities and associated equipment for the dry storage of irradiated fuel, known as CSA N292.2-07, *Interim Dry Storage of Irradiated Fuel*. The Canadian nuclear sector uses this standard as a guide to facilitate the licensing process.

G.8 Safety of spent fuel and radioactive waste management

In Canada, spent fuel management and radioactive waste management and associated facilities are regulated in a similar fashion. Safety and licensing issues are regulated according to NSCA requirements and associated regulations.

G.8.1 General safety requirements

Canada ensures that individuals, society and the environment are adequately protected at all stages of spent fuel and radioactive waste management. This is accomplished through the Canadian regulatory regime. Canada's approach to the safety of spent fuel and radioactive waste management is in line with the guidelines provided by the IAEA *Safety Guides and Practices*.

G.8.2 Canadian licensing process

The Canadian licensing process covers site preparation, construction, operation, decommissioning and abandonment. No phase may proceed without the required applications, documentation, assessments and approvals. A full description of Canada's comprehensive licensing system is provided in section E.4.

G.8.3 Protection and safety fundamentals

The main objective in the regulation of spent fuel and radioactive waste management is to ensure that facilities and activities do not pose unreasonable risks to health, safety, security and the environment. The regulation of spent fuel and radioactive waste can be divided into:

- generic performance requirements
- generic design and operational principles
- performance criteria

G.8.3.1 Generic performance requirements

There are three main generic performance requirements:

- The applicant must make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of security.

- The applicant must comply with all applicable laws, regulations and limits (e.g., dose limits, ALARA principle).

- The applicant must assure or demonstrate compliance with tests, analyses, monitoring programs, records, data and relevant reports.

G.8.3.2 Generic design and operational principles

There are two main principles for generic design and operations:

- Multiple engineered barriers are used to ensure spent fuel and radioactive waste are adequately contained and isolated from humans and the environment during normal and abnormal conditions.

- Administrative controls and procedures are used to augment and monitor the performance of the engineered barriers.

G.8.3.3 Performance criteria

The performance criteria accepted by the CNSC are as follows:

- Structural integrity must be maintained over the design life of the structure.
- Radiation fields at one metre from the storage structure and at the facility perimeter must not exceed regulatory limits for the public and for workers.
- There must be no loss of effective shielding during the design life of the storage container.
- There must be no significant release of radioactive or hazardous contaminants over the design life of the storage container.
- There must be no significant tilt or upset of the storage containers under normal conditions.
- Physical security systems of the contents and facility components must be maintained.

G.8.4 Safety requirements

Spent fuel and radioactive waste management facilities must be operated in a safe manner that protects the environment and the health and safety of workers and the public. System components that may require periodic maintenance must be readily accessible and designed to permit safe and efficient maintenance.

Safety requirements at spent fuel and radioactive waste facilities include the following:

- nuclear criticality safety
- radiation safety
- physical security and safeguards
- industrial safety

G.8.4.1 Nuclear criticality safety

As per CNSC regulatory document RD-327, *Nuclear Criticality Safety*, criticality safety requirements must address both normal and abnormal conditions. Criticality safety analyses must be performed when significant quantities of fissionable materials are stored or handled. Each analysis must clearly demonstrate that the storage and handling of the nuclear waste is safe, which means that an inadvertent criticality cannot occur under normal (or credible abnormal) conditions. The analysis of a facility must consider the offsite consequences of improbable or inadvertent criticality events and demonstrate that these consequences do not violate the public evacuation criteria established by international standards (IAEA Safety Standards Series GS-R-2) and national guidelines (*Canadian Guidelines for Intervention During a Nuclear Emergency*).

G.8.4.2 Facility design

The spent fuel storage and radioactive waste systems must be designed to reduce occupational radiation doses and radioactive emissions to the environment, in accordance with the ALARA principle. The current regulatory requirement is that dose rates at the storage area boundary or at any accessible point within the storage area must be maintained at a level that would not result in an exposure to workers or to a member of the public that exceeds the regulatory limit.

At present, all spent fuel and radioactive waste management facilities operate at a small fraction of the public regulatory limit.

G.8.4.3 Physical security and safeguards

The CNSC monitors and assesses the effectiveness of the physical security of nuclear facilities and nuclear materials and provides advice and assistance to licensees on how to apply the *Nuclear Security Regulations* (NSR). The CNSC is the designated governmental authority for Canada responsible for implementing the requirements of the Canada/IAEA safeguards agreements within the regulatory framework established through the *Nuclear Safety and*

Control Act and the associated regulations. As a result of these agreements, much of the nuclear material and many of the facilities that are identified in this report are also subject to verification undertaken by the IAEA.

G.8.4.4 Industrial safety

At every stage in the lifecycle of a spent fuel and radioactive waste management facility, the licensee must take into consideration the occupational health and safety of workers. The handling of hazardous materials must meet all federal and provincial legislation.

G.9 Protection of existing facilities

Canadian regulations ensured the safety of the spent fuel management facilities that existed when the Joint Convention entered into force, as all facilities were under a CNSC licence. Consequently, the operation of spent fuel management facilities must be conducted according to NSCA requirements, associated regulations and licence conditions.

Storage facilities for spent fuel and radioactive waste have been designed to ensure there are no effluent discharges to the environment. Effluent discharges from the processing of spent fuel or radioactive waste (e.g., incineration of combustible radioactive waste) are monitored to ensure that they do not exceed regulatory guidelines. All discharges from nuclear facilities must conform with the NSCA, its associated regulations and, if applicable, conditions specified in the licence.

G.10 Protection in the siting of proposed facilities

As discussed in section E.3.2, spent fuel storage facilities are considered to be Class I nuclear facilities, in accordance with the definition provided in the *Class I Nuclear Facilities Regulations*. These Regulations stipulate several licensing steps for these types of facilities:

- a site preparation licence
- a construction licence
- an operating licence
- a decommissioning licence
- an abandonment licence

The requirements for a licence to prepare site for a Class I nuclear facility are listed in section 4 of these Regulations. Other requirements are indicated in section 3 of the *General Nuclear Safety and Control Regulations* and section 3 of the *Class I Nuclear Facilities Regulations*.

G.10.1 Public information programs

It is a regulatory requirement for licence applicants and licensed operators of Class I nuclear facilities and uranium mines and mills to launch public information programs about their activities. The CNSC has issued a guide that provides general information about the regulations regarding public information programs. This document, entitled G-217, *Licensee Public Information Programs,* is available at the CNSC Web site, nuclearsafety.gc.ca

For example, at the Bruce site, OPG operates the Western Waste Management Facility (WWMF), which accommodates all of the low- and intermediate-level nuclear waste for all 20 OPG-owned nuclear units, including those leased to Bruce Power. In addition, the WWMF has spent fuel dry storage facilities that it is using for the interim management of spent fuel from the Bruce reactors. OPG operates an extensive public information program at the Bruce site, as described in section H.7.1.1. OPG also operates spent fuel dry storage facilities at the Darlington and Pickering nuclear generating stations. The public information programs at those sites are integrated and include many of the same communication strategies used at the Bruce site, such as brochures, newsletters, tours, media briefings and the Internet. The information centres at the Darlington and Pickering sites have also created displays on spent fuel dry storage.

G.10.2 International arrangements with neighbouring countries that could be affected

The Canadian regulatory regime does not obligate the proponents of domestic nuclear facilities that may affect the United States to consult with foreign jurisdictions or with the public about the proposed siting of such facilities.

Canada and the United States, however, are signatories to the *International Convention on Environmental Impact Assessment in a Transboundary Context* (Espoo, Finland, February 25, 1991). When this Convention is ratified, both parties will be bound by its provisions. Ratification obliges the "Party of origin" to:

- "take all appropriate and effective measures to prevent, reduce, and control significant adverse transboundary environmental impacts of proposed activities" (including the site preparation, construction and operation of nuclear installations)
- "ensure that affected Parties are notified" of the proposed installation
- "provide an opportunity to the public in the areas likely to be affected to participate in relevant environmental impact assessment procedures regarding proposed activities, and to ensure that the opportunity provided to the public of the affected Party is equivalent to that provided to the public of the Party of origin"
- include in the notification "information on the proposed activity, including any available information on its possible transboundary impact"

The Governments of Canada and the United States, in cooperation with state and provincial governments, are also obligated to have programs in place for the abatement, control and prevention of pollution from industrial sources. This includes measures to control the discharges of radioactive materials into the Great Lakes system. These obligations are contained within the *Great Lakes Water Quality Agreement* (1978), as amended by the protocol signed November 18, 1987.

Since the 1950s, the CNSC and the United States Nuclear Regulatory Commission have practised cooperation and consultation. On August 15, 1996, they entered into a bilateral administrative arrangement for "cooperation and the exchange of information on nuclear regulatory matters." This commitment includes the exchange of certain technical information that "relates to the regulation of health, safety, security, safeguards, waste management and environmental protection aspects of the siting, construction, commissioning, operation and decommissioning of any designated nuclear facility" in Canada and the United States.

G.11 Design, construction and assessment of safety of facilities

After the granting of a licence to prepare site, the second formal licensing step for nuclear facilities is the construction licence.

The requirements for a licence to construct a Class I nuclear facility are listed in section 5 of the *Class I Nuclear Facilities Regulations*. Information listed in section 3 of the GNSCR and section 3 of the *Class I Nuclear Facilities Regulations* is also required. It includes items such as the proposed design (including systems and components), the QA program, the possible effects on the environment and the proposed measures to control releases to the environment, a waste management strategy and a preliminary decommissioning plan (refer to section F.8).

Prior to construction of a new spent fuel storage facility, an application to the CNSC for a licence could require the CNSC to initiate an EA before making a decision. The CEA Act requires that early in the project an integrated environmental assessment of the possible impacts on individuals, society and the environment – at all licensing stages – must be carried out. The CEA Act is further described in annex 2.5. At the end of the environmental assessment process, if it has been determined that the project is not likely to cause significant adverse environmental effects, licensing can proceed.

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management* (see section B.6), assists licensees and applicants as they assess the long-term safety of storage and disposal of spent fuel and radioactive waste.

G.12 Operation of facilities

The third step in the licensing process is obtaining an operating licence.

Requirements to operate a Class I nuclear facility are listed in section 6 of the *Class I Nuclear Facilities Regulations*. Information listed in section 3 of the GNSCR and section 3 of the *Class I Nuclear Facilities Regulations* is also required. It includes such items as a safety analysis report, commissioning program, the measures to prevent or mitigate releases of nuclear substances and hazardous substances to the environment, and a preliminary decommissioning plan.

Also, as a requirement of a licence to operate, the licensee must keep a record of the results of:

- effluent and environmental monitoring programs
- operating and maintenance procedures
- commissioning programs
- inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the nuclear facility
- the status of each worker's qualifications, re-qualification and training

G.13 Monitoring of spent fuel dry storage facilities

Dry storage facilities are required if a facility is to have an operational monitoring performance assessment program. The program is the means by which the performance of individual barriers – as well as the entire containment system – are evaluated with respect to:

- established safety criteria
- standards related to potential impacts on human health and safety, as well as to non-human biota and the physical environment

A monitoring program for a dry storage facility must be able to detect any unsafe condition or the degradation of structures, systems and components. A typical monitoring program for a spent fuel dry storage facility may include the following elements:

- gamma radiation monitoring
- canister monitoring for leaks, tightness verification of the baskets and canister liners
- effluent monitoring (including airborne emissions and liquid emissions)
- an environmental monitoring program

G.13.1 Gamma radiation monitoring experience

Routine gamma radiation surveys are performed by using a handheld monitor at appropriate points inside the dry storage facility fence and on all sides of the dry storage containers, or by using thermoluminescent dosimeter (TLD) mounted devices to monitor cumulative fields. Experience has demonstrated that gamma radiation at dry storage facilities is significantly less than predicted during the design phase.

G.13.2 Leak tightness verification experience

Leak tightness verification of the AECL-type fuel baskets and concrete canisters consists of connecting a pump to the liner cavity and recirculating the air through filters. Excessive humidity indicates either a liner leak or water holdup in the canister from operations carried out before sealing. The presence of radioactivity indicates a basket leak. For the OPG-type dry storage containers, leak tightness is verified through helium leak testing before containers are placed in storage. Subsequent aging management activities provide assurance that the container condition and weld integrity are not compromised and that helium cannot leak out.

Experience indicates that the various dry storage structures and components currently used in Canada effectively contain the fission products in the fuel bundles.

G.13.3 Environmental monitoring experience

Every nuclear power plant, including AECL's research facilities, has an environmental monitoring program. Spent fuel dry storage facilities at these sites are addressed in the site environmental monitoring programs, which:

- provide an early indication of the appearance or accumulation of radioactive material in the environment
- verify the adequacy and proper functioning of effluent controls and monitoring programs
- provide an estimate of actual radiation exposure to the surrounding population
- provide assurance that the environmental impact is known and within anticipated limits
- provide standby monitoring capability for rapid assessment of risk to the general public in the event of accidental releases of radioactive material

Experience shows that spent fuel dry storage facilities in Canada operate safely and within prescribed regulatory limits.

G.13.4 Effluent monitoring experience

G.13.4.1 AECL

AECL fuel baskets are wet-loaded in the generating station's fuel bay area. The loaded fuel basket is raised into the shielded workstation. While being raised, an annular ring with spray nozzles sprays the chain and loaded fuel basket with demineralized water to clean them. All liquids are returned to the spent fuel storage bay. Once in the shielded workstation, the loaded fuel basket is air-dried and weld-sealed. The air-drying system consists of:

- two air heaters
- blowers with high efficiency particulate air (HEPA) filters
- associated ductwork
- dampers

The hot air is blown in via a swan neck duct and removed via a plenum formed by the basket cover and the rotating table. The return air is filtered before being exhausted into the spent fuel bay active ventilation system. Monitoring results have shown no significant levels of particulates in the ventilation system resulting from the dry storage operations. Because the fuel baskets are processed in the fuel bay area where active ventilation is provided, and any liquids generated by the drying of the spent fuel are returned to the storage pool, no airborne or liquid emissions are encountered during the transfer of the loaded basket to the dry storage facility. At the dry storage facility, the cylinders are filled with loaded baskets and a cover plate is then welded in place. Monitoring results have shown that the loaded baskets in the sealed storage cylinders generate no significant levels of airborne or liquid effluents.

G.13.4.2 OPG

OPG dry storage containers are wet-loaded in the fuel bay, decontaminated, drained and dried, and a transfer clamp and seal are installed to secure and seal the lid during onsite transfer. The fuel bay area is equipped with an active ventilation system, and most of the liquids resulting from the draining and vacuum drying are returned to the fuel bay. Other liquids from the draining and vacuum drying are directed to the station's active liquid waste system. At the dry storage facility, a special workshop houses the following dedicated systems for dry storage container processing:

- closure welding and welding-related systems
- non-destructive examination of welds

- vacuum drying system
- helium backfilling system
- helium leak detection system

Airborne contamination hazards may present a danger if any loose surface contamination on the dry storage container becomes airborne, or if there is leakage of the dry storage container internal gas (such gas may contain krypton-85, as well as radioactive particulates). The processes that could give rise to this airborne hazard are:

- dry storage container draining and drying
- transfer clamp and seal removal
- dry storage container backfilling with helium

Airborne particulate monitors and gamma radiation monitors are used to detect any abnormally high levels. The workshop also has active ventilation, which consists of exhaust fans, radioactive filter assemblies and a discharge stack. Any airborne radioactive particulate contamination, if present in the ventilation exhaust, is effectively removed by HEPA filters in the active ventilation system. Monitoring results to date, from the Pickering Used Fuel Dry Storage Facility, Darlington Waste Management Facility and the Western Used Fuel Dry Storage Facility, have shown no significant levels of particulates in the active ventilation exhaust.

Because the dry storage containers are fully drained and vacuum dried at the generating station fuel bay area, there are no liquid emissions from the dry storage container during onsite transfer to the dry storage workshop. The exterior surfaces of dry storage containers are decontaminated prior to their transfer from the fuel bay area to the dry storage workshop. Spot decontamination operations do not generate liquids, and liquids are not normally used in the storage areas. Because of this, and because loose contamination is not permitted on dry storage containers or facility surfaces, no contaminated liquid effluents are expected from the dry storage operations. However, some liquid effluents may originate in the processing area as a result of maintenance. Such liquids are sampled and placed in appropriate containers for proper disposal or, when acceptable, pumped into the generating station's active liquid waste management system at the Pickering Used Fuel Dry Storage Facility. Monitoring results at the Pickering Used Fuel Dry Storage Facility have shown no significant levels of radioactivity in the drainage effluent transferred to the generating station system. As a result, the Darlington Waste Management Facility and the Western Used Fuel Dry Storage Facility do not have an active liquid waste management system.

G.14 Disposal of spent fuel

Currently, Canada does not have a disposal facility for spent fuel. Any proposal for the siting, construction, and operation of a disposal facility must satisfy the requirements of the CEA Act, the NSCA and its associated regulations.

G.15 New facilities

No new spent fuel management facilities were constructed in Canada during the reporting period of April 1, 2008 to March 31, 2011.

G.16 Proposed facilities

Spent fuel from the operation of research reactors at AECL CRL is currently stored below ground in vertical cylindrical concrete structures called "tile holes". These are situated in Waste Management Area B. The fuel initially loaded into these storage structures from 1963 to 1983 was research reactor prototype fuel and included uranium metal fuel that has less corrosion resistance than modern-day alloy fuels. These fuels consist of about 700 prototype and research reactor fuel rods, with a total mass of approximately 22 tonnes. While these fuels are safety stored, monitoring and inspection have shown that some of the fuel containers and fuels are corroding.

AECL is constructing and will operate a new above ground dry storage array to store this selected spent legacy research fuel. The new dry storage system will be located in a Fuel Packaging and Storage (FPS) building.

This building will contain a packaging and vacuum drying station and a monitored storage structure. The existing storage container will be placed – with the spent fuel remaining inside it – in a new stainless steel container with a vented closure and then dried before being placed in the monitored storage structure. The storage structure will be engineered to last at least 50 years and will provide safe and interim storage for the packaged fuel until a long-term management facility is available.

G.17 Long-term management of spent fuel

Since the early days of the CANDU program, several concepts for long-term management of spent fuel waste have been under consideration. The options for long-term management in Canada were reviewed by a royal commission in 1977. Subsequently, Canada's spent fuel waste management program was formally initiated by the Governments of Canada and Ontario. AECL was assigned responsibility to develop a concept for placing spent fuel in a deep underground repository within the plutonic rock of the Canadian Shield. Ontario Hydro (now Ontario Power Generation Inc.) was assigned responsibility to study and develop technology to store and transport spent fuel. It was also designated to provide technical assistance to AECL in the area of repository development. In 1981, the Governments of Canada and Ontario announced that site selection for a repository would not be undertaken until after the disposal concept had been accepted.

In 1994, AECL submitted for review to a federal Environmental Assessment Panel its Environmental Impact Statement (EIS) for the deep geological repository concept. This review included input from government agencies, non-governmental organizations and the general public. Public hearings associated with the review took place during 1996 and 1997.

The report of the federal Environmental Assessment Panel was submitted to the Government of Canada in 1998. It made recommendations to help the Government of Canada reach a decision on the acceptability of the disposal concept and the steps to be taken to ensure the safe long-term management of spent fuel waste in Canada (CEA Agency, 1998).

The Government of Canada responded to the Environmental Assessment Panel report later in 1998 and announced the steps it would require the producers and owners of nuclear fuel waste in Canada to take, including the formation of the NWMO by the nuclear utilities. In 2002, the Canadian Parliament passed the *Nuclear Fuel Waste Act* (NFWA), which indicates that the Governor in Council will select one approach for the long-term management of nuclear fuel waste from those examined by the NWMO. Under the NFWA, the following actions were to take place:

- The nuclear energy corporations were to establish a waste management organization, the purpose of which would be to study and propose approaches for the management of nuclear fuel waste and to implement the approach selected by the Governor in Council. The study was to include a technical description and a comparison of the benefits, risks and costs and ethical, social and economic considerations associated with each approach, together with specification of economic regions for implementation and plans for implementation of each approach in the study. The waste management organization was to consult the general public and in particular Aboriginal peoples on each approach.

- The waste management organization was to create an Advisory Council, which would reflect a broad range of scientific and technical disciplines. Its expertise should include public affairs, other social sciences as needed and traditional Aboriginal knowledge. It was also to include representatives of the local and regional governments and Aboriginal organizations affected by the selected approach because of their geographic location.

- The waste management organization was to submit, within three years of the NFWA coming into force, a study setting out proposed approaches for the management of nuclear fuel waste, as well as its final recommendation. The study would have to include approaches based on the following methods:

    - a modified AECL concept for deep geological disposal in the Canadian Shield
    - storage at nuclear reactor sites
    - centralized storage, either above or below ground

Under the NFWA, the Government of Canada was tasked with reviewing the study prepared by the waste management organization, selecting a long-term management option from those proposed and providing oversight during implementation. NRCan would oversee how the waste management organization implements the management approach and ensure compliance with the NFWA. The waste management organization was to report annually to the Minister of Natural Resources. Every third year – following the selection of an approach by the Governor in Council – this report would include a summary of activities and a strategic plan for the following five years.

Canada's plan has now moved forward against this legislative framework.

Pursuant to the NFWA, the waste management organization – the NWMO – was established in 2002 by the nuclear-energy corporations – OPG, HQ, and NB Power. Upon its establishment in 2002, the NWMO's first mandate was to develop collaboratively with Canadians a management approach for the long-term care of Canada's spent fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible. From 2002 to 2005, the NWMO studied various approaches to the long-term management of Canada's spent fuel.

In 2005, the NWMO recommended the Adaptive Phased Management (APM) approach to the Minister of Natural Resources. APM includes a technical method based on an end point of centralized containment and isolation of the spent fuel in a deep geological repository in a suitable rock formation. It provides for continuous monitoring of the spent fuel and the potential to retrieve it for an extended time. There is provision for contingencies such as the optional step of shallow storage at the selected central site if circumstances favour early centralization of the spent fuel before the repository is ready.

The management system is based on phased and adaptive decision-making. Flexibility in the pace and manner in which the project is implemented allows for phased decision-making, with each step supported by continuous learning, research and development and public engagement. An informed, willing community will be sought to host the centralized facilities. Sustained engagement of people and communities is a key element of the plan, as the NWMO continues to work with citizens, communities, municipalities, all levels of government, Aboriginal organizations, non-governmental organizations, industry and others.

On June 14, 2007, following a review of the NWMO's study *Choosing the Way Forward*, the Government of Canada announced that it had selected the APM approach for the long-term management of spent fuel in Canada.

With this government decision, the NWMO assumed responsibility for implementing the APM approach. Governance and organization staffing have evolved to provide the oversight, skills and capabilities required to implement APM. The Advisory Council continues to provide advice as required by the NFWA, and the NWMO issues its reports annually to the Minister of Natural Resources Canada and to the public. In March 2011, the NWMO submitted its first Triennial Report to the Minister as required by the NFWA. To support financing of the plan, waste owners continue to make regular deposits to the segregated trust funds established in 2002. In 2008, the NWMO submitted to the Minister of Natural Resources a funding formula and schedule for trust fund deposits. The Minister approved this funding formula in 2009. Implementation of APM will be regulated at all stages, with the CNSC responsible for regulatory matters pursuant to the NSCA. The NWMO will be required to obtain licences from the CNSC for site preparation, construction, operation and decommissioning of the repository facilities.

Refer to Section K.4 for further information on plans for the long-term management of spent fuel and on the public consultation process.

Section H – Safety of Radioactive Waste Management

H.1 Scope of the section

This section addresses Article 11 (General Safety Requirements) to Article 17 (Institutional Measures After Closure). It provides a comprehensive description of radioactive waste management in Canada.

At every stage of radioactive waste management there are effective defences that protect individuals, society and the environment against potential hazards and the harmful effects of ionizing radiation now and into the future. In addition to describing facilities and their normal operation, this section describes the steps or controls that are in place, with the dual purpose of preventing accidents with radiological consequences and of mitigating their consequences should accidents occur.

The information contained in this section demonstrates that the requirements of the following applicable IAEA Safety Standards are addressed.

Article 11 – General Safety Requirements – IAEA Safety Requirements NS-R-1, WS-R-1 and WS-R-2
Article 13 – Siting of Proposed Facilities – IAEA Safety Requirement NS-R-3
Article 14 – Design and Construction of Facilities – IAEA Safety Requirements NS-R-1 and WS-R-1
Article 15 – Assessment of Safety of Facilities – IAEA Safety Requirements NS-R-1, WS-R-1 and Safety Series 115
Article 16 – Operation of Facilities – IAEA Safety Standards NS-R-1, WS-R-1WS-R-2 and Safety Series 115

H.2 Radioactive waste in Canada

Nuclear facilities and users of certain prescribed substances produce radioactive waste. The Government of Canada establishes the policy framework for the management of these wastes. The CNSC regulates the management of radioactive waste to ensure that it causes no undue radiological hazard to the health and safety of persons or to the environment. The radioactive content of the waste varies with the source. Management techniques, therefore, depend on the characteristics of the waste (see section H.3).

Certain types of radioactive waste, such as that from hospitals, universities and industry, contain only small amounts of radioactive materials with short half-lives. This means that radioactivity decays away in hours or days. After holding the waste until the radioactivity has decayed to the acceptable levels authorized by the CNSC, it can be disposed of by conventional means (in local landfill or sewer systems).

With the notable exception of waste from nuclear power plants – which is contaminated with long-lived radioisotopes – radioactive waste is generally shipped directly or via a waste broker to the waste management facility operated by AECL at its CRL site. The typical storage facilities at CRL include shielded above ground storage buildings, concrete bunkers and concrete tile holes. In some cases, radioactive waste is shipped to United States waste treatment and disposal facilities. For information on the amount shipped to the United States, refer to annex 5.1.8.

Canadian methods for the management of radioactive waste are similar to those of other countries. Primary emphasis is placed on minimization, volume reduction, conditioning and long-term storage of the waste, since long-term management facilities are not yet available. Radioactive waste is stored on site or off site, in above- or below-ground engineered structures. Some of the waste may be reduced in volume by compaction or incineration prior to storage. All radioactive waste currently generated is stored in such a way that it can be retrieved when necessary. Operators have instituted methods to recover storage space by cascading the waste after sufficient radioactive decay or reclaiming existing storage space through further compaction (super compaction), segregation or both.

As for all nuclear activities, the facilities for handling radioactive waste must be licensed by the CNSC and conform to all pertinent regulations and licence conditions. The waste management objective throughout the industry – from mines to reactors – is the same, which is to control and limit the release of potentially harmful substances into the environment.

H.3 Characteristics of radioactive waste in Canada

H.3.1 Fuel manufacturing waste

In the past, wastes from refineries and conversion facilities were managed by means of direct in-ground burial. This practice was discontinued in 1988 after the closure of the Port Granby Waste Management Facility. The volume of low-level radioactive waste produced from these operations has been greatly reduced through recovery and reuse of feedstock materials, the conversion of waste materials into by-products and the decontamination of wastes for disposal with non-radioactive wastes. The residual volume of low-level radioactive waste (LLW) now being produced is drummed and stored in warehouses pending the establishment of an appropriate long-term waste management facility. The seepage and runoff from the waste management facilities where direct in-ground burial was practised continues to be collected and treated prior to discharge.

Fuel manufacturing waste consists of a variety of potentially uranium-contaminated wastes including the following:

- uncontaminated and contaminated zirconium dioxide
- graphite crucibles used to cast billets
- filters
- scrap lumber
- pallets
- rags
- paper
- cardboard
- rubber
- plastic
- oils
- solvents

H.3.2 Electricity generation waste

Radioactive wastes resulting from nuclear reactor operations are stored in a variety of structures located in waste management facilities at nuclear reactor sites. Prior to storage, the volume of the wastes may be reduced by incineration, compaction or shredding. In addition, within the nuclear power plant there are facilities for the decontamination of parts and tools, laundering of protective clothing and the refurbishment and rehabilitation of equipment. Electricity generation waste consists of varying types of low- and intermediate-level activity waste such as:

- filters
- light bulbs
- cable
- used equipment
- metals
- construction debris
- absorbents (sand, vermiculite, sweeping compound)
- ion exchange resins
- reactor core components
- retube materials
- paper
- plastic
- rubber
- wood
- organic liquids

Figure H.1 – OPG low- and intermediate-level waste storage bins at Western Waste Management Facility

H.3.3 Historic waste

Historic LLW in Canada refers to LLW that was managed in the past in a manner no longer considered acceptable, but for which the current owner cannot reasonably be held responsible and for which the Government of Canada has accepted the long-term responsibility. In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL as the federal agent for the cleanup and management of historic low-level radioactive waste in Canada. NRCan provides policy direction and funding to the LLRWMO. The LLRWMO has completed historic waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination. At some sites, materials have been placed in interim storage pending the development of a long-term management approach. Ongoing site monitoring, inspection and maintenance are conducted at these sites.

In keeping with the 1996 *Policy Framework for Radioactive Waste,* Canada has taken different approaches for the management of spent fuel, low- and intermediate-level radioactive waste and uranium mine and mill tailings. These different approaches reflect not only the different scientific and technical characteristics of the wastes, but also the economics and the geographic dimensions of Canada and the locations of the waste. Long-term strategies and solutions for historic LLW are evolving for the various regions of the country. The LLRWMO helps develop and implement the Government of Canada's strategic approach to historic waste management by working with communities and federal stakeholders to develop solutions to safely and cost-effectively reduce liabilities and associated risks. These community-based solutions apply sound waste management and environmental principles in the best interests of Canadians.

H.3.4 Radioisotope production and use waste

Radioisotope production and use generate a variety of radionuclides for commercial use, such as cobalt-60 for sterilization and cancer therapy units, and molybedenum-99 or other isotopes for use as tracers for medical research, diagnoses and therapy. A number of waste management facilities process and manage the wastes that result from the use of radioisotopes for research and medicine. In general, these facilities collect and package waste for shipment to approved storage sites. In some cases, the waste is incinerated or allowed to decay to insignificant radioactivity levels and then discharged into the municipal sewer system or municipal garbage system.

H.3.5 Uranium mining and milling waste

Uranium mining and milling waste comprises three major waste streams: mill tailings, waste rock and waste water.

After ore is removed from the ground, either by underground mining or from an open pit, it is milled. The milling process, in which the ore is crushed and treated with chemicals, extracts the ore's uranium content, leaving a waste product known as mill tailings.

The method used to manage tailings from uranium mine operations varies from mine to mine. Much depends on where the mine is located. The quantity of tailings produced at any uranium mine is determined by the grade of the ore, as well as the size of the deposit. Canada's operating mines (all in northern Saskatchewan) have high-grade ore deposits in comparison to past mining operations in Canada; therefore, smaller volumes of tailings are being produced.

Due to varying mineralogy, different mines use different chemicals, concentrates or mixtures of chemicals in the milling process. As a result, tailings vary in composition from mine to mine.

Tailings management facilities (TMFs) have evolved over the decades, from simple deposition into natural landforms and lakes or into abandoned underground mine workings, to the construction of engineered surface storage facilities, complete with seepage collection systems, to the current practice of placing the tailings in engineered mined-out open pits converted to TMFs. Tailings in modern facilities are covered with water (subaqueous deposition) to enhance radiation protection and avoid oxidization and winter freezing of the tailings.

Waste rock ranges from benign material, devoid of the metal or mineral being sought, to mineralized material that contains sub-economical concentrations of the metal or mineral that was being extracted.

Waste rock characteristics are highly variable. Some waste rock contains sufficient concentrations of sulphide to generate moderate levels of acidity. This can mobilize potential contaminants from secondary minerals. In Saskatchewan, some waste rock contains secondary arsenic and nickel minerals, often to the point where the long-term care and control of these non-radioactive contaminants – not the waste rock's radioactivity – drive the level of care needed to manage it.

The waste water (effluent) generated from mining and milling processes is treated as required, and the treated water discharged to the environment is monitored to ensure it meets regulatory standards prescribed by the provincial and federal governments. These limits ensure that the impact on the environment is minimal.

H.3.6 Radioactive waste at research reactors

At all research reactors, radioactive waste materials are segregated by licensees into short-lived and long-lived radioactive waste. Short-lived radioactive wastes are stored on site to allow for decay until they can be disposed of in a conventional manner. Long-lived radioactive wastes are kept on site temporarily until a certain amount or volume is accumulated; thereafter they are generally transported to AECL CRL for storage. This is also the case for TRIUMF (TriUniversity Meson Facility) radioactive waste.

Liquid wastes from research reactors mostly consist of water that contains radioactive contamination. Typically, the water is cleaned up through a water purification system, which would include filtration and ion exchange. Once ion exchange resins are used up, they are stored with the long-lived radioactive waste that is eventually sent to AECL CRL. At the TRIUMF (accelerator), there is also a small amount of contaminated oil, produced annually from oil used in the vacuum pumps. All of this slightly contaminated oil (approximately 2 litres per year) is presently stored on site. Waste management at AECL CRL is described in detail in annex 5.

H.4 Waste minimization

Canada has adopted IAEA waste minimization practices as described in CNSC policy document P-290, *Managing Radioactive Waste,* which expects that the "generation of radioactive waste is minimized to the extent practicable".

In addition, CNSC regulatory guide G-219, *Decommissioning Planning for Licensed Activities*, indicates that waste management plans should include "specific plans for the reuse, recycling, storage or disposal of that waste" (G-219, section 6.2.2 (9)). Canada has also developed an industry standard, Canadian Standards Association (CSA) Standard N294-09, *Decommissioning of Facilities Containing Nuclear Substances*, which indicates that strategies for waste management must consider and prioritize "the potential for recycling or reuse of equipment and materials". (N294-09 Clause 6.1.3 (*e*)). (Regulatory policy P-290 is described in section B.5.)

The Canadian nuclear sector actively promotes and practises waste minimization. For example, OPG policy is to minimize the production of radioactive waste at source by preventing materials from unnecessarily becoming radioactive. Waste minimization is also a key principle espoused in the Canadian industry standard CSA N292.3, *Management of Low- and Intermediate-Level Waste*. The Canadian nuclear sector practises waste minimization by:

- implementing material control procedures to prevent materials from unnecessarily entering into radioactive areas
- implementing enhanced waste monitoring capabilities to reduce inclusion of non-radioactive wastes in radioactive wastes
- implementing improvements to waste handling facilities
- enhancing employee training and awareness

Canadian licensees follow various forms of waste minimization, depending upon site and operational specifics. As an example, OPG is implementing a number of waste minimization activities. Specific initiatives include the following:

- establishment of a waste minimization culture at OPG
- establishment of a clean zone area for de-packaging materials
- exclusion of unnecessary materials in zoned areas
- use of reusable equipment and materials as much as possible
- segregation of waste into radioactive and likely clean at many collection points for further monitoring and characterization of likely clean waste
- segregation of waste into waste and recycling at collection points
- use of washable protective equipment to replace disposable protective equipment such as gloves and booties
- use of washable bags, cloths and mops
- additional waste characterization
- use of industry best practices related to free release standards and segregation
- development of five-year radioactive waste minimization plan
- development of suitable metrics to monitor improvements

AECL is undertaking similar activities and has a project underway to design, construct and operate a facility to enhance its capability to effectively utilize free-release standards and segregation.

The CNSC supports the internationally adopted and environmentally friendly principles of good waste management practices in the nuclear industry to reduce the volume of radioactive waste requiring storage. In 2010, in an effort to adopt these new technologies to improve waste minimization practices, Bruce Power applied to ship steam generators to Sweden. The CNSC issued a transport licence and certificate to Bruce Power for the transport of 16 decommissioned steam generators to Sweden after public hearings on September 28 and 29, 2010, and further supplementary written submissions. The licence allows Bruce Power to ship the steam generators through the Great Lakes and St. Lawrence Seaway to Sweden. In Sweden, they will be processed to recycle the clean steel shell and reduce the volume of waste by 90 percent. The remaining contaminated steel will be sent back to Canada where it will be stored safely. The licence is valid for a period of one year from February 4, 2011 until February 3, 2012.

In making its decision, the Commission Tribunal considered various issues related to Bruce Power's qualifications to carry out the proposed activities and the adequacy of the proposed measures to protect the environment, the health and safety of persons, national security and Canada's international obligations.

As of March 31, 2011, Bruce Power has not yet set a date for shipping the decommissioned steam generators.

Figure H.2 – Steam generator being transported near the plant as part of the refurbishment

H.5 General safety requirements

The main objective in the regulation of either a spent fuel dry storage facility or a radioactive waste management facility is to ensure that such facilities and their activities do not pose unreasonable risks to health, safety, security and the environment. Canada's comprehensive licensing system, described in detail in section E.4, does not differentiate between a spent fuel management facility and a radioactive waste management facility. The design, construction and operation of either facility must ensure the safety of human health and the environment.

H.5.1 Protection and safety fundamentals

The regulation of spent fuel and radioactive waste can be divided into generic performance requirements, generic design and operational principles and performance criteria. These criteria are described in sections G.8.4 to G.8.6.

It is worthwhile noting that the uranium mines and mills governed by the same principles as those for spent fuel or radioactive waste are also governed by the *Uranium Mines and Mills Regulations*.

H.5.2 Safety requirements

Safety requirements for the management of spent fuel and radioactive waste must provide for the protection of the environment and the health and safety of workers and the public. During normal operations, spent fuel and radioactive waste management facilities must be operated in a safe manner. System components that may require periodic maintenance must be readily accessible and designed to permit safe and efficient maintenance. The safety requirements are described in detail in section G.8.7.

H.6 Protection of existing facilities

The safety of radioactive waste management facilities that existed when the Joint Convention entered into force was ensured through the Canadian regulatory regime. The operation of radioactive waste management facilities must be conducted in accordance with the NSCA, its associated regulations and the licence conditions. The CNSC compliance program activities verify that operators comply with the requirements for safe operation of radioactive waste management facilities. A list of facilities is included in section D.

H.6.1 Past practices

Legacy radioactive wastes at AECL sites date back to the Cold War and the birth of nuclear technologies in Canada. These include contaminated buildings that have been shut down and contaminated lands that are managed by AECL on behalf of the Government of Canada. The liabilities include high-level waste, in particular spent research reactor fuel and high-level liquid waste from the production of medical isotopes and fuel processing experiments conducted in the Cold War era. In 2006, the Government of Canada initiated the Nuclear Legacy Liabilities Program (NLLP) (as described in section K.6.2) to deal with the liabilities at AECL sites. A description of AECL waste management facilities is included in annex 5.

In 1982, the Government of Canada established the LLRWMO within AECL as the federal agent for the cleanup and management of historic low-level radioactive waste in Canada. Canada's historic waste inventory consists largely of radium- and uranium-contaminated soils. The Government of Canada has accepted responsibility for the long-term management of this waste.

NRCan provides policy direction and funding to the LLRWMO, enabling it to carry out its work. The LLRWMO has completed historic waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination. The bulk of Canada's historic low-level radioactive waste is located in the southern Ontario communities of Port Hope and Clarington. In March 2001, the Government of Canada and the local municipalities partnered on community-developed proposals to address the cleanup and long-term management of these wastes. This partnership launched the Port Hope Area Initiative (PHAI). The PHAI and other initiatives to deal with historic waste are described in section K.6.3.

As already shown in section F.4, when remedial actions are required at uranium mine and mill tailings facilities where the owner no longer exists, the federal and provincial governments ensure that the sites are safely decommissioned. In Ontario, home of the former Elliot Lake uranium mining complex, the Governments of Canada and Ontario entered into a Memorandum of Agreement in 1996 that outlined their respective roles in the management of abandoned uranium mine and mill tailings. In keeping with the *Policy Framework for Radioactive Waste*, best efforts are made to identify the uranium producer or property owner of a site. Where such an owner cannot be identified, the governments have agreed to share costs, including a 50/50 sharing of costs associated with any necessary remediation. To date, these arrangements have not been necessary, as all Ontario sites have owners that are complying with their responsibilities.

In a similar vein, the Governments of Canada and Saskatchewan entered into a Memorandum of Agreement that defines roles and responsibilities for the remediation of certain Cold War era uranium mine sites, principally the Gunnar mine and mill site in northern Saskatchewan. On April 2, 2007, the two governments announced the first phase of the cleanup. The total cost, which the governments will share, will be $24.6 million. NRCan advanced $1.13 million as its share of Phase 1. A comprehensive environmental assessment of the project began on June 15, 2007. In October 2007, the Government of Saskatchewan and EnCana Corporation entered into an agreement for the decommissioning and reclamation of the nearby Lorado uranium mill site. The Gunnar and Lorado mine sites are described in annex 8.1.1.2.

H.7 Protection in the siting of proposed facilities

The *Class I Nuclear Facilities Regulations* stipulate a lifecycle licensing approach for radioactive waste management facilities:

- a site preparation licence
- a construction licence
- an operating licence
- a decommissioning licence
- an abandonment licence

The GNSCR, NSR, RPR, and NSRDR also have requirements that must be met.

The requirements for a licence to prepare site for a Class I radioactive waste management facility are listed in section 3 and 4 of the *Class I Nuclear Facilities Regulations*. Note that section 3 of the GNSCR requires additional information.

At the time this report was written, there were no contracting parties that could be affected by the siting of a nuclear waste facility in Canada. However, the United States and Canada have a *Nuclear Cooperation Agreement* that was concluded in 1955. Article 2 of that agreement provides for the exchange of "classified and unclassified information, etc., with respect to the application of atomic energy for peaceful uses, including research and development relating thereto, and including problems of health and safety". Article 2 also covers the entire field of health and safety as it relates to the Joint Convention.

H.7.1 Public information programs

The CNSC's regulatory guide on public information programs is addressed in section G.10.1. Information on OPG's public information program for spent fuel is also addressed in section G.10.1. Information on OPG's existing public information program for its low- and intermediate-level waste storage (section H.7.1.1) and an example of public information for a new uranium mine or mill (section H.7.1.2) are included below.

H.7.1.1 Public information program for low- and intermediate-level nuclear waste storage

The following is an example of an existing public information program where spent fuel (see section 10.1) and radioactive waste are located.

OPG operates an extensive public information program in the Municipality of Kincardine and surrounding communities where it has facilities to store low- and intermediate-level radioactive waste and spent fuel. Since 2002, OPG, in partnership with the host Municipality of Kincardine and surrounding communities, has worked to establish a deep geological repository for the long-term management of low- and intermediate-level nuclear waste. In support of current operations and this project, OPG operates a broad information program designed to inform and engage the public in dialogue and discussion on nuclear waste issues. Communication strategies include the use of advertising, brochures, videos, tours, briefings for community leaders, media and politicians, open houses, transportation seminars for first responders, newsletters, direct mailings, radio open line shows, speaking engagements, exhibits at many community events, sponsorships. To reach beyond the local communities, strategies include extensive use of the Internet, where reports, brochures, videos and newsletters can be obtained. OPG considers itself a member of the communities in which it operates. It strives to be open and transparent in all its operations.

H.7.1.2 Public information for a new uranium mine or mill

The CNSC is committed to operating with a high level of transparency. This includes engaging Aboriginal groups, the public and other stakeholders through a variety of consultation processes, information sharing and communications.

An environmental assessment for a new uranium mine or mill – conducted either through a comprehensive study or through a panel review – provides significant opportunities for public participation. This includes encouraging the public to comment on draft environmental assessment guidelines and a comprehensive study report (CSR). Comprehensive studies and panel reviews also offer funding for people who wish to participate in the review. Opportunities may include commenting on the EA process, the project and/or reports generated through the EA. After the public hearing phase, the Commission Tribunal considers licence applications for new uranium mines as set out in the CNSC *Rules of Procedure*, available on the CNSC Web site at: nuclearsafety.gc.ca

Typically, public hearings for licensing applications take place over two hearing days within a 90-day period, with public intervenor submissions taking place on the second hearing day. Public hearings give affected parties and members of the public an opportunity to be heard before the Commission Tribunal. Usually, the Record of Proceedings and Reasons for Decision are published for the public within six weeks of the hearing. Refer to section E.4.3 for information on the public hearing process.

In addition to the formal licensing process, the CNSC encourages licence applicants to consult with the public during the pre-application phase about their plans for new uranium mines and mills. For example, licensees along with other organizations may host public information sessions about uranium mines and mills where CNSC staff may participate. This allows CNSC staff to learn more about the local communities and the outreach activities conducted by licensees.

H.8 Design, construction and assessment of facilities

The second formal licensing step for nuclear facilities, including radioactive waste management facilities, is the construction licence. Requirements for a licence to construct a Class I nuclear facility are listed in sections 3 and 5 of the *Class I Nuclear Facilities Regulations*. Note that section 3 of the GNSCR requires additional information.

Before the CNSC can make a decision about whether to grant a licence to a party that has applied to construct a Class I radioactive waste management facility, the CNSC may have to initiate an environmental assessment. The CEA Act requires that early in the project an integrated environmental assessment of the possible impacts on individuals, society and the environment of all licensing stages must be carried out. The CEA Act is further described in annex 2.5. At the end of the environmental assessment process, if the CNSC concludes that the project is not likely to cause significant adverse environmental effects, licensing can proceed.

Regulatory guide G-320, *Assessing the Long Term Safety of Radioactive Waste Management* (see section B.6 of this report), helps licensees and applicants assess long-term safety of storage and disposal of radioactive waste.

H.9 Operation of facilities

The third step in the licensing process is the operating licence. Requirements to operate a Class I nuclear facility are listed in sections 3 and 6 of the *Class I Nuclear Facilities Regulations*. Section 3 of the GNSCR and section 3 of the *Class I Nuclear Facilities Regulation* require additional information. The information includes such items as a safety analysis report, commissioning program, measures to prevent or mitigate releases of nuclear substances and hazardous substances to the environment, and a preliminary decommissioning plan.

H.9.1 Records

As a requirement of a licence to operate, the licensee must also keep a record of:

- the results of effluent and environmental monitoring programs
- operating and maintenance procedures
- the results of the commissioning program
- the results of the inspection and maintenance programs
- the nature and amount of radiation, nuclear substances and hazardous substances within the
- nuclear facility
- the status of each worker's qualifications, re-qualification and training

H.9.2 Criticality safety

As per CNSC regulatory document RD-327, *Nuclear Criticality Safety*, criticality safety requirements must address both normal and abnormal conditions. Criticality safety analysis must be performed when significant quantities of fissionable materials are stored or handled. The analysis must clearly demonstrate that the storage and handling of the nuclear waste is safe and, therefore, an inadvertent criticality cannot occur under normal (or credible abnormal) conditions. The analysis must consider the offsite consequences for low-probability, high-consequence inadvertent criticality events and demonstrate that the consequences of such events do not violate the public evacuation criteria established by international standards (IAEA Safety Standards Series GS-R-2) and national guidelines (*Canadian Guidelines for Intervention During a Nuclear Emergency*).

H.10 Institutional measures after closure

H.10.1 Introduction

Article 17 applies to institutional measures that must be taken after a disposal facility has been closed. Disposal means that the radioactive waste is disposed of in a manner where there is no intent to retrieve it and that surveillance and monitoring is not required. Canada does not currently have a disposal facility. Examples of institutional controls for proposed future radioactive waste repositories are discussed in sections H.10.2 (i) and (ii). Decommissioned tailings management facilities require long-term institutional controls. These will vary from minimal – after the closure of the current generation of in-pit TMFs, which were designed for future decommissioning – to ongoing monitoring and maintenance programs at older sites where tailings have been deposited in surface facilities. Section H.10.3 describes the institutional control program developed by the Government of Saskatchewan for decommissioned mine sites, including former uranium mining and milling sites situated on Crown lands in that province.

H.10.1.1 Regulatory body requirements

Any proposal for the siting, construction and operation of a disposal facility must satisfy the requirements of the NSCA and its associated regulations as well as the CEA Act. If a licence application is received for a disposal facility, current nuclear regulations in Canada require that the CNSC oversee the nuclear inventory there. This implies perpetual licensing from the CNSC unless the risks are very minimal and oversight by another regulatory or governmental body allows the Commission Tribunal to exempt the site indefinitely from pursuing a CNSC licence. (This is determined on a case-by-case basis).

Several requirements are imposed by the NSCA and its associated regulations, including the following;

- A licence from the CNSC must be held for anyone to possess and use nuclear substances.
- Persons and the environment must be protected from unreasonable risk arising from the production, possession and use of nuclear substances and the development, production and use of nuclear energy.
- A licensee must conform with international obligations to which Canada has agreed (such as the commitments in the Joint Convention Report).

Regulatory guide 320, *Assessing the Long Term Safety of Radioactive Waste Management*, helps licensees and applicants assess the long-term safety of storage and disposal of radioactive waste, including institutional controls (see section B.5). The Guide describes typical ways to assess the impacts that radioactive waste storage and disposal methods have on the environment and on the health and safety of people. It addresses topics that include the use of institutional controls.

After closure of a disposal facility, institutional controls may be a part of an abandonment licence application. Current Canadian regulations do not allow removal from licence control (abandonment) without an explicit exemption by the CNSC. Such an exemption would require the licensee to present a safety case demonstrating long-term safety. The case would have to cite engineering design and barriers and/or other forms of institutional controls, including periodic site verification. The CNSC would examine on a case-by-case basis the proposed institutional controls for long-term safety, for cost, for consequences of failure of the institutional controls and for reliability of the institutional controls. The CNSC must be satisfied that the abandonment of the nuclear substance and the prescribed equipment or information does not pose an unreasonable risk to the environment or the health and safety of persons, or pose an unreasonable risk to national security or result in a failure to achieve conformity with measures of control and Canada's international obligations.

Pursuant to section 8 of the CNSC *Class I Nuclear Facilities Regulations*, an application for a licence to abandon a Class I nuclear facility that includes spent fuel management facilities shall contain the following information:

- the name and location of the land, buildings, structures, components and equipment that are to be abandoned
- the proposed time and location of the abandonment

- the proposed method of and procedure for abandonment
- the effects on the environment and the health and safety of persons that may result from the abandonment and the measures that will be taken to prevent or mitigate those effects
- the results of the decommissioning
- the results of the environmental monitoring

H.10.1.2 Records

According to the GNSCR, every person must keep records that the NSCA requires and must do so for the period specified in the regulations or, if no such period is specified, until one year after the expiry of the licence that authorizes the activity in respect of which the records are kept. No person may dispose of a record unless the NSCA no longer requires him or her to keep that record or unless he or she has notified the regulatory body of the date of disposal and of the nature of the record at least 90 days before disposing of it.

Records relating to an abandonment licence or an exemption from licensing may also need to be archived or stored indefinitely under the oversight of another government or regulatory body.

H.10.2 Examples of the use of institutional controls for proposed spent fuel and radioactive waste repositories

The following are examples of Canadian initiatives for repositories:

(i) The NWMO's Proposed Repository for the Long-Term Management of Spent Fuel

On November 3, 2005, the NWMO submitted to the Government of Canada a final study, *Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel*, and a recommendation. The recommended approach, APM, includes centralized containment and isolation of spent fuel in a deep geological repository in a suitable rock formation. In June 2007, the Government of Canada issued its decision, accepting the APM as Canada's Plan.

After a decision is made to close the deep repository, a provision will come into play for post-closure monitoring of the facility. The precise nature and duration of post-closure monitoring and any requirements to restrict public access to the area will be developed collaboratively during implementation and take advantage of modern technology. This is a decision to be made by a future society.

(ii) OPG's Deep Geologic Repository (DGR) for Low- and Intermediate-Level Radioactive Waste

Regulatory approval processes following closure of this facility and dismantling of the surface facilities may require institutional controls to prevent the public from accessing the site for some period of time. For OPG's proposed DGR, it is expected that unrestricted access could be allowed eventually with all activities permitted except deep drilling (subject to any ongoing use of the site for nuclear activities). Restrictions could be put on zoning and land use. At the current stage of the DGR program, specific details of these and any additional activities have yet to be defined.

H.10.3 Example of the development of institutional control for decommissioned uranium mines and mills in Saskatchewan

An initiative is underway in Saskatchewan, entitled *Institutional Control Program – Post Closure Management of Decommissioned Mine/Mill Properties on Crown Land in Saskatchewan (draft)*, under the auspices of the provincial Ministry of Energy and Resources (April 2008).

Under this initiative, Saskatchewan started the formal development of an institutional control framework for the long-term management of decommissioned mine and mill sites on provincial Crown land. The development of the framework was to ensure the health, safety and well-being of future generations, provide certainty and closure for the mining industry and recognize obligations by the province and national and international obligations for storage of radioactive materials. The Ministry of Energy and Resources was assigned responsibility for the Institutional Control Registry. An interdepartmental Institutional Control Working Group (ICWG) of senior representatives from the Ministries of Environment, Energy and Resources, Northern Affairs, Justice, Finance and Executive Council developed a framework and consulted with stakeholders from the Government of Canada, industry, Aboriginal peoples and Northern residents, special interest groups and the general public.

In May 2006, the provincial legislature promulgated the *Reclaimed Industrial Sites Act* to implement and enforce a recognized need for institutional control. With the *Reclaimed Industrial Sites Act* in place, the ICWG proceeded with the development of the *Reclaimed Industrial Sites Regulations,* which were subsequently approved in March 2007. The *Reclaimed Industrial Sites Act* and *Reclaimed Industrial Sites Regulations* legislate the establishment of the Institutional Control Program (ICP). In the case of a former uranium mining or milling site, the ICP recognizes the jurisdictional authority of the NSCA as enforced by the CNSC.

The two primary components of the ICP are:

- the Institutional Control Registry and the Institutional Control Funds
- the Monitoring and Maintenance Fund and the Unforeseen Events Fund

The Registry will maintain a formal record of closed sites, manage the funding and perform any required monitoring and maintenance work. Registry records will include the location and former operator, site description and historical records of activities, site maintenance, monitoring and inspection documentation and future allowable land use for the site. In the case of a decommissioned uranium mining or milling site, it will reference the related CNSC documentation and decisions.

The Monitoring and Maintenance Fund will pay for long-term monitoring and maintenance. The Unforeseen Events Fund will pay for unforeseen future events. Examples of unforeseen events include damage resulting from floods, tornadoes or earthquakes. To reduce the province's risk when it accepts custodial responsibility for sites, and to offset the cost of future monitoring, maintenance and unforeseen events, dedicated site-specific funding will be established by the site holder. The funds will be managed by the province but are legislated and stand alone from provincial revenue.

The ICP completes the regulatory framework for the province, helping the province respond to industry's requirement for clarity in the investment climate and accepting responsibility for safety and environmental concerns. This helps create a sustainable mining industry and protect future generations.

The Ministry of Energy and Resources is responsible for the Institutional Control Registry. During a dialogue with the stakeholders a discussion paper was prepared to introduce the structure and operation of the Registry – and the requirements for a company applying to enter a site into it. The discussion paper can be viewed at: ir.gov.sk.ca

H.11 Monitoring programs

Each radioactive waste management facility in Canada must have in place an approved monitoring program. The monitoring program for a waste management facility must detect unsafe conditions and degradation of structures, systems and components that could result in an unsafe condition. This is how the performance of the individual storage structures – and the entire waste storage system – is evaluated. It helps ensure standards will create a safe environment for humans, non-human biota and the physical environment. For more information on environmental monitoring programs, refer to section F.6.6. Radiological effluent discharge levels for radioactive waste management facilities are provided throughout annexes 5–8.

A typical monitoring program for a radioactive waste management facility, including a uranium mine tailings area, may include the following elements:

- gamma radiation monitoring
- effluent monitoring, including airborne and liquid emissions

- an environmental monitoring program, which may include water quality, soil sampling, sediment sampling and fish sampling
- surface water and groundwater monitoring

Section I – Transboundary Movement

I.1 Scope of the section

This section addresses Article 27 (Transboundary Movement) of the Joint Convention and provides information on Canada's experience and practices pertaining to the transboundary movement of radioactive material. The information in this section demonstrates that such movements are undertaken in a manner consistent with the provisions of the Joint Convention and relevant binding international instruments.

I.2 Introduction

The Canadian laws and regulations used to control the import and export of nuclear substances in accordance with Canada's bilateral and multilateral agreements are:

- the NSCA and the associated *Nuclear Non-proliferation Import and Export Control Regulations*
- the CEPA and the associated *Export and Import of Hazardous Wastes Regulations*
- the *Export and Import Permits Act*
- the *United Nations Act*

The NSCA deals specifically with nuclear substances, while the other acts and regulations are more generic and deal with other environmentally significant substances.

I.3 Controlled substances

Licences issued by the CNSC stipulate limitations on licensees' ability to import and export the nuclear substances they possess.

Under the NSCA, the CNSC regulates the import and export of nuclear substances. The *Nuclear Non-proliferation Import and Export Control Regulations* (NNIECR) contain a Schedule of controlled nuclear substances that require authorization to be legally exported from Canada. There are no *de minimis* quantities on these controlled nuclear substances.

Foreign Affairs and International Trade Canada (DFAIT) regulates the export of certain types of nuclear substances under the *Export and Import Permits Act*.

Under the NNIECR, the following nuclear materials and radioisotopes are defined as "controlled nuclear substances" and require transaction-specific export authorizations from the CNSC:

- plutonium
- uranium
- thorium
- deuterium
- tritium
- radium-226 (greater than 370 MBq)
- alpha-emitting radioisotopes with a half-life of 10 days or greater, but less than 200 years, with a total alpha activity of 37 GBq/kg or greater (with the exception of material with less than 3.7 GBq of total alpha activity)

The export of a sealed source of a radioisotope identified by the IAEA as a Category 1 or Category 2 radioactive source under the *Code of Conduct on the Safety and Security of Radioactive Sources* requires authorization by the CNSC under the NSCA.

I.4 Exporting state

The CNSC and DFAIT have adopted a one-window approach for granting export authorizations required under the NSCA and the *Export and Import Permits Act* for controlled nuclear substances listed in section I.3. The export applications for a DFAIT permit and a CNSC licence are sent to DFAIT and the CNSC four to six weeks before the proposed export to allow sufficient time to process the application, hold intra- and inter-departmental consultations and issue the CNSC licence and the DFAIT export permit. It is important to note that both the permit and licence application evaluations are performed independently and in parallel with each other. The CNSC and DFAIT consult on issues pertaining to a specific export licence and permit application prior to issuance of the licence and permit.

As a matter of Canadian nuclear non-proliferation policy, nuclear exports can go forward only to countries with which Canada has established a *Nuclear Cooperation Agreement* (NCA). NCAs establish reciprocal obligations to ensure, among other things, that nuclear materials will only be used for peaceful, non-explosive purposes. Exports of nuclear substances may still go forward to countries with which Canada does not have an NCA, provided they are of small quantities and/or for non-nuclear use. Canada may also import nuclear substances from countries with which it does not currently have an NCA.

I.5 State of destination

Possession licences issued by the CNSC specify the nuclear substances that the licensee is authorized to hold. These possession licences may also authorize certain types and maximum quantities of nuclear substances to be imported without further authorization. When substances (as defined in section I.3) are imported, transaction-specific authorization must be obtained. This authorization verifies that the applicant holds the necessary possession licences for receiving and properly handling the nuclear substances. If the applicant does not hold the necessary licence, the applicant is notified of the requirements for holding the substance shown in the application.

The Canada Border Services Agency assists the CNSC in administering export and import controls under the NSCA. An importer/exporter must present a valid CNSC licence to a customs officer when importing or exporting a nuclear substance. If a valid licence is not presented upon import or export, the licence holder may be in violation of the conditions of the import or export licence.

I.6 Destination south of latitude 60 degrees

Antarctica is the only land mass south of 60 degrees latitude in the southern hemisphere as defined under the *Antarctic Treaty (1959)*. Seven states currently claim unofficial sovereignty rights to portions of Antarctica. Canada is not one of the seven states. The procedures for ensuring that radioactive material is not transferred to Antarctica are the same as for other destinations. In addition, this international obligation was incorporated under Canadian national law through the CEPA.

Section J – Disused Sealed Sources

J.1 Scope of the section

This section addresses Article 28 (Disused Sealed Sources) of the Joint Convention, which requires that:

1. Each contracting body shall, in the framework of its national law, take appropriate steps to ensure that the possession, re-manufacturing or disposal of disused sealed sources is done safely.

2. A contracting party shall allow for the re-entry into its territory of disused sealed sources if, in the framework of its national laws, it has accepted that the sealed sources can be returned to a manufacturer qualified to receive and possess the disused sealed sources.

J.2 Introduction

In Canada, the NSCA establishes requirements for the protection of health, safety, security and the environment, as well as the fulfillment of Canada's international obligations and commitments on the peaceful use of nuclear energy. The CNSC is the regulatory authority responsible for controlling the export and import of risk-significant sealed sources in Canada and is mandated by the NSCA to:

- regulate the development, production and use of nuclear energy in Canada

- regulate the production, possession, use and transport of nuclear substances, along with the production, possession and use of prescribed equipment and information

- implement measures that respect international control of the development, production, transport and use of nuclear energy and nuclear substances, including the non-proliferation of nuclear weapons and explosive devices

- disseminate objective scientific, technical and regulatory information that concerns the CNSC's activities and their effects on the environment and the health and safety of persons of the development, production, possession, transport and use of nuclear substances referred to above

Radioactive nuclear substances, whether in sealed or unsealed source form, have many industrial, medical and academic applications. A wide variety of organizations, including universities, hospitals, research organizations and government departments, are typical users of sealed sources.

Most sealed sources are physically small, but their radioactivity may range from tens to billions of becquerels (Bq). When a sealed source is no longer required or has decayed beyond its useful life and is not intended to be used for the practice for which an authorization has been granted, it becomes a disused source. It may then be treated as radioactive waste and sent to a licensed waste management facility. If a source's radioactivity has decayed below its exemption quantity or its clearance level, it may be released from regulatory control, pursuant to section 5.1 of the NSRDR. Sources that remain within regulatory control must be managed in consideration of all existing regulations.

Figure J.1 – Cesium-137 sealed source

J.3 Regulatory framework for sealed sources

In accordance with section 26 of the NSCA and subject to regulatory requirements, no person shall possess, transfer, import, export, use, abandon, produce or service a sealed source, except in accordance with a licence.

As defined in the NSRDR, “sealed source” refers to a radioactive nuclear substance in a sealed capsule or bonded to a cover. The capsule or cover must be strong enough to prevent contact with or dispersion of the substance – under the conditions for which the capsule or cover is designed.

As reported in Canada’s *Third National Report*, the NSRDR was amended to include the latest international exemption levels established in the 1996 edition of the IAEA *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*. Exemption quantities are threshold values below which regulatory control is not required. Nuclear substances in these quantities may still contain a small quantity of radioactivity; however, they do not pose any significant risk to persons or the environment.

Individuals who wish to obtain a licence to import, export, use, abandon, produce, manage, store or dispose of a sealed source must provide the information required under section 3 of the GNSCR and section 3 of the NSRDR. For controlled nuclear substances or for the export or import of Category 1 and 2 radioactive sources as identified in the *IAEA Code of Conduct on the Safety and Security of Radioactive Sealed Sources* and *IAEA Safety Guide RS-G-1.9 Categorization of Radioactive sources*, separate licence requirements are prescribed by the *Nuclear Non-Proliferation Import and Export Control Regulations*. Additional requirements for persons wishing to apply for a licence to transport nuclear substances are prescribed by the *Packaging and Transport of Nuclear Substances Regulations*.

J.4 Sealed sources used in Canada

Through Canada’s regulatory control program, the CNSC must license activities involving sealed sources. Each licence specifies the isotope and the maximum activity (in Bq) of each radioactive nuclear substance and the maximum activity per sealed source.

J.4.1 Disposal of sealed sources in Canada

A sealed source may only be transferred in accordance with the conditions of a licence or the written instructions issued by the CNSC. For long-term management, radioactive sealed sources may be returned to a manufacturer. They may then be sent to a licensed waste management facility for management, or transferred to a person licensed to possess the sealed sources. If a sealed source has decayed below its exemption quantity or its clearance levels – as identified in Schedule 1 and Schedule 2 of the NSRDR – it may also be released from CNSC regulatory control, pursuant to section 5.1 of the NSRDR. The sealed sources may no longer be under CNSC regulatory control; however persons must still follow applicable federal, provincial and/or municipal regulations.

Once a sealed source is no longer needed or wanted, it may be shipped directly or through licensed collection firms to AECL CRL for management at its licensed waste management facility or returned to its country of origin.

J.4.2 The National Sealed Source Registry and Sealed Source Tracking System

In 2004, the CNSC formed a project team to develop the National Sealed Source Registry (NSSR) and the Sealed Source Tracking System (SSTS) in order to enhance the safety and security of radioactive sources.

The team worked throughout the following year to design and build the system. In 2005, the team recommended to the Commission Tribunal that 278 licences involving Categories 1 and 2 high-risk radioactive sealed sources be amended to require licensees to report the movements of their sealed sources.

On January 1, 2006, the CNSC implemented the NSSR and the SSTS. The NSSR was designed to hold information about radioactive sources in all categories for licensees. The SSTS was designed to enable licensees to report changes in inventory of all high-risk radioactive sources within strict time limits. This tracking is done throughout the complete lifecycle of the sources.

During its first year of operation, the CNSC conducted outreach activities to inform licensees about the regulatory changes concerning source-tracking and reporting requirements. The CNSC also prepared demonstration CDs with how-to guides about the source tracking system. An information package – which consisted of a letter, a demonstration CD and security authorization codes – was sent to each CNSC licensee whose licence required the reporting of all Category 1 or 2 sources under their control. For the first half of 2006, all SSTS transactions were reported by mail, fax or email. In July 2006, the CNSC launched a secure Web site for online reporting of SSTS transactions, using the Government of Canada "epass" secure technology. In 2010, the Government of Canada implemented "Access Key" as its new secure technology.

Each change in inventory is called a "transaction" for SSTS purposes. By the end of 2006, the SSTS had logged more than 30,000 transactions for radioactive source imports, exports, transfers and receipts. This gradually increased to over 44,000 transactions in 2009. The majority of these transactions represented bulk shipments, including imports and exports, by a single, large Canadian source manufacturer. In December 2006, the CNSC was tracking over 5,500 Category 1 and 2 radioactive sources in Canada. By 2009, this number had increased to include the tracking of over 20,000 high risk sources, an increase of over 360 percent.

In 2011, the NSSR will continue to be expanded to include the electronic registry and reporting of all Category 3, 4 and 5 sealed sources in Canada.

J.4.3 Import and export of radioactive sealed sources

The enhancement of Canada's export and import control program for radioactive sources is the result of the government's commitment to two key IAEA documents: the *Code of Conduct on the Safety and Security of Radioactive Sources* (the Code) and its supplementary *Guidance on the Import and Export of Radioactive Sources* (the Guidance). Under the leadership of the IAEA, the Code and the IAEA Guidance were developed to improve the safety and security of radioactive sources around the world. In support of the IAEA and its efforts to develop a global regime for the control and secure management of high-risk radioactive sources, the Government of Canada committed to meet the provisions contained within the Code and implement an export and import control program as outlined in the Guidance.

As Canada's nuclear regulatory authority, the CNSC is responsible for controlling the export and import of radioactive sources under the *Nuclear Safety and Control Act*. Risk-significant radioactive sources reflect the Code's categorization of radionuclides based on their threshold activity. Category 1 and Category 2 sources are defined as risk-significant sources for the purpose of the CNSC export and import control program.

By implementing export and import control measures, the CNSC enhances national and international safety and security. These measures ensure that only authorized persons can receive Category 1 and 2 radioactive sources. The CNSC's export and import control program is consistent with the Code and Guidance and aims to:

- achieve a high level of safety and security regarding Category 1 and 2 radioactive sources
- reduce the likelihood of accidental harmful exposure to risk-significant radioactive sealed sources or the malicious use of such sources intended to harm individuals, society and the environment
- mitigate or minimize the radiological consequences of any accident or malicious act involving Category 1 and 2 radioactive sources

The CNSC amended operating licences to remove general authorization for the export of Category 1 and 2 radioactive sources. A CNSC licensee authorized to use or possess a Category 1 or 2 source must apply for and be issued an export licence before exporting that source.

In considering an application to export risk-significant radioactive sources, the CNSC must satisfy itself that the importing state meets the expectations specified in paragraph 8(*b*) of the supplementary guidance, regarding Category 1 sources, and paragraph 11(*b*) with respect to Category 2 sources. Where such assurances cannot be obtained, the CNSC may consider authorizing the export under the requirements described in paragraphs 15 and 16 of the Guidance.

In assessing the capabilities of an importing country or facility, the CNSC may also take into consideration some of the following concerns:

- whether the recipient facility has been engaged in clandestine or illegal procurement of Category 1 and 2 radioactive sources
- whether import or export authorizations for radioactive sources have been previously denied to the recipient facility
- whether the recipient facility has diverted, for purposes inconsistent with the Code, any previous import or export of radioactive sources
- whether the recipient country has the ability to protect against diversion or malicious acts involving radioactive sources

Prior to issuing an export licence, the CNSC also ensures – through the use of special IAEA forms available to member states – that the importing state has granted its consent for the import of Category 1 sealed sources (import consent is not required for Category 2 sealed sources).

All export licences issued by the CNSC include a licence condition requiring the submission of a seven-day prior shipment notification to the CNSC and the importing state authority. Export licences also contain a post-shipment notification condition whereby exporters must provide information on shipments within two business days of a shipment taking place. The prior-shipment notification and post-shipment reporting conditions are a means of verifying compliance with the terms of an export authorization.

The CNSC has published INFO-0791, *Control of the Export and Import of Risk-Significant Sealed Sources*, which provides information on the CNSC import and export control program for Category 1 and 2 sources. An application form and accompanying instructions for obtaining a licence to export Category 1 and 2 sources are also available on the CNSC Web site.

Since implementation of the program on April 1, 2007, the CNSC has received more than 850 applications to export Category 1 and 2 sources to over 80 countries. Of these 850 applications, the CNSC received 243 in 2008, 179 in 2009 and 210 in 2010.

J.4.4 Records

Section 36 1(*c*) of the NSRDR requires every licensee to keep a record of the receipt, disposal or abandonment of a nuclear substance. Requirements include:

- the date of the transfer, receipt, disposal or abandonment
- the name and address of the supplier or the recipient
- the number of the licence of the recipient
- the name, quantity and form of the nuclear substance transferred, received, disposed of, or abandoned
- when the nuclear substance is a sealed source, the model and serial number of the source
- when the nuclear substance is contained in a radiation device, the model and serial number of the device

J.4.5 Safety of sealed sources

In Canada all Category 1 and 2 radioactive sources are referenced in a licence (pursuant to the NSRDR) to ensure that throughout its lifecycle a sealed source is possessed, transferred, imported, exported, used, abandoned, produced or serviced in accordance with regulatory requirements.

J.5 Sealed sources in the international community

The re-entry of previously exported sealed sources is permitted either by an import licence (with respect to controlled nuclear substances) or in accordance with a general import authorization licence issued by the CNSC.

Section K – Planned Activities

K.1 Scope of the section

This section provides a summary of key activities and programs mentioned throughout this report, including planned next steps. Where appropriate, these include measures of international cooperation.

K.2 Introduction

Canada is currently pursuing several initiatives in order to better manage the spent fuel and radioactive waste produced inside its borders and to ensure the safety of humans, society and the environment. These initiatives include:

- improving the regulatory framework
- updating, revising and developing new regulatory documents that provide guidance to licensees
- developing long-term management options for spent fuel and radioactive waste
- addressing historic and legacy issues

K.3 Regulatory framework initiatives

In September 2007, CNSC staff presented a new approach for the regulatory framework to the Commission Tribunal. The CNSC is continually making improvements to the framework to make it more robust and more responsive to current and emerging needs. For example,

- international standards (IAEA, ISO) are being adapted or adopted as appropriate
- external consultations are being aligned with the Treasury Board of Canada's *Guidelines for Effective Regulatory Consultations*
- an online consultation form was launched to encourage people to participate in the development of regulatory documents

For future regulatory documents, emphasis will be put on setting requirements for regulations and licence conditions and to provide guidance in regulatory documents. This initiative will result in documents being developed more efficiently while spanning a wider regulatory subject matter.

A regulatory framework analysis is being prepared for regulations and related documents to identify any gaps and to help develop long-term plans for the framework. The Regulatory Framework Steering Committee is providing strategic direction to coordinate the identification, development and implementation of the framework.

Planned initiatives for regulatory documents include regulatory policy P-319, *Policy Financial Guarantees for Nuclear Facilities and Licensed Activities,* and regulatory guide G-306, *Financial Guarantees for Decommissioning of Licensed Activities*. For information on these two regulatory documents, refer to section F.4.3.

Future planned initiatives for regulatory documents, specific to spent fuel and radioactive waste, include reviewing P-290, *Managing Radioactive Waste,* and G-320, *Assessing the Long Term Safety of Radioactive Waste Management,* to ensure their continued relevancy for licensees. The CNSC also may consider revising G-219, *Decommission Planning for Licensed Activities*, published in 2000, to ensure it remains relevant to licences.

K.4 Long-term management of spent fuel

K.4.1 Assessment of options for long-term management of spent fuel (2002–2005)

From 2002 to 2005, the NWMO studied approaches for long-term management of Canada's spent fuel.

The NWMO began by analyzing management options that have been considered internationally. Following this review and screening, the NWMO selected as the basis for its initial assessment the three methods specified in the *Nuclear Fuel Waste Act* (NFWA): deep geological disposal in the Canadian Shield, storage at nuclear reactor sites and centralized, above or below ground storage. From the insights gained through the NWMO analysis and public consultation, the NWMO proposed a fourth option, Adaptive Phase Management (APM). The NWMO believes APM would best meet the objectives and expectations of Canadians.

The management options were subject to multiple assessment processes. The NWMO developed an assessment framework for evaluating the options according to citizen values, ethical principles and eight objectives:

- fairness
- public health and safety
- worker health and safety
- community well-being
- security
- environmental integrity
- economic viability
- adaptability

The analysis included ethical and social considerations. A preliminary assessment of the three options in the NFWA examined the strengths and limitations of each approach, through an application of multi-attribute utility analysis. Extensive comparative analysis of the costs, benefits and risks of the three options in the NFWA and the NWMO's fourth option provided quantitative and qualitative assessments. The assessment processes were supported by multi-disciplinary research contributions, workshops, and submissions from Canadians, guidance on values and ethical principles from citizens, Aboriginal traditional knowledge and the NWMO's Roundtable on Ethics.

The NWMO developed its recommendation, APM, following the input of technical specialists, the public and Aboriginal peoples. The NWMO engaged Canadians in a wide-ranging dialogue on the values, principles and objectives they believe are required of a nuclear waste management approach for the approach to be socially acceptable, environmentally responsible, technically sound and economically feasible. In studying these options, the NWMO held 120 public consultations and numerous full-day dialogues on values, covering a cross-section of the population in every province and territory. Approximately 18,000 citizens contributed to the study. More than 60,000 people expressed their interest by visiting the NWMO Web site. The final study report*, Choosing a Way Forward*, which contains the detailed recommendation and the NWMO's supporting assessment findings and research, is available at nwmo.ca for download.

K.4.2 Adaptive Phased Management: NWMO proposal to government (2005)

In November 2005, the NWMO submitted its study and recommended the APM approach to the Minister of Natural Resources.

APM is composed of:

1. a technical method that:

    - is based on centralized containment and isolation of the spent fuel in a deep geological repository of suitable rock formations, such as the crystalline rock of the Canadian Shield or formations such as sedimentary rock

- is flexible in the pace and manner of implementation, through a phased decision-making process that will be supported by a program of continuous learning, research and development
- provides for an interim step in the implementation process, in the form of shallow underground storage of spent fuel at the central site, prior to final placement in a deep repository
- monitors the spent fuel to support data collection and confirmation of the safety and performance of the repository
- is able to retrieve the spent fuel over a long period, until such time as a future society makes a determination on the final closure and the appropriate form and duration of post-closure monitoring

and

2. a management approach, whose key characteristics include:

   - responsiveness to advances in technology, natural and social science research, Aboriginal traditional knowledge and societal values and expectations
   - sustained engagement of people and communities while making and implementing decisions
   - financial stability, through funding by the nuclear energy corporations (currently OPG, HQ and NB Power) and AECL, according to a financial formula required by the NFWA
   - site selection, focused on provinces that currently benefit from the nuclear fuel cycle: Saskatchewan, Ontario, Quebec and New Brunswick, although communities in other regions will also be considered
   - selecting a site which preferably has a willing community to host the central facilities
The site must meet the scientific and technical criteria to ensure that multiple engineered and natural barriers will protect human beings, other life forms and the biosphere.

APM was designed to build upon the advantages of each of the other three approaches and in order to provide safety and fairness to this and future generations.

In proposing an APM, the NWMO tried to provide a risk-management approach that comprises deliberate stages and periodic decision points. The APM program:

- commits this generation of Canadians to take the first steps to manage the spent fuel it has created
- includes a design and process that ensure that the APM meets rigorous safety and security standards
- features a step-by-step decision-making process that will provide the flexibility to adapt to experience and societal change
- provides genuine choice by taking a financially conservative approach and by allowing capacity to be transferred from one generation to the next
- promotes continuous learning – improvements in operations and design can be made to enhance performance and reduce uncertainties
- provides a viable, safe and secure long-term storage capability, with the potential for retrieving waste, which can be exercised until future generations have confidence to close the facility
- is rooted in values and ethics and engages citizens, allowing for societal judgments as to whether there is sufficient certainty to proceed with each step

K.4.3 Government decision (June 2007)

Following a government-wide review, the Government of Canada announced on June 14, 2007, that it had selected the APM approach for the long-term management of spent fuel, as proposed by the NWMO.

When the Government of Canada accepted this management approach, the NWMO assumed responsibility for implementing it. The NWMO began its implementation activities in 2007.

K.4.4 Implementing the long-term management plan (2008 to 2011)

Following the Government of Canada's decision in 2007, the NWMO developed and confirmed through public review seven strategic objectives that would serve as the foundation of strategic plans for the important first phase of work to implement the approach. It is against these seven strategic areas that the NWMO presents its progress for 2008 to 2011.

From 2007 to 2008, the NWMO grew into a broader implementing agency and began its initial implementation activities in seven key areas of its initial five-year plan. These activities are described in the following sections.

K.4.4.1 Relationship building

Throughout the reporting period, building and nurturing relationships with those potentially affected by the NWMO's work has remained an important focus, with the ongoing invitation to interested organizations and individuals to contribute to shaping implementation plans for the APM project. Important foundations for the APM site selection process were laid through the collaborative development of a process to identify a safe site in an informed and willing host community. Engagement activities sought input on NWMO plans and policies and strategic objectives for APM. Activities included:

- engaging a cross-section of Canadians (more than 7,000 people) in 2008 and 2009 in developing the APM site selection process through public information sessions, citizen panels, multi-party dialogues, Aboriginal dialogues, national surveys and other activities, providing a range of perspectives
- establishing a Municipal Forum and stronger liaisons with municipal associations
- expanding work and collaboration with national and provincial Aboriginal organizations, NWMO Elders Forum and the Niigani working group
- expanding relationships with all levels of government
- expanding a suite of communication materials to support general public outreach, including an enhanced Web site, an APM exhibit on the repository concept, DVDs on site selection process (available in English, French and nine Aboriginal languages), backgrounders and fact sheets
- convening a Youth Roundtable to advise on future outreach and engagement

K.4.4.2 Site selection

A further milestone was marked with the initiation of the site selection process in 2010 and the invitation to communities to learn more about the APM project. Activities on site selection included:

- collaboratively developing (2008, 2009) a process for identifying a safe, secure location in an informed and willing community to host the deep geological repository
- initiating the APM site selection process (May 2010), supported by a broad-based program of activities to raise awareness of the APM project

- inviting and responding to early interest from communities in 2010 in engaging in the Learn More phase

  As of the end of March 2011, eight communities became engaged in the Learn More phase, without obligation to continue in the process. Communities initiated participation in programs to build their understanding of APM. Communities requested initial screenings as part of this period of learning more about APM and the siting process.

- providing materials on APM and setting up public kiosks provided to support early community information and dialogue

K.4.4.3 Design and safety case for an APM deep geological repository

In parallel, refinements to the technical reference designs and safety cases for the deep geological repository continued, supported by a breadth of design and development work in collaboration with international partners. Activities included:

- updating APM conceptual designs for repositories (see figure K.1) in both crystalline and sedimentary rock formations

- initiating work towards a pre-project review by the CNSC

- collaborating on a technical research program with Canadian universities and international partners in Sweden, Finland, Switzerland and France

K.4.4.4 Funding of NWMO activities

The *Nuclear Fuel Waste Act* (NFWA) requires that Canada's nuclear energy corporations – OPG, HQ, NB Power and AECL – ensure there is enough money to pay for the full costs of implementing the plan. Since 2002, waste owners have been contributing to individual trust funds, which total more than $2.1 billion as of the end of 2010. The NFWA built in explicit provisions to ensure that the trust funds are maintained securely and used only for the intended purpose. The NWMO cannot access the NFWA trust fund until the NWMO has been issued a construction licence from the CNSC.

This money is in addition to other segregated funds and financial guarantees the companies have set aside for spent fuel and radioactive waste management and decommissioning. These funds and financial guarantees are used to satisfy the financial guarantees requirements that all NWMO members – OPG, HQ and NB Power – have provided to the CNSC. These guarantees for the year 2011 total $13 billion and equal the total cost (in terms of present value) of managing the decommissioning of all reactors and permanently managing all radioactive waste (including spent fuel) produced to date. A large portion of these guarantees, approximately $12 billion (as of the end of 2010), exists in segregated funds dedicated to spent fuel and radioactive waste management and decommissioning, with the remainder in the form of provincial guarantees. These guarantees include the NFWA trust fund contributions made by NWMO members.

In addition to making financial provision for work required after the construction licence is issued, the cost of the NWMO's activities up to receipt of this licence is covered by contributions made by the nuclear energy corporations.

Activities related to the funding of NWMO activities included:

- elaborating, through the funding formula developed by the NWMO and subsequently approved by the Minister of Natural Resources, the framework for financing the APM program in the future

- receiving approval from the Minister of Natural Resources (2009) of the funding formula proposed by the NWMO, to ensure that those who benefit from nuclear energy pay for the management of spent fuel and that financial burdens are not passed on to future generations

- initiating a process to renew and update the total cost estimate for the APM project

K.4.4.5 Plan adaptation

All work progressed through the important lens of adaptive management, as the organization sought to stay abreast of evolving developments and expectations that may impact on future activities. Activities included:

- tracking opinions and expectations of Canadians for APM project

- tracking emerging technologies, spent fuel inventory projections and potential impacts of new nuclear build on APM program

- tracking best practices in engagement, and potential social, economic and cultural effects of APM

- continuing work to understand the values and ethical considerations of APM implementation

- continuing work to understand opportunities to interweave Aboriginal traditional knowledge

K.4.4.6 Accountability and governance

As the NWMO grew, accountability and governance frameworks grew through:

- expanding the Board of Directors and its committee structure

- expanding Advisory Council membership, with the Advisory Council providing ongoing advice to the NWMO and developing independent comments

- establishing the Independent Technical Review Group (ITRG) to review the APM technical program; annual ITRG reviews confirming that the full range of relevant scientific topics is covered by the NWMO

- receiving ISO 9001 certification and expanding quality assurance and management systems

- deciding that, as part of the service agreement with the NWMO, the CNSC will undertake pre-project design reviews of reports that the NWMO submits on the conceptual design and illustrative post-closure safety assessment for the APM deep geological repository for spent fuel

- signing a Memorandum of Understanding with Natural Resources Canada on consultation with Aboriginal peoples

- initiating five-year strategic plans for APM implementation

K.4.4.7 Organization building

The NWMO itself developed and expanded in recent years, as it transitioned into a larger implementing organization with the range of skills, oversight and governance required to capably deliver on the NWMO's mandate and earn the confidence of Canadians. Activities included:

- becoming an employer in its own right with supporting legal and financial infrastructure
- significant strengthening of its capabilities through recruitment of a highly qualified, experienced multidisciplinary team – the NWMO grew from 27 employees in 2007 to 120 employees by the end of 2010

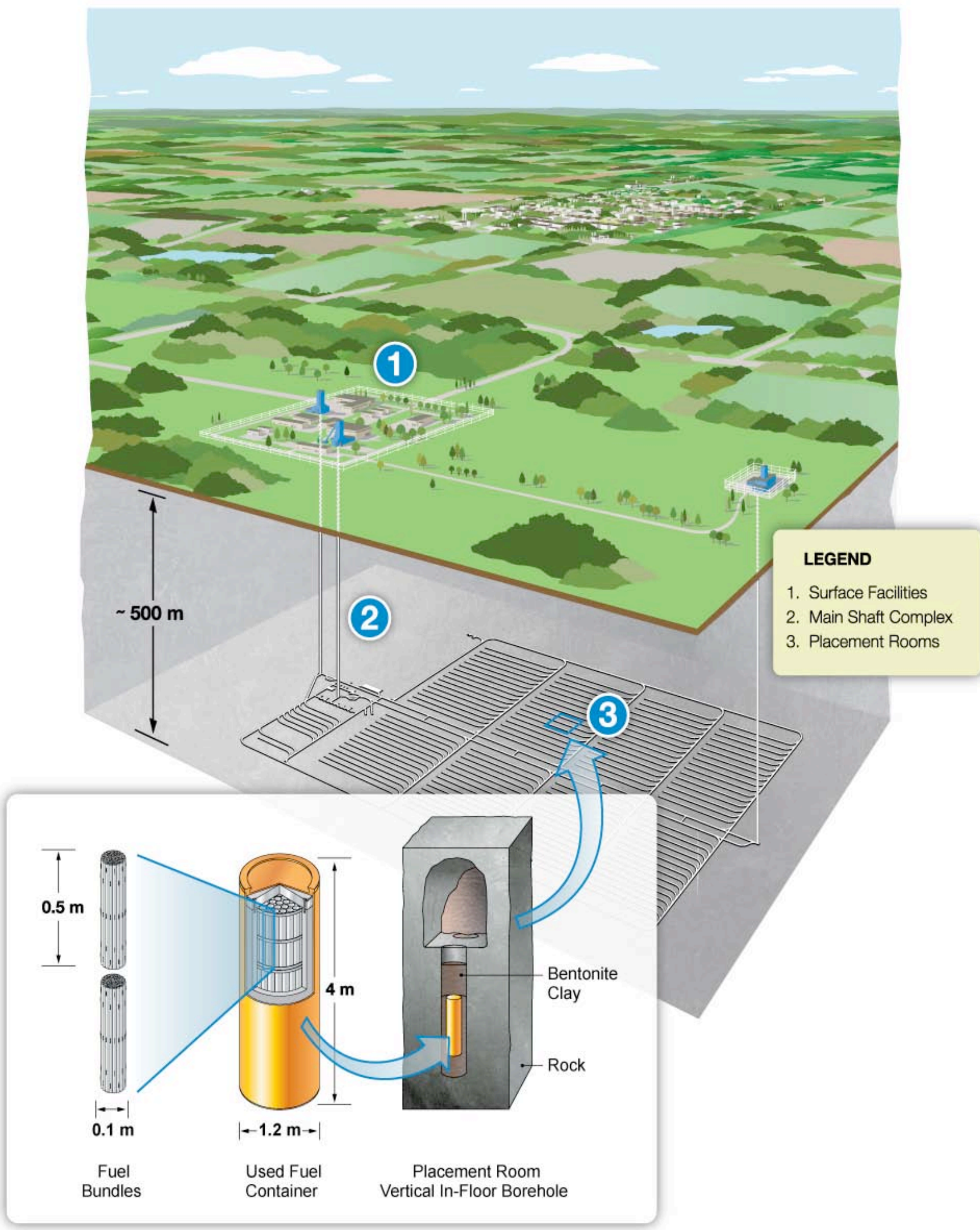

Figure K.1- Deep geological repository

K.5 The CNSC's role and early involvement in the APM project for the long-term management of Canada's spent fuel

As a best practice, the CNSC gets involved early in proposed new nuclear projects to ensure that licence applicants and affected communities have a comprehensive understanding of the CNSC's role in regulating Canada's nuclear sector.

Future applicants are provided with CNSC information and guidance on the regulatory requirements and licensing process prior to the submission of a licence application and the initiation of the environmental assessment process. The CNSC engages affected communities to provide factual and unbiased information about how it regulates the nuclear sector to protect the health, safety and security of Canadians and the environment, and how it respects Canada's international commitments on the peaceful use of nuclear energy. More information is available at the CNSC Web site at: nuclearsafety.gc.ca

K.5.1 Service arrangement between the CNSC and NWMO

The CNSC signed a service arrangement with the NWMO to provide regulatory guidance and support for implementing the NWMO's APM. The service arrangement identifies the terms under which the CNSC provides services to the NWMO prior to the submission of a licence application. Services include providing pre-project design reviews of APM deep geological repository concepts, identifying regulatory requirements for a geological repository and participating in public meetings to provide information on the CNSC's role. For more information about the service arrangement, refer to the CNSC Web site at: nuclearsafety.gc.ca

As part of this arrangement, the CNSC will undertake pre-project design reviews of reports that the NWMO submits on the conceptual design and illustrative post-closure safety assessment for the APM deep geological repository for spent fuel.

A design review is an assessment of a proposed design based on the concepts presented by a future licence applicant. The word "pre-project" signifies that a design review takes place before a licence application is submitted to the CNSC.

At this time, it is not known where the repository will be located in Canada; therefore the NWMO is developing conceptual designs – these are draft designs (i.e., models) for two hypothetical sites. The NWMO will also be submitting reports that will assess the safety of these two hypothetical sites after a decision is made to close the sites (i.e., post-closure). The CNSC will review the conceptual design and post-closure safety assessment reports for the two hypothetical, but realistic, sites in representative rock formations, one in crystalline rock and one in sedimentary rock.

The CNSC provides reviews as an optional service when requested by a future licence applicant. This service does not certify a concept design or involve issuing a licence under the NSCA and it is not required as part of the licensing process for the deep geological repository. The conclusions of any design reviews do not bind or otherwise influence decisions that the Commission Tribunal makes. For more information about pre-project design reviews, refer to the CNSC Web site at: nuclearsafety.gc.ca

K.5.2 CNSC independent research and assessment on the safe long-term management of spent fuel in geological repositories

Since 1978, the CNSC has been involved in independent research and assessment, including international collaboration, on the safe long-term management of spent fuel in geological repositories. In particular, these activities looked at the Canadian Shield's granitic rock as suitable rock formation for this type of repository.

At this time, OPG's DGR project for the long-term management of low- and intermediate-level wastes is assessing sedimentary rock formation for the facility. To provide sufficient independent knowledge for assessing future proposals involving geological repositories, the CNSC is expanding its technical expertise from granitic rock to include knowledge and understanding of geological disposal in sedimentary rock.

The CNSC is conducting a three-year program to evaluate long-term (up to a million years) safety issues related to the disposal of radioactive waste and spent fuel in sedimentary rock. This program consists of independent scientific research conducted by CNSC staff in collaboration with national and international institutions. It also includes monitoring and review of state-of-the-art scientific advancements, and participation in international forums to exchange information and knowledge related to geological repositories.

K.5.3 CNSC outreach activities

An important part of the CNSC's mandate is to disseminate objective scientific and regulatory information. The CNSC has agreed to meet with communities who express interest in learning more about its role in the NWMO's APM project. Communities can also request that CNSC staff visit them to answer technical and scientific questions on topics such as:

- the nuclear regulatory process and the factors that go into the review of a licence application
- the CNSC's environmental assessment process in place to protect the environment
- Aboriginal consultation
- technical aspects of a deep geological repository
- opportunities for the public to get involved during Commission Tribunal hearings and during the environmental assessment process
- other regulatory bodies the CNSC works with to fulfill its mandate in licensing nuclear facilities and activities

In addition, to assist the public, CNSC staff have included information on the NWMO and APM on the CNSC external Web site nuclearsafety.gc.ca and, in February 2011, developed a fact sheet, *Regulating Canada's Geological Repositories*. The CNSC's external Web site will be updated as the APM project proceeds and will inform those interested in the CNSC's role and early involvement in the APM project.

Figure K.2 – Example of information available on the CNSC's external Web site

K.6 Long-term management of low- and intermediate-level radioactive waste

All Canadian low- and intermediate-level radioactive waste is currently in safe storage. Canada's two major low- and intermediate-level radioactive waste owners, OPG and AECL (which are responsible for about 98 percent of the waste), have initiatives underway to develop and implement long-term solutions. Furthermore, the Government of Canada's PHAI involves the cleanup and long-term management of historic LLW in Port Hope, Ontario.

Ongoing initiatives to address the long-term management of low- and intermediate-level radioactive waste in Canada are described in the following sections.

K.6.1 Proposed low- and intermediate-level waste deep geological repository at the Bruce nuclear site

OPG has recognized that, while its current approach to radioactive waste storage is safe, secure, and environmentally responsible, a new approach will be required for the long term. A long-term management approach will ensure that waste can be kept safely isolated from the environment without burdening future generations.

The Municipality of Kincardine currently hosts OPG's Western Waste Management Facility (WWMF), which is the centralized storage site for low- and intermediate-level radioactive waste (L&ILW) resulting from the operation of the 20 OPG-owned reactors in Ontario. OPG has safely managed L&ILW for the Pickering, Darlington and Bruce reactors at the Bruce site for over 35 years. Currently, an estimated 85,000 cubic metres of L&ILW is in interim storage. Throughout the life of the facility, emissions have been less than one percent of the regulatory limit.

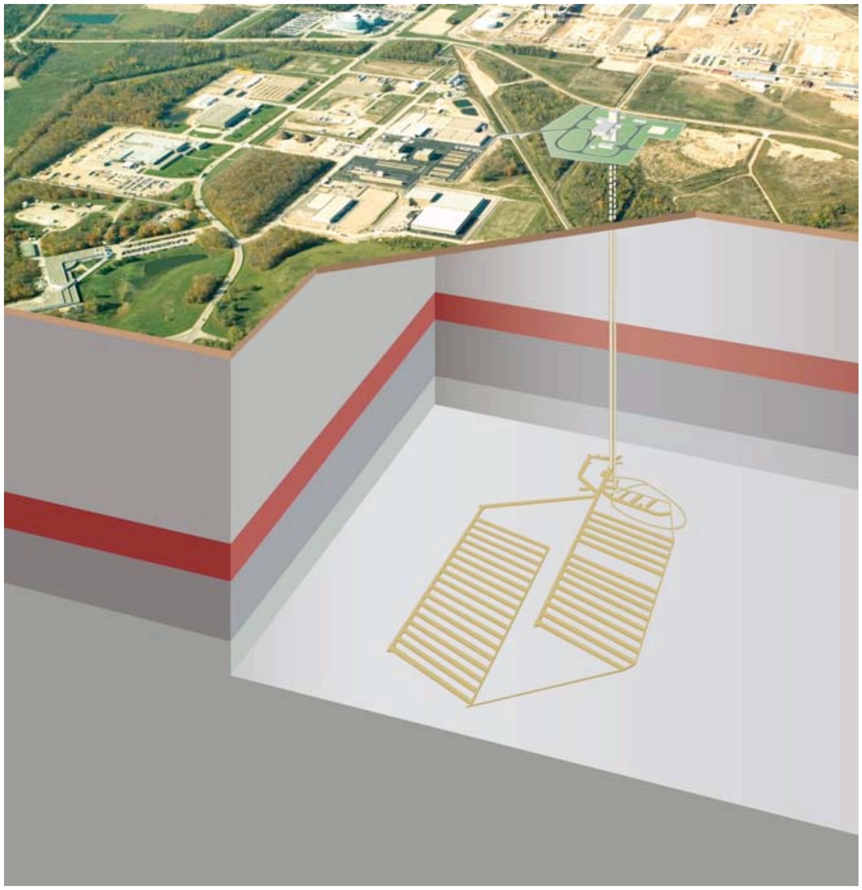

Figure K.3 – Artist's concept of the Deep Geologic Repository

Following a request by the Municipality of Kincardine to explore, jointly with OPG, the options for a long-term management of L&ILW within the municipality, the concept for the Deep Geologic Repository (DGR) at the Bruce nuclear site was developed.

Under the terms of a Memorandum of Understanding, OPG and Kincardine engaged a consulting firm to conduct an independent assessment study (IAS) of the feasibility, safety, social and economic feasibility and the potential environmental effects of a proposed long-term management facility at the WWMF.

Three options were studied: enhanced processing and storage, covered above ground concrete vault and deep geological repository. A geotechnical feasibility study, a preliminary safety assessment, a social and economic assessment, a community attitude survey, interviews with local residents, businesses and tourists and an environmental review led to the creation of the IAS. Another component of the IAS was a public consultation program, conducted in Kincardine and surrounding municipalities.

The IAS concluded that each of the options was feasible. The options could be constructed to meet international and Canadian safety standards with a high margin of safety, would not have significant residual environmental effects and would not have a negative effect on tourism. The geology of the Bruce site was considered ideal for the DGR option. The study report can be accessed at opg.com/dgr

In April 2004, the Kincardine Council passed a resolution to "endorse the opinion of the Nuclear Waste Steering Committee and select the Deep Rock Vault option as the preferred course of study in regards to the management of low- and intermediate-level radioactive waste". The DRV (i.e., deep geological repository) has the highest margin of safety and is consistent with best international practices.

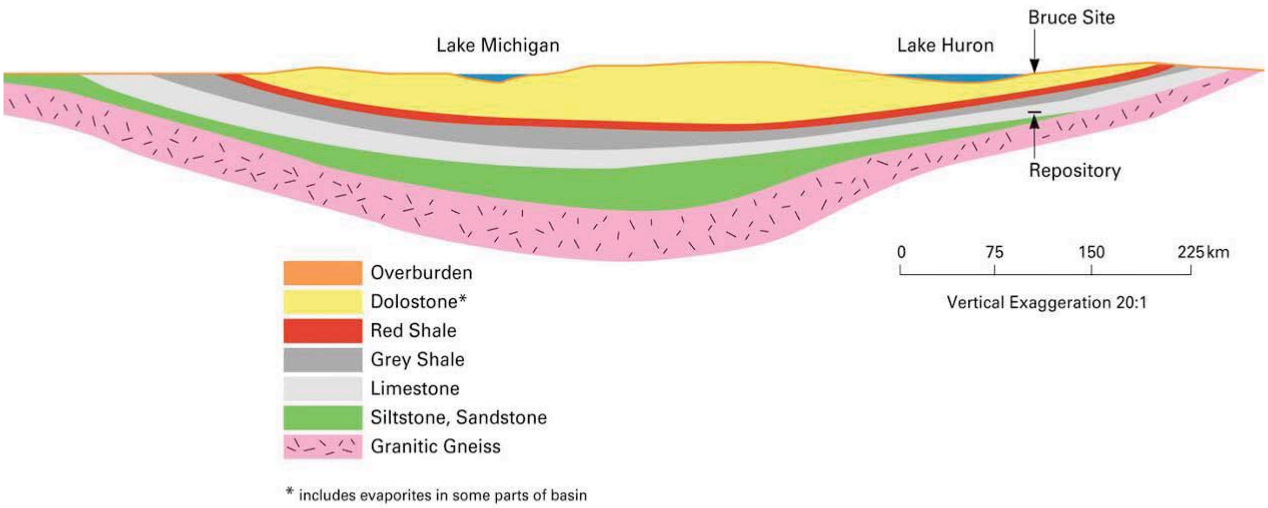

Figure K.4 – Michigan basin geology

Following the Council resolution, Kincardine and OPG began to negotiate terms for a hosting agreement. Hosting agreements have been implemented in a number of jurisdictions in Canada and internationally by communities that support the location of a long-term waste management facility. The model for this agreement was the Port Hope agreement, which was negotiated between the Government of Canada and the local municipalities in the Port Hope area. It provided for the cleanup and long-term management of approximately 2 million cubic metres of historic radioactive and specified industrial wastes currently in the communities.

The Kincardine Hosting Agreement was signed on October 13, 2004. It set out the terms and conditions under which the project would proceed.

From mid-October 2004 to mid-January 2005, OPG assisted Kincardine to undertake a public dialogue on the DGR proposal. In particular, an independent consultant completed a community consultation to determine the level of community support. Each residence in Kincardine was telephoned during the first three weeks of January 2005. The telephone calls were followed up with a mail-out as required. The results of the poll were announced at the Kincardine Council Meeting on February 16, 2005, and were as follows:

- 60 percent in favour
- 22 percent against
- 13 percent neutral
- 5 percent didn’t know/refused to answer

Seventy-two percent of the eligible residents participated in the telephone poll. In December 2005, OPG submitted a letter of intent to construct the DGR to the CNSC, thus initiating the environmental assessment (EA) process. The EA process is now underway and has involved detailed geoscientific investigations, preliminary design work and environmental and safety assessments.

Six deep boreholes were drilled at the site from 2007 to 2010. These boreholes have confirmed the expected stratigraphy at the site. More than 200 metres of low-permeability shale form a protective cap over the low-permeability limestone formation where the repository will be constructed. Hydraulic conductivity measurements, in both the limestone and shale formations, have shown values of 10^{-13} m/s and below. These values indicate that any solute movement away from the repository will be diffusion controlled (i.e., there will be little chance of water seeping into the repository).

The DGR model is composed of horizontally excavated emplacement rooms which will be arranged in two panels with access provided via two vertical, concrete-lined shafts. The proposed depth of the repository is 680 metres below ground.

The Environmental Impact Statement, Preliminary Safety Report and supporting reports were submitted to the CNSC in March 2011. A Joint Review Panel is to be established in 2011. The submission package documents can be viewed at opg.com/dgr. EA approval and a site preparation and construction licence are expected to be received in 2012–2013; earliest in-service is expected in 2018.

K.6.2 Nuclear Legacy Liabilities Program (NLLP)

Canada's nuclear legacy liabilities have resulted from 60 years of nuclear research and development carried out on behalf of the Government of Canada and AECL. These liabilities are largely located at AECL research sites and consist of shutdown research buildings (including several prototype and research reactors), a wide variety of buried and stored wastes, and contaminated lands. The shutdown buildings and contaminated lands need to be safely decommissioned to meet federal regulatory requirements, and long-term solutions need to be developed and implemented for management of the wastes. More than half of the liabilities are the result of Cold War activities during the 1940s, 1950s and early 1960s. The remaining liabilities stem from research and development for nuclear reactor technology, the production of medical isotopes and national science programs.

About 70 percent of the liabilities are located at AECL's CRL site in Ontario and a further 20 percent are located at AECL's shutdown Whiteshell Laboratories site, in Manitoba, which is being decommissioned. The remaining 10 percent relate largely to three shutdown prototype reactors in Ontario and Quebec, which are in a storage-with-surveillance state, and which were key during the development of Canada's CANDU reactor technology.

The inventory of legacy waste includes spent fuel and low- and intermediate -level solid and liquid radioactive waste. Most of the waste is in an unconditioned form, and limited characterization information is available for the waste generated in past decades.

In 2006, the Government of Canada adopted a new long-term strategy to deal with the nuclear legacy liabilities over a 70-year period. The overall objective of the long-term strategy is to safely and cost-effectively reduce the liabilities and associated risks based on sound waste management and environmental principles in the best interests of Canadians. The estimated cost to implement the strategy over 70 years is about $7 billion (current Canadian dollars).

Strategy development was based on two key assumptions:

- CRL will continue to operate the site with the majority of legacy liabilities for the foreseeable future.
- A range of additional waste management facilities will be required.

Implementation of the strategy at CRL is coordinated with ongoing site operations. The strategy deals with operational facilities and other infrastructure over time, as they are shut down and taken out of service. Further waste characterization, processing, conditioning, treatment, packaging, storage and long-term waste management facilities are being designed and constructed to deal effectively with the existing legacy waste inventory, as well as the waste that will be generated by decommissioning and cleanup activities.

Implementation of the long-term strategy was initiated in 2006 with a $520 million (Canadian dollars) commitment by the Government of Canada to fund the start-up phase of the Nuclear Legacy Liabilities Program (NLLP) (see nuclearlegacyprogram.ca). The start-up phase is focused on:

- addressing immediate health, safety and environmental priorities
- accelerating the decommissioning of shutdown buildings
- laying the groundwork for subsequent phases of the strategy

While continuing necessary care and maintenance activities continue to maintain the liabilities in a safe state until they can be fully addressed in subsequent phases of the program, the long-term strategy is being further developed and refined. Further, the NLLP has initiated public consultation activities, including a series of information sessions held in the vicinity of CRL in May 2010.

The program is being implemented through a Memorandum of Understanding between NRCan and AECL whereby NRCan is responsible for policy direction and oversight, including control of funding, and AECL is responsible for carrying out the work and holds and administers the licences, facilities, land, materials and other asset responsibilities.

The NLLP is now in its sixth year of implementation, with funding of $129 million in fiscal year 2011-12.. Program progress and achievements during the last three years of implementation (April 2008 to March 2011) are summarized below.

K.6.2.1 Accelerating the decommissioning of shutdown buildings

Shutdown, unoccupied buildings, particularly the older, contaminated wood-framed buildings at CRL, present a continuing risk. Substantial costs may be incurred to monitor, maintain and repair shutdown buildings to ensure that they remain in a safe and compliant state until they are demolished. One objective of the start-up phase is to accelerate building decommissioning and reduce the current backlog of shutdown buildings.

During the last three years, key decommissioning work at CRL and WL included:

- demolishing the original CRL Security Monitoring/Reception and Human Resources Building
- stripping equipment from and decontaminating seven hot cells and the storage blocks in the WL Shielded Facilities
- demolishing the WL Engineering and Administration Building
- demolishing the WL Cafeteria

Demolition can produce a large amount of construction materials as waste. Radiological surveys of buildings and equipment, as well as the treatment of some materials to remove contamination, have resulted in significant quantities of waste being designated "likely clean" and being cleared for recycling, reuse or disposal in local landfills. These activities have helped to minimize the quantity of waste requiring long-term management in the onsite radioactive waste management areas.

At CRL, a 30-metre section of the wood-framed building, which connected the shutdown National Research Experimental (NRX) reactor to its former fuel handling and storage facility, was decontaminated and demolished to create a fire break between the two facilities. The work was complex, requiring AECL to improve and advance its radiation protection safety protocols, develop new training programs and revise its dosimetry program to permit decommissioning work in areas with significant alpha contamination.

Decommissioning of the main nuclear research laboratory complex (Building 300) at WL continues; about 120 laboratory rooms have been decontaminated, with furnishings and services removed, and the decommissioning of the related office space is complete. AECL staff in the north extension of the building are being relocated to other WL buildings to permit the decommissioning of the approximately 50 remaining laboratory rooms and associated offices. The devices (fume hoods, glove boxes and other enclosures) served by the building's active ventilation system have been removed and dismantled.

Other decommissioning initiatives at WL have resulted in the demolition of redundant non-nuclear buildings on the main laboratory campus and of redundant infrastructure in the areas surrounding the main campus.

The decommissioning of the underground works of the Underground Research Laboratory (URL) near WL has been completed. The URL has been placed in a safe, sustainable closure state, underground furnishings have been removed, the deep boreholes and the shaft and ventilation raise have been sealed, and site restoration is underway.

Preparation of environmental assessments and detailed decommissioning work plans continues for the future decommissioning of shutdown buildings at CRL and WL. AECL continues to compile and archive historical data and records to provide for the long-term preservation of information for decommissioning projects.

K.6.2.2 Laying the groundwork for subsequent phases of the strategy

Radioactive wastes generated from decommissioning and environmental restoration activities are shipped offsite for treatment where possible and when cost effective, or are stored on site pending the development of long-term waste management facilities. Projects and activities that "lay the groundwork" for future strategy phases contribute to the development and construction of facilities to characterize, handle, process, treat and package the waste, as well as of facilities for long-term management of the waste.

An important element in laying the groundwork for subsequent phases is the development of an integrated waste plan (IWP) for the NLLP to ensure the selection of the optimal mix of enabling facilities and the minimization of current and future liabilities. An initial version of the IWP for CRL has been developed. The IWP will be expanded to the other sites and go through much refinement.

The volume of concrete waste represents approximately 75 percent of all decommissioning waste volume, and over 140,000 cubic metres of likely clean waste concrete will be generated from decommissioning activities at CRL over the next 70 years. CRL has acquired mobile concrete crushing equipment that will be able to cost-effectively process the likely clean concrete waste. This equipment will crush the concrete to a form that permits final clearance and becomes a valuable product suitable for reuse on site.

An investigation began in 2006 to assess the feasibility of the bedrock at the CRL site to host the proposed Geologic Waste Management Facility (GWMF). The GWMF is envisioned as an underground engineered geological repository located at a nominal depth of 500 to 700 metres in the bedrock at the CRL site. The GWMF, if constructed, would be the final enabling facility (i.e., storage location) to safely manage CRL's non-fuel nuclear wastes. At the CRL site, seven deep characterization boreholes have been drilled to support an assessment of the suitability of the site to host the GWMF for the long-term management of low- and intermediate-level solid radioactive waste.

AECL has initiated discussions with the NWMO on the long-term management of AECL's varied inventory of spent legacy research reactor fuel rods.

During the reporting period, riverbed sediments downstream of the CRL site continued to be sampled and analyzed to develop a well-informed, risk-based recommended path forward that will address any potential impact on the Ottawa River from earlier operations on the site.

Significant savings in long-term waste management costs at CRL could be achieved by constructing a very-low-level waste (VLLW) facility to receive large volumes of VLLW wastes such as soil, concrete, vegetation, asphalt and/or building materials/rubble that NLLP projects and activities are generating. All pre-project activities have been completed to support the development of a VLLW facility.

Major achievements at WL include the design and construction of a long-term fit-for-purpose waste storage shielded modular above ground storage (SMAGS) building, the commissioning of a new waste clearance facility for monitoring likely clean waste to confirm that it can be recycled or disposed of as non-radioactive waste, and the construction of a low-level contaminated soil storage compound. A waste handling facility has been established in the shielded facilities to process the radioactive waste generated by the decommissioning activities. The facility has two compactors and an automated gamma waste assay system.

Much of the decommissioning effort at WL is focused on reconfiguring site utilities and services to consolidate the "nuclear operations" campus, to "right-size" (i.e., reduce) the required site infrastructure and supporting operations based on the reduced requirements for decommissioning, to reduce utility costs, and to permit building decommissioning to proceed more efficiently. For example, a feasibility study is examining options to determine the best feasible technical approach for replacing the site's original low- and intermediate-level liquid waste treatment systems and the personal protective clothing and equipment decontamination system.

Experiments and redundant equipment occupying approximately half of the existing Shielded Facilities have been decommissioned and removed from the building to provide a centralized space for the liquid waste treatment, solid waste processing and laboratory services required to support site-wide decommissioning activities. Stand-alone individual electrical heating systems will be installed in all non-redundant buildings on the main campus by 2012, so that these buildings can be disconnected from the existing centralized oil-fired hot-water heating system. This will allow for the decommissioning and demolition of individual buildings without requiring utility reconfiguration for adjacent buildings.

A number of studies are underway to better define the waste processing, treatment and long-term management facilities required to deal with the wide variety of legacy waste types at AECL sites. This will help to define, for example, the volume reduction and waste immobilization technologies to be used, the extent to which buried waste can be managed in place over the long term, and the available options for the long-term management of the waste that needs to be recovered.

AECL is supporting the NLLP public consultation process led by NRCan. At CRL, information on the program is regularly communicated to local stakeholders through forums such as an Environmental Stewardship Council and local council member briefings. Additionally, a series of information sessions were held in local communities in early 2010. Regular communication with the general public in the Chalk River area continues via AECL's *Contact* publication and as required to support NLLP project-specific environmental assessments. At WL, information on the program is regularly communicated to the Public Liaison Committee (every six months) as a requirement of the environmental assessment follow-up program. Presentations on the program have been made to the First Nations communities near CRL and WL.

K.6.2.3 AECL Stored Liquid Waste Cementation (SLWC) project

Over a 50-year period, the liquid waste has accumulated from various sources: AECL's medical radioisotope program, the fuel processing program, decontamination of test loops in CRL's research reactors, and regeneration of ion exchange resins used to purify water in fuel storage bays at CRL's research reactors. Except for waste streams from the radioisotope program, the generation of such wastes has stopped. The wastes are currently stored in 21 monitored storage tanks at CRL.

Projects were initiated in 2002–2003 to provide processes and equipment to retrieve and transfer the stored liquid waste (SLW) to an upgraded storage facility (in liquid form). As a result of cost and schedule increases, these projects were reassessed through a formal review in early 2009 with the objective of determining the best value-for-money strategy to address the health, safety, security and environmental risks associated with storage of the SLW. The re-evaluation concluded that the best approach was to develop a new project to retrieve and solidify the waste. Waste contained in seven tanks is suitable for treatment through the CRL Waste Treatment Centre. The contents of the remaining 14 tanks are to be retrieved and cemented by the SLWC project.

Significant pre-project development work has been undertaken to confirm the strategic direction and the optimum tactical approach for cementing the SLW. These include engineering studies, development of waste acceptance criteria, radiation dose evaluations and cement formulation and testing. SLWC project initiation will occur during 2011–12.

The scope of the SLWC project includes:

- design, construction and commissioning of waste retrieval equipment and a cementation plant
- processing operations to retrieve and process the SLW to a solid cemented product
- provision of interim storage facilities
- emplacement of the cemented waste in storage facilities
- placing the remaining redundant storage facilities in a safe shutdown state

K.6.2.4 The Fuel Packaging and Storage (FPS) project

A Fuel Packaging and Storage Project is being implemented to improve the storage of selected spent legacy research reactor fuel rods. The project addresses the older, experimental fuels from approximately 100 tile holes (in-ground vertical structures used to store all spent research reactor fuel at CRL) with problematic and degraded fuel and storage conditions. The project involves the design, licensing, construction and commissioning of a modern above ground facility to dry, repackage and store the fuel. The facility design is complete, and manufacturing and testing of the equipment and major components is well advanced. Construction is scheduled to be completed in 2011–2012, and legacy fuel recovery operations will commence once the facility has been fully commissioned. Related ongoing activities include investigations and studies to prepare for fuel recovery, sludge removal, drainage of the tile holes that have become flooded over time, and treatment of the water recovered.

K.6.3 Management of historic waste

In 1982, the Government of Canada established the LLRWMO within AECL to be the federal agent for the cleanup and management of historic low-level radioactive waste (LLW) in Canada. NRCan provides policy direction and funding to the LLRWMO to carry out its work. Over the course of its existence, the LLRWMO has completed historic waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination.

K.6.3.1 Port Hope Area Initiative

The bulk of Canada's historic LLW is located in the southern Ontario communities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 2 million cubic metres. They originate from the operations of a radium and uranium refinery in the Municipality of Port Hope, dating back to the 1930s. While recognizing that there are no urgent risks from a health or environmental standpoint, the Government of Canada determined that intervention measures are required in order to implement more appropriate long-term management measures for these materials.

In March 2001, the Government of Canada and the local municipalities entered into an agreement on community-developed proposals to address the cleanup and long-term management of these wastes, thereby launching the Port Hope Area Initiative (PHAI). The PHAI will result in the long-term management of these historic wastes in two above ground mounds that will be constructed in the local communities. The initiative includes two projects – the Port Hope Project and the Port Granby Project.

This $260 million initiative includes an environmental assessment (EA) and regulatory review phase, an implementation phase and a long-term monitoring phase, as well as a property value protection program. In 2008, the Government of Canada approved a transition phase to bridge the completion of the regulatory review and the commencement of the implementation phase. The transition phase is scheduled to finish in September 2011. AECL is the proponent for the PHAI on behalf of the Government of Canada. AECL, Natural Resources Canada, and Public Works and Government Services Canada have formed the PHAI Management Office to plan and manage overall PHAI execution.

The Port Hope Project entails the cleanup of the urban area and 14 major sites and the consolidation of all of the wastes (approximately 1.2 million cubic metres) in the Municipality of Port Hope at one long-term waste management facility (WMF). This facility is to be located at the present site of the existing Welcome WMF. The Government of Canada, through its responsible authorities – NRCan, the CNSC and Fisheries and Oceans Canada – completed the EA Screening Report in 2007 and concluded that the project is not likely to result in significant adverse environmental effects. In October 2009, the Commission Tribunal issued a five-year licence to AECL to undertake the cleanup and the interim operation of the Welcome WMF and, in 2011, it plans to request an amendment to extend the licence duration based on the detailed designs and health and safety plans developed for the cleanup. EA monitoring programs have been launched to re-establish the baseline data against which socio-economic and biophysical effects of the Port Hope Project activities can be measured.

The Port Granby Project involves the relocation of the existing Port Granby wastes (approximately 500,000 cubic metres) to a new above ground, long-term WMF. The WMF is to be located at a nearby site approximately 700 metres north of the current site and away from the Lake Ontario shoreline. In August 2009, the responsible authorities, NRCan and the CNSC, completed the EA Screening Report and concluded that the project is not likely to result in significant adverse environmental effects. AECL intends to seek a licence from the CNSC for the Port Granby Project in 2011 and will support its application with detailed design reports and health and safety plans.

Furthermore, the EA monitoring programs have also been initiated. Delivery of the programs committed to in the 2001 agreement is ongoing. These programs include Interim Waste Management (IWM), Property Value Protection (PVP) and community consultation. IWM activity has remained stable in the past three years, while use of the PVP program that compensates property owners for losses upon sale that can be linked to project effects has increased significantly with the approach of the long-awaited cleanup. Regular dialogue occurs with Aboriginal groups and members of the community stakeholders (see photos below). Information for the public at large is transmitted through newsletters, open house events, direct contact with communications specialists in the Project Information Exchange and via phai.ca, the redesigned PHAI Web site. In 2010, an observer group, comprising local citizens with a cross-section of knowledge and viewpoints, provided a lay perspective in an assessment of a pilot demonstration of proposed remediation techniques for a small-scale property in the Municipality of Port Hope.

Figure K.5 – Port Hope trial remediation

Figure K.6 – Public open house to discuss monitoring plans

Federal approvals to proceed with the implementation phase of the PHAI will be sought in 2011. With these approvals, activities such as tendering will be initiated to hire the contractors to complete the cleanup and associated works. The cleanups in Port Hope and Port Granby are anticipated to be completed by 2020. Following the emplacement of wastes and the closure of the new WMFs, the long-term monitoring and maintenance phase will commence and continue for hundreds of years.

Figure K.7 – Visualization of proposed waste management facility, Port Hope Project

K.6.3.2 Other historic waste initiatives

Most of the remaining historic waste to be dealt with in Canada is located along the Northern Transportation Route between Port Radium, Northwest Territories and Fort McMurray, Alberta. The waste has resulted from the past transport of radium- and uranium-bearing ore and concentrates from the Port Radium Mine to the barge-to-rail transfer point at Fort McMurray.

The sites that still have to be remediated – including Sawmill Bay, Bennett Landing, Bell Rock and Fort Fitzgerald – are regularly inspected and monitored by the CNSC and the LLRWMO. All these sites are exempted from CNSC licensing and have been placed under institutional control. Strategies are currently being developed for the cleanup of these remaining sites. They are estimated to consist of about 10,000 cubic metres of contaminated soils.

K.7 Other contaminated lands

The CNSC established the Contaminated Lands Evaluation and Assessment Network (CLEAN) program to deal with sites previously not licensed under the AECA but that required regulatory control under the NSCA. This CLEAN program effectively ended during the 2006–2007 period, as all of the identified contaminated land sites across Canada had been assessed and their regulatory oversight requirements evaluated in accordance with the NSCA.

Annex 1 – Federal Structure

1.0 Introduction

Canada is a confederation of 10 provinces and three territories, administered by a Government of Canada. The provinces are self-governing in the areas of legislative power assigned to them by the Canadian Constitution, as expressed in the *Constitution Acts* of 1867 and 1982. These areas include local commerce, working conditions, education, direct health care, energy and resources in general.

The Constitution gives the Parliament of Canada legislative power over works declared by it to be for the general advantage of the country. The Parliament of Canada used this declaratory power in the *Atomic Energy Control Act* of 1946 and again in the *Nuclear Energy Act* of 2000. It declared certain works and undertakings to be for the general advantage of Canada and therefore subject to federal legislative control. Such works and undertakings are constructed for the following purposes:

- production, use and application of nuclear energy
- research or investigation of nuclear energy
- production, refinement or treatment of nuclear substances

This means that the Government of Canada is responsible for certain aspects of nuclear energy applications that would otherwise have been under provincial jurisdiction. Examples of these aspects include:

- occupational health and safety
- regulation of boilers and pressure vessels
- coordination of federal response to nuclear emergencies
- environmental protection

Under the Canadian Constitution, provincial laws may also apply in these areas when they are not directly related to nuclear energy and do not conflict with federal law. Because both federal and provincial laws may apply in some regulated areas, the approach taken has been to avoid redundant regulations by seeking cooperative arrangements between the federal and provincial departments and agencies that have responsibilities or expertise in these areas.

Although these cooperative arrangements have been successful in achieving industry compliance, they need a firmer legal basis. The NSCA binds both the federal and provincial governments and the private sector. Like private companies, government departments and agencies must hold a licence from the regulatory body (the Canadian Nuclear Safety Commission (CNSC)) to perform any of the nuclear-related activities otherwise prohibited by the NSCA. In addition, the NSCA provides authority for the regulatory body and the Governor in Council to incorporate provincial laws by reference and to delegate powers to the provinces in areas better regulated by them or where licensees would otherwise be subject to overlapping regulatory provisions. The major Government of Canada organizations involved in the Canadian nuclear sector are as follows.

1.1 Natural Resources Canada

Natural Resources Canada (NRCan) is responsible for developing Canadian policy concerning energy sources. NRCan provides federal policy leadership concerning uranium, nuclear energy, and radioactive waste management. NRCan provides expert technical, policy and economic information and advice to the Minister and the Government of Canada on issues affecting:

- Canadian uranium exploration and development
- environmental protection
- production and supply capability
- foreign ownership
- domestic and international markets
- exports

- international trade
- end uses

The Government of Canada, through NRCan, is responsible for ensuring that the long-term management of radioactive waste is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. Canada's approach to radioactive waste management is that the producers and owners of radioactive waste are responsible for the funding, organization, management and operation of long-term waste management and other facilities required for their wastes.

NRCan is also responsible for administering the *Nuclear Fuel Waste Act* on behalf of the Minister. The organizational unit responsible for carrying out this function is the Nuclear Fuel Waste Bureau. The Bureau's mandate is to support the Minister of Natural Resources in discharging the Minister's responsibilities under the NFWA by overseeing, monitoring, reviewing and commenting on relevant activities of the waste owners and ensuring all NFWA requirements are met. The Bureau's Web site address is nfwbureau.gc.ca

NRCan is responsible for policy direction and oversight, including control of funding, for the Government of Canada's Nuclear Legacy Liabilities Program. This program deals with legacy waste and contamination at AECL research sites. AECL carries out the work under the program to ensure compliance with regulatory requirements and the protection of health, safety and the environment. NRCan also provides policy direction and funding to the Low-Level Radioactive Waste Management Office (LLRWMO). The LLRWMO is Canada's agent for the management of historic waste.

1.2 Canadian Nuclear Safety Commission

The Canadian Nuclear Safety Commission (CNSC) is Canada's nuclear regulatory body, created by the Governor in Council under the NSCA. The CNSC reports to the Canadian Parliament through the Minister of Natural Resources. It is not part of the Department of Natural Resources; however, the Minister of Natural Resources can seek information from the CNSC on its activities. Under the NSCA*,* the Governor in Council may issue directives to the Commission Tribunal of general application on broad policy matters. The Governor in Council cannot give direction to the Commission Tribunal on specific licensing matters.

The CNSC is an independent federal regulatory agency and a quasi-judicial administrative tribunal. To serve Canadians, the ultimate outcome of the CNSC work must be the establishment of safe and secure nuclear installations and processes solely for peaceful purposes, and of public confidence in the nuclear regulatory regime's effectiveness. Consistent with the Government of Canada's SMART Regulation principles, the CNSC engages in extensive consultation and sharing of information to ensure that the desired results are understood and accepted by stakeholders and licensees.

The CNSC reports to Parliament through the Minister of Natural Resources, but it is an independent entity. This independence is critical for the CNSC to maintain an arms-length relationship with government when making legally binding regulatory decisions. The CNSC is not an advocate of nuclear science or technology. Its mandate and responsibility is to regulate users of nuclear energy or materials to ensure their operations will not pose unreasonable risks to Canadians. The people of Canada are the sole clients of the CNSC.

The CNSC's mission is to "regulate 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". In pursuing its mission, the CNSC is working to become one of the best nuclear regulators in the world. The CNSC values quality, integrity, competence, dedication and respect of others.

The CNSC's *Regulatory Fundamentals Policy* (P-299), which was adopted in January 2005, states that persons and organizations subject to the NSCA and its associated regulations are directly responsible for managing regulated activities in a manner that protects health, safety, security and the environment, while respecting Canada's international obligations. Through Parliament, the CNSC is responsible to the public for assuring that these responsibilities are properly discharged.

1.3 Atomic Energy of Canada Limited

Atomic Energy of Canada Limited (AECL) is a Crown Corporation wholly owned by the Government of Canada. AECL designs, markets, sells and builds Canadian-designed CANDU power reactors (including the Advanced CANDU Reactor – ACR-1000), and Modular Air-Cooled Storage (MACSTOR™) spent fuel storage modules.

AECL has developed expertise in the areas of project management, engineering and consulting services, maintenance services, the development of new technologies, and decommissioning and waste management. In addition, AECL has ongoing research and development programs that support operating CANDU reactor products.

AECL works nationally and internationally with Canadian private sector businesses. It is responsible for the operations of the Chalk River Laboratories, the Whiteshell Laboratories and the decommissioning of shutdown facilities on those sites and three prototype reactor sites. AECL provides a national service for safely storing radioactive waste at the CRL site from institutions across Canada, including hospitals and universities, on a fee-for-service basis.

1.4 Low-Level Radioactive Waste Management Office

The Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) to carry out the relevant federal responsibilities for historic low-level radioactive waste management in Canada. The LLRWMO operates under a Memorandum of Understanding between NRCan and AECL. While the LLRWMO receives its funding and policy direction from NRCan, it is organizationally established as a separate division of AECL within AECL's Decommissioning and Waste Management Organization. While the LLRWMO mandate is fairly broad, its function is to manage historic wastes. The LLRWMO also provides public information on radioactive wastes.

1.5 Canadian Environmental Assessment Agency

The Canadian Environmental Assessment Agency (CEA Agency) is charged with the administration of the *Canadian Environmental Assessment Act* (CEA Act, see annex 2). The CEA Act is a tool for federal decision-makers and establishes an open and balanced process to assess the environmental effects of projects requiring federal action or decision. The CEA Act ensures that the environmental effects of projects are considered as early as possible in a project's planning stages. One of the CEA Act's goals is to provide public participation opportunities in the EA process.

1.6 Foreign Affairs and International Trade Canada

Foreign Affairs and International Trade Canada (DFAIT) is charged with promoting nuclear cooperation and safety both bilaterally and multilaterally. DFAIT also implements key non-proliferation and disarmament agreements in Canada and abroad.

Implementation of these agreements requires Canadian domestic law to be consistent with Canada's responsibilities under the agreements. It also requires the capacity to ensure effective monitoring to verify that treaty obligations and commitments are being honoured. DFAIT is responsible for the implementation of the *Chemical Weapons Convention* and the *Comprehensive Nuclear-Test-Ban Treaty*. In addition, DFAIT oversees foreign policy, including global security issues, and is a required interlocutor for dealings with other governments.

1.7 Health Canada

Health Canada (HC) is the federal department responsible for helping the people of Canada maintain and improve their health. In the area of radiation protection, HC contributes to maintaining and improving the health of Canadians by investigating and managing the risks from natural and artificial sources of radiation. It accomplishes this mission through:

- maintaining the National Radioactivity Monitoring Network

- developing guidelines for exposure to radioactivity in water, food and air following a nuclear emergency
- providing advice and assistance to environmental assessments and reviews, as required by the CEA Act
- providing a full range of dosimetry services to workers through the National Dosimetry Services, the National Dose Registry, the National Calibration Reference Centre and biological dosimetry services
- contributing to the control of the design, construction and function of radiation emitting devices imported, sold, or leased in Canada, under the *Radiation Emitting Devices Act*
- administering the Federal Nuclear Emergency Plan

The National Dosimetry Services, operated through HC, provide occupational monitoring for ionizing radiation to Canadians everywhere. Among the services offered are whole body and extremity thermoluminescent dosimetry services, as well as neutron dosimetry services and dosimetry for uranium miners. The National Dosimetry Services is licensed by the CNSC. The National Dose Registry is a centralized radiation dose record system, managed by HC. It contains the occupational radiation dose records for all the monitored radiation workers in Canada, from the 1940s to the present.

1.8 Environment Canada

Environment Canada's mandate is to:

- preserve and enhance the quality of the natural environment, including water, air and soil quality
- conserve Canada's renewable resources, including migratory birds and other non-domestic flora and fauna
- conserve and protect Canada's water resources
- carry out meteorology
- enforce the rules made by the Canada–United States International Joint Commission, relating to boundary waters
- coordinate environmental policies and programs for the Government of Canada

Environment Canada administers the *Canadian Environmental Protection Act* (CEPA).

1.9 Transport Canada

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

Annex 2 – Canadian Legislative System and Institutional Framework

2.0 Introduction

Five pieces of legislation currently govern the nuclear sector in Canada: the *Nuclear Safety and Control Act* (NSCA), the *Nuclear Energy Act* (NEA), the *Nuclear Fuel Waste Act* (NFWA), the *Nuclear Liability Act* (NLA), and the *Canadian Environmental Assessment Act* (CEA Act). The NSCA is the main legislation dealing with safety considerations.

2.1 *Nuclear Safety and Control Act*

The NSCA was passed by Parliament on March 20, 1997. This was the first major overhaul of Canada's nuclear regulatory regime since the *Atomic Energy Control Act* (AECA) and the creation of the Atomic Energy Control Board (AECB) in 1946. The NSCA provides legislative authority which covers the nuclear sector regulatory developments. These developments include health and safety standards for nuclear energy workers, environmental protection measures, security regarding nuclear facilities and public input into the licensing process.

The NSCA established the CNSC, which comprises the Commission Tribunal (the tribunal that makes licensing decisions) and the CNSC staff, who make recommendations to the Commission Tribunal, exercise delegated licensing and authorization powers and assess licensee compliance with the NSCA, its associated regulations, and licence conditions.

Section 26 of the NSCA states that, "Subject to the regulations, no person shall, except in accordance with a licence

- "possess, transfer, import, export, use or abandon a nuclear substance, prescribed equipment or prescribed information
- "mine, produce, refine, convert, enrich, process, reprocess, package, transport, manage, store or dispose of a nuclear substance
- "produce or service prescribed equipment
- "operate a dosimetry service for the purposes of this Act
- "prepare a site for, construct, operate, modify, decommission or abandon a nuclear facility, or
- "construct, operate, decommission or abandon a nuclear-powered vehicle or bring a nuclear-powered vehicle into Canada."

The NSCA authorizes the CNSC to make regulations. Regulations had to be developed before the NSCA could be fully implemented and include:

- *General Nuclear Safety and Control Regulations*
- *Radiation Protection Regulations*
- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Uranium Mines and Mill Regulations*
- *Nuclear Substances and Radiation Devices Regulations*
- *Packaging and Transport of Nuclear Substances Regulations*
- *Nuclear Security Regulations*
- *Nuclear Non-Proliferation Import and Export Control Regulations*

Canada is a signatory of the *Treaty on the Non-Proliferation of Nuclear Weapons*. Pursuant to that Treaty, Canada signed the *Agreement Between Canada and the Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* as well as a Protocol additional to that Agreement. Pursuant to these legal instruments, Canada must account for and maintain control of all uranium, thorium and plutonium which is subject to measures implemented by the IAEA to verify that all declared nuclear material is in peaceful use and that there are no undeclared nuclear material or activities in Canada. As a result of these commitments, much of the nuclear material and many of the facilities that are identified in this report, in accordance with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, are also subject to the terms and conditions of the safeguards agreements. The CNSC is the designated governmental authority responsible for implementing the requirements of the safeguards agreements under the regulatory framework established through the NSCA and the associated regulations.

2.2 *Nuclear Energy Act*

Concurrent with the NSCA, the *Nuclear Energy Act* (NEA) came into force in 2000. It is a revision of the AECA (1946) to address the development and utilization of nuclear energy (with the regulatory aspects of the AECA having been removed to the NSCA). AECL is authorized under the NEA. The NEA gives the designated government minister the authority to:

- undertake or cause to be undertaken research and investigations with respect to nuclear energy
- with the approval of the Governor in Council, utilize, cause to be utilized and prepare for the utilization of nuclear energy
- with the approval of the Governor in Council, acquire or cause to be acquired, by purchase, lease, requisition or expropriation, nuclear substances and any mines, deposits or claims of nuclear substances and patent rights relating to nuclear energy and any works or property for production or preparation for production of, or for research or investigations with respect to, nuclear energy
- with the approval of the Governor in Council, license or otherwise make available or sell or otherwise dispose of discoveries and inventions relating to, and improvements in processes, apparatus or machines used in connection with, nuclear energy and patent rights acquired under this Act and collect royalties and fees on and payments for those licences, discoveries, inventions, improvements and patent rights

2.3 *Nuclear Fuel Waste Act*

Three provincial nuclear utilities, Ontario Power Generation (OPG), Hydro-Québec and New Brunswick Power (NB Power), own 98 percent of the nuclear fuel waste in Canada. AECL owns most of the remainder. Following a decade-long environmental assessment for a deep geologic disposal concept for spent fuel, which ended in 1998, it became clear that the Government of Canada needed to put in place a process to ensure that a long-term management approach for Canada’s spent fuel would be developed and implemented. Given the relatively small volume of spent fuel in Canada, it was determined that a national solution would be in the best interest of Canadians.

On November 15, 2002, Parliament passed the *Nuclear Fuel Waste Act* (NWFA), which made the owners of spent fuel clearly responsible for the development of long-term waste management approaches. The legislation required nuclear energy corporations to establish a waste management organization as a separate legal entity to manage the full range of long-term spent fuel management activities. It also required waste owners to establish trust funds with independent financial institutions so as to finance their long-term waste management responsibilities. Through the waste management organization, the owners of spent fuel were required to prepare and submit a study to the Government of Canada of proposed approaches for the long-term management of the waste, along with a recommendation on which of the proposed approaches should be adopted. The NFWA required this analysis to include feedback from comprehensive public consultations that included Aboriginal peoples and to be evaluated in terms of social and ethical considerations.

Under the NFWA, the Government of Canada is responsible for reviewing the study prepared by the waste management organization, selecting a long-term management option from those proposed and providing oversight during its implementation.

Shortly after the NFWA came into force, and as required by the NFWA, the nuclear energy corporations established the NWMO and the trust funds necessary to finance the implementation of long-term waste management activities. Following extensive studies and public consultation, the NWMO submitted its study of options to the Government of Canada on November 3, 2005. The NWMO presented four options, including those listed in the NFWA:

- long-term storage at the reactor sites
- central shallow or below ground storage
- deep geological disposal
- a fourth option called the Adaptive Phased Management (APM) approach, which combines the three previous options within a flexible, adaptive management decision-making process

On June 14, 2007, the Government of Canada announced that it had selected the APM approach for the long-term management of spent fuel in Canada. The APM approach recognizes that people benefiting from nuclear energy produced today must take steps to ensure that the wastes are dealt with responsibly and without unduly burdening future generations. At the same time, it is sufficiently flexible to adjust to changing social and technological developments. The NWMO is required to implement the Government's decision according to the NFWA, using funds provided by the nuclear energy corporations.

Following the selection of the APM approach as the most appropriate option for managing spent fuel over the long term, the next important government decision, pursuant to the NFWA, required the Minister of Natural Resources to approve the NWMO's funding formula. On March 27, 2008, the NWMO submitted its proposed funding formula in its 2007 annual report. The formula calculates the costs that each waste owner is required to set aside, per year, in trust to pay for the full costs of implementing the APM approach. After a thorough review and examination, the Minister of Natural Resources approved the funding formula on April 7, 2009.

On August 14, 2009, the Minister of Natural Resources, acting on behalf of the Crown, entered into a Memorandum of Understanding (MOU) with the NWMO. The MOU clarifies the roles and responsibilities of the Crown and the NWMO with respect to any obligation for consultations with Aboriginal peoples, pursuant to the Crown's duty to consult and the NWMO's statutory obligations in relation to the NFWA. In accordance with the MOU, the NWMO has the primary consultation role throughout the site selection process which was initiated in May 2010.

The NWMO initiated this site selection process with the publication of *Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*. This document sets out the parameters and the process to be followed to identify a safe, secure and suitable site for a deep geological repository for managing nuclear fuel waste in an informed and willing host community. An invitation was made to enable communities to learn more about the repository project, the process and the plan to safely manage Canada's spent fuel over the long term. A number of communities have inquired about the project and are exploring their interest with the NWMO. It is expected to take a number of years before a suitable site within an informed and willing host community is confirmed.

2.4 *Nuclear Liability Act*

The *Nuclear Liability Act* (NLA) establishes the legal regime that would apply in the event of a Canadian nuclear incident resulting in civil damages. The NLA is administered by the CNSC, while NRCan has responsibility for policy direction. The NLA can be viewed at laws.justice.gc.ca

The NLA places total responsibility for nuclear damage on the operator of a nuclear installation. It requires the operator to carry $75 million in insurance and also provides for the establishment of a Nuclear Damage Claims Commission, in the event of a serious nuclear incident. This commission would deal with claims for compensation when the Government of Canada deems that a special tribunal is necessary (for example, if claims are likely to exceed $75 million).

On April 16, 2010, the Minister of Natural Resources introduced Bill C-15 in Parliament. The proposed legislation, "an Act respecting civil liability and compensation for damage in case of a nuclear incident", updates and modernizes the current NLA (1976). Bill C-15's features include increased liability of nuclear operators ($650 million versus the current $75 million), a mechanism for periodic updating of the operator's liability, a longer limitation period for submitting compensation claims for bodily injury (30 years versus the current 10 years), the clarification of a number of key concepts and definitions, and greater definition of compensation procedures. On March 26, 2011, Canada's Parliament was dissolved, and a federal election was announced for May 2, 2011.

Following the May 2 election, the new Government will decide on next steps for proposals to revise the Nuclear Liability Act.

At present, Canada is not a member of any of the international nuclear civil liability conventions; however, Canada has a reciprocity arrangement governing nuclear civil liability with the United States.

2.5 *Canadian Environmental Assessment Act*

The *Canadian Environmental Assessment Act* (CEA Act) sets out responsibilities and procedures on projects for which the Government of Canada holds decision-making authority – whether as a proponent, land administrator, source of funding, or regulator. The CEA Act can be viewed online at laws.justice.gc.ca

There are three types of environmental assessments (EAs): screenings, comprehensive studies and review panels. Each offers a systematic approach to documenting the environmental effects of a proposed project and determining the need to eliminate or minimize the adverse effects, if any, to modify the project plan or to recommend further action.

The CEA Act requires the EA of a proposed project to evaluate the possible impacts of all licensing stages before any irrevocable decisions are made. The CEA Act has four objectives:

1. to ensure that the environmental effects of the project receive careful consideration before a responsible authority takes an action

2. to encourage responsible authorities to take actions that promote sustainable development, thereby achieving or maintaining a healthy environment and a healthy economy

3. to ensure that projects to be carried out in Canada or on federal lands do not cause significant adverse environmental effects outside the jurisdictions in which the projects are carried out

4. to ensure that there will be an opportunity for public participation in the environmental assessment process, as appropriate project

The CNSC is responsible for determining if a project is likely to cause significant adverse environmental effects. As a responsible authority (RA) under the CEA Act, the CNSC determines the scope of the EA and of the factors to be considered in the process. The CNSC is directly involved in and responsible for managing the EA process and for ensuring that an EA report is prepared. Finally, the CNSC is the federal decision-maker.

In practice, the project proponent may be delegated to conduct technical studies for the EA, or ensure that mitigation measures and/or a follow-up program is implemented. The RA remains directly responsible for ensuring that the EA is carried out in compliance with the CEA Act and for deciding on the course of action for the project.

Annex 3 – Canadian Nuclear Safety Commission and the Regulatory Process

3.0 Introduction

The Canadian nuclear sector is diverse. From radioisotopes to electricity generation, to radiation devices and non-proliferation of nuclear substances – all are regulated by the CNSC, which replaced the former AECB with the implementation of the NSCA on May 31, 2000.

3.1 *Nuclear Safety and Control Act* (NSCA)

A description of this NSCA is provided in annex 2.

3.2 Canadian Nuclear Safety Commission (CNSC)

The CNSC's regulatory regime covers the entire nuclear substance lifecycle from production, to use, to final disposition of any nuclear substances. Its mandate, derived from the NSCA, is as follows:

- to regulate the development, production and use of nuclear energy and materials to protect health, safety, security and the environment
- to regulate production, possession and use of nuclear substances, prescribed equipment, and prescribed information
- to implement measures respecting international commitments on the peaceful use of nuclear energy and substances
- to disseminate scientific, technical and regulatory information concerning the CNSC's activities

3.3 The CNSC in the government structure

In accordance with the Canadian system of parliamentary government, the decision to introduce government legislation such as the NSCA into Parliament is made by the federal Cabinet, on the advice and recommendation of the appropriate minister. The NSCA established the CNSC as a departmental corporation, named in Schedule II of the Government of Canada *Financial Administration Act*. The CNSC reports to the Parliament of Canada through a member of the Queen's Privy Council for Canada, designated by the Governor in Council as the minister for purposes of the Act. This designate is currently the Minister of Natural Resources. The CNSC is a departmental corporation, an independent agency, and is not part of any government department.

The NSCA requires the Commission Tribunal to comply with any directives of general application on broad policy matters, with respect to the objects of the Commission Tribunal issued by order of the Governor in Council. It is an accepted constitutional convention in Canada that any political directives given to agencies such as the CNSC are general and cannot interfere with Commission Tribunal decisions in specific cases. An example of such a directive might be the government-wide commitment to the SMART Regulation initiative.

CNSC staff routinely interact with management and staff of NRCan in areas of mutual interest. NRCan has a general interest in various matters relating to nuclear energy and natural resources. Further information is provided in annex 1.1.

In keeping with federal policies on public consultation and regulatory fairness, the CNSC routinely consults with parties and organizations that have an interest in its regulatory activities. These include:

- licensees
- the nuclear sector
- federal, provincial and municipal departments and agencies
- special interest groups
- individual members of the public

As required by federal policies on access to information and in accordance with Canada's SMART Regulation principles, formal consultations are conducted in an open and transparent manner.

The CNSC licensees include publicly funded institutions or agents of the federal and provincial governments. These include:

- AECL (the federal nuclear research and development company)
- nuclear operations of provincially owned electrical utilities (OPG, New Brunswick Power, and Hydro-Québec)
- Canadian universities
- hospitals and research institutions

The CNSC regulates the health, safety, security and environmental impacts of the nuclear activities of these organizations in the same manner and according to the same standards as required from privately owned companies or operations.

3.4 Organizational structure

The task of the CNSC is to regulate 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 consists of a president, the federally appointed members of the Commission Tribunal, and approximately 850 staff members as of the end of March 2011. The organization's general structure is defined by the NSCA. The CNSC consists of two components:

- The Commission Tribunal refers to the agency's tribunal component.
- The CNSC refers to the organization and its staff in general.

3.4.1 The Commission Tribunal

The Commission Tribunal is an independent, quasi-judicial administrative tribunal and court of record. It can consist of up to seven permanent members. Commission Tribunal members are appointed by the Governor in Council (Cabinet) of Canada for terms not exceeding five years and may be reappointed. In addition, the Governor in Council may appoint temporary members for a renewable term not exceeding six months. The members are to be independent of all influences, whether political, governmental, special interest or private sector. The president of the CNSC is a full-time Commission Tribunal member. Other members generally serve on a part-time basis.

The Commission Tribunal's key roles are to:

- establish regulatory policy on matters relating to health, safety, security and the environment
- make legally binding regulations
- make independent decisions on the licensing of nuclear-related activities in Canada

The Commission Tribunal takes into account the views, concerns and opinions of interested parties and intervenors when establishing regulatory policy, making licensing decisions and implementing programs.

The CNSC public hearings are the public's primary opportunity to participate in the regulatory process. CNSC staff attend these hearings to advise the Commission Tribunal. Subsection 17(1) of the NSCA stipulates that the Commission Tribunal can also hire external staff members to advise it independently of the CNSC's staff, although this is not currently being done.

The Commission Tribunal Secretariat supports the Commission Tribunal by planning its business and offering technical and administrative support to the president and other members. It is also the official registrar of Commission Tribunal documentation.

The Commission Tribunal administers the NSCA and its associated regulations. Among these regulations are the CNSC *Rules of Procedure*, which outline the public hearing process, and the CNSC By-laws*,* which outline the Commission Tribunal's meeting process.

3.4.2 The CNSC staff

The CNSC staff are primarily located at headquarters in Ottawa. The Uranium Mines and Mills Division is located in Saskatoon, close to Canada's major uranium mining operations. The CNSC satellite offices are located at each of the five nuclear power plants in Canada and at the Chalk River Laboratories (AECL). Regional offices, located in Quebec, Ontario and Alberta, conduct compliance activities for nuclear substances, transportation, radiation devices and equipment containing nuclear substances. They also respond to unusual events involving nuclear substances.

The CNSC staff support the Commission Tribunal by:

- developing proposals for regulatory development and recommending regulatory policies
- carrying out licensing, certification, compliance inspections and enforcement actions
- coordinating the CNSC's international undertakings
- developing the CNSC-wide programs in support of regulatory effectiveness
- maintaining relations with stakeholders
- providing administrative support to the organization

In addition, CNSC staff prepare recommendations on licensing decisions, present them to the Commission Tribunal for consideration during public hearings and subsequently administer the Commission Tribunal's decisions. Where so designated, CNSC staff also render licensing decisions.

In terms of organizational structure, the President's Office provides administrative support services to the president. Other groups in the CNSC organizational structure include the Secretariat, Legal Services and the Office of Audit and Ethics.

There are four major branches of the CNSC staff: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services.

1. The **Regulatory Operations Branch** is responsible for regulating the development, production and use of nuclear energy. It is also responsible for regulating the production, possession, transport and use of nuclear substances and radiation devices in accordance with the requirements of the NSCA and its associated regulations. The Regulatory Operations Branch comprises the Directorate of Power Reactor Regulation, the Directorate of Nuclear Cycle and Facilities Regulation, the Directorate of Nuclear Substance Regulation, the Directorate of Regulatory Improvement and Major Projects Management. These four directorates are responsible for licensees in matters of licensing, compliance and enforcement.

2. The **Technical Support Branch** provides specialist engineering, scientific and technical functions in support of regulatory operations and the licensing and implementation of international safeguards agreements. The TSB comprises the Directorate of Assessment and Analysis, the Directorate of Safety Management, the Directorate of Security and Safeguards and the Directorate of Environmental and Radiation Protection Assessment. These four directorates also support the CNSC's regulatory mandate.

3. The **Regulatory Affairs Branch** is responsible for providing strategic direction and implementation of the CNSC's regulatory policy, communications and stakeholder engagement, strategic planning, international relations and Executive Committee services. The RAB comprises the Strategic Planning Directorate, the Regulatory Policy Directorate and the Strategic Communications Directorate.

4. **Corporate Services** is responsible for policies and programs related to the management of the CNSC's finances and administration, human resources, information technology and information management. The CSB consists of the Human Resources Directorate, Finance and Administration Directorate and Information Management Technology Directorate.

3.4.3 The CNSC's Research and Support Program

The CNSC's Research and Support Program is managed within the Regulatory Affairs Branch. The program provides staff with access to independent advice: expertise, experience, information and other resources, via contracts or contribution agreements placed with other agencies and organizations in Canada and internationally. The work undertaken through the Research and Support Program is intended to support staff in meeting the CNSC's regulatory mission. Each year, the program is reviewed and evaluated, the need for research and support in the following year is identified and a commensurate budget is allotted. The CNSC is in the process of strengthening its Research and Support Program and will be developing a three-year strategic research plan in fiscal year 2011–2012. The CNSC Research and Support Program is independent of research and development programs conducted by industry.

3.5 Regulatory philosophy and activities

The CNSC's regulatory philosophy is based on two principles as outlined in the CNSC regulatory policy P-299, *Regulatory Fundamentals*:

- Persons and organizations subject to the NSCA and its associated regulations are directly responsible for ensuring that the regulated activities that they engage in are managed so as to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.

- The CNSC is responsible to the public for regulating persons and organizations subject to the NSCA and its associated regulations, to ensure that they are properly discharging their obligations.

The CNSC establishes a strategic framework, which encompasses the following outcome areas:

1. a clear and practical regulatory framework
2. individuals and organizations that operate safely and conform to safeguards and non-proliferation requirements
3. high levels of compliance with the regulatory framework
4. cooperation and integration of CNSC activities in national and international nuclear programs
5. stakeholders' understanding of the regulatory program

The following activities are to achieve the above outcomes:

1. regulatory framework
2. licensing and certification
3. compliance
4. cooperative undertakings, both domestic and international
5. stakeholder relations

The CNSC establishes and requires compliance with regulatory requirements, makes independent objective decisions based on regulatory action on the level of risk and seeks public input.

In carrying out its responsibilities, the CNSC issues licences (after assessing whether regulatory requirements and international obligations are met), verifies compliance with the licences that have been issued, sets standards for meeting regulatory requirements and communicates the work of the CNSC to its licensees and other stakeholders.

3.6 Regulatory framework

3.6.1 General framework

The CNSC's mandate, regulatory responsibilities and powers are set out in:

- The *Nuclear Safety and Control Act* (NSCA)
- The *Safeguards Agreement and Additional Protocol* between Canada and the IAEA
- Canada's bilateral and multilateral nuclear cooperation agreements

The CNSC also conducts environmental assessments under the CEA Act and administers the NLA.

To carry out these responsibilities, the CNSC uses the following regulatory tools:

- regulations
- licences, with licence conditions
- regulatory documents that provide guidance to the CNSC licensees on meeting criteria set out in the regulations

In line with the *Cabinet Directive on Streamlining Regulation*, the CNSC took steps to enhance stakeholder consultation by holding information sessions on key regulatory documents, posting public comments related to key documents on its Web site and initiating an online public input form. Also in line with this directive, the CNSC is continuing to adopt or adapt national and international standards in regulatory documents.

3.6.2 The CNSC's regulatory documents

Regulatory documents support the CNSC's regulatory framework by expanding on expectations set out in the NSCA, its associated regulations and legal instruments such as licences and orders. These documents provide instruction, assistance and information to the licensees.

Additional information on the CNSC's regulatory documents program is available at nuclearsafety.gc.ca on the CNSC Web site.

Table 3.1 – Regulatory documents published by the CNSC (as of January 31, 2011)

Document number	Document title	Date of publication
Current reporting period		
RD-361	*Criteria for Explosive Substance Detection, X-ray Imaging, and Metal Detection Devices at High-Security Sites*	December 2010
RD-321	*Criteria for Physical Protection Systems and Devices at High-Security Sites*	December 2010
RD-327	*Nuclear Criticality Safety*	December 2010
RD/GD-254	*Application Guide – Certification of Radiation Devices or Class II Prescribed Equipment*	December 2010
GD-327	*Guidance for Nuclear Criticality Safety*	December 2010
RD/GD-120	*Licence Application Guide – Radiotherapy*	November 2010
RD-336	*Accounting and Reporting of Nuclear Material*	June 2010
GD-336	*Guidance for Accounting and Reporting of Nuclear Material*	June 2010

Document number	Document title	Date of publication
GD-52	*Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms*	May 2010
GD-150	*Designing and Implementing a Bioassay Program*	May 2010
RD-364	*Joint Canada–United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages*	March 2009
RD-363	*Nuclear Security Officer Medical, Physical, and Psychological Fitness*	November 2008
RD-353	*Testing the Implementation of Emergency Measures*	November 2008
RD-346	*Site Evaluation for New Nuclear Power Plants*	November 2008
RD-337	*Design of New Nuclear Power Plants*	November 2008
RD-58	*Thyroid Screening for Radioiodine*	July 2008
Earlier publications		
RD-360	*Life Extension of Nuclear Power Plants*	February 2008
RD-310	*Safety Analysis for Nuclear Power Plants*	February 2008
RD-204	*Certification of Persons Working at Nuclear Power Plants*	February 2008
G-323	*Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement*	August 2007
S-210	*Maintenance Programs for Nuclear Power Plants*	July 2007
G-320	*Assessing the Long Term Safety of Radioactive Waste Management*	December 2006
G-313	*Radiation Safety Training Programs for Workers Involved in Licensed Activities with Nuclear Substances and Radiation Devices, and with Class II Nuclear Facilities and Prescribed Equipment*	July 2006
G-144	*Trip Parameter Acceptance Criteria for the Safety Analysis of CANDU Nuclear Power Plants*	May 2006
G-306	*Severe Accident Management Programs for Nuclear Reactors*	May 2006
P-325	*Nuclear Emergency Management*	May 2006
S-106 rev 1	*Technical and Quality Assurance Requirements for Dosimetry Services*	May 2006
S-296	*Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*	March 2006
G-296	*Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*	March 2006
S-98 rev 1	*Reliability Programs for Nuclear Power Plants*	July 2005
S-294	*Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*	April 2005
P-299	*Regulatory Fundamentals*	April 2005
S-260	*Making Changes to Dose-Related Information Filed with the National Dose Registry*	October 2004

Document number	Document title	Date of publication
G-129 rev 1	*Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"*	October 2004
P-290	*Managing Radioactive Waste*	July 2004
G-229	*Certification of Exposure Device Operators*	March 2004
G-217	*Licensee Public Information Programs*	January 2004
G-205	*Entry to Protected and Inner Areas*	November 2003
G-218	*Preparing Codes of Practice to Control Radiation Doses at Uranium Mines and Mills*	November 2003
G-4	*Measuring Airborne Radon Progeny at Uranium Mines and Mills*	June 2003
G-91	*Ascertaining and Recording Radiation Doses to Individuals*	June 2003
G-278	*Human Factors Verification and Validation Plans*	June 2003
G-276	*Human Factors Engineering Program Plans*	June 2003
G-221	*A Guide to Ventilation Requirements for Uranium Mines and Mills*	June 2003
G-147	*Radiobioassay Protocols for Responding to Abnormal Intakes of Radionuclides*	June 2003
G-273	*Making, Reviewing and Receiving Orders under the Nuclear Safety and Control Act*	May 2003
G-274	*Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities*	March 2003
G-208	*Transportation Security Plans for Category I, II or III Nuclear Material*	March 2003
S-99	*Reporting Requirements for Operating Nuclear Power Plants*	March 2003
G-225	*Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*	August 2001
P-211	*Compliance*	May 2001
G-228	*Developing and Using Action Levels*	March 2001
P-223	*Protection of the Environment*	February 2001
P-242	*Considering Cost-benefit Information*	October 2000
P-119	*Policy on Human Factors*	October 2000
G-149	*Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors*	October 2000
G-219	*Decommissioning Planning for Licensed Activities*	June 2000
G-206	*Financial Guarantees for the Decommissioning of Licensed Activities*	June 2000
G-121	*Radiation Safety in Educational, Medical and Research Institutions*	May 2000
R-9	*Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants*	February 1991
R-8	*Requirements for Shutdown Systems for CANDU Nuclear Power*	February 1991

Document number	Document title	Date of publication
	Plants	
R-7	*Requirements for Containment Systems for CANDU Nuclear Power Plants*	February 1991
R-85	*Radiation Protection Requisites for the Exemption of Certain Radioactive Materials from Further Licensing Upon Transferral for Disposal*	August 1989
R-89	*The Preparation of Reports of a Significant Event at a Uranium Processing or Uranium Handling Facility*	August 1988
R-77	*Overpressure Protection Requirements for Primary Heat Transport Systems in CANDU Power Reactors Fitted with Two Shutdown Systems*	October 1987
R-72	*Geological Considerations in Siting a Repository for Underground Disposal of High-Level Radioactive Waste*	September 1987
R-100	*The Determination of Effective Doses from the Intake of Tritiated Water*	August 1987
R-26	*Preparation of a Quarterly Health Physics Compliance Report for a Uranium Fuel Fabrication Plant*	September 1985
R-27	*Preparation of an Annual Compliance Report for a Uranium Fuel Fabrication Plant*	October 1984
R-25	*Preparation of a Quarterly Report on the Operation of a Uranium Refinery or Uranium Chemical Conversion Facility*	July 1984
R-10	*The Use of Two Shutdown Systems in Reactors*	January 1977

The draft regulatory documents listed in Table 3.2 have been issued for external stakeholder comment. The comment period is now closed and these drafts are under revision, incorporating the comments received during consultation.

Table 3.2 – Draft regulatory documents

Document number	Document title	Issued for public consultation
Current reporting period		
RD-99.1	*Reporting Requirements for Operating Nuclear Power Plants: Events*	November 2010
RD-99.2	*Reporting Requirements for Operating Nuclear Power Plants: Compliance Monitoring*	November 2010
RD-99.3	*Requirements for Public Information and Disclosure*	November 2010
RD-308	*Deterministic Safety Analysis for Small Reactors*	September 2010
RD-367	*Design of Small Reactors*	September 2010
RD-334	*Aging Management for Nuclear Power Plants*	August 2010

Document number	Document title	Issued for public consultation
Earlier publications		
S-322	*Physical Security Requirements for the Storage of Sealed Sources*	November 2006
S-338	*Physical Security Requirements for Sealed Sources during Transport*	November 2006
S-308	*Safety Analysis for Non-Power Reactors*	September 2006
S-339	*Nuclear Facility Access Authorization*	December 2005
S-307	*Requirements for the Disposal of Nuclear Substances* *** Note: S-307 is temporarily on hold pending the outcome of proposed amendments to the *Nuclear Substances and Radiation Devices Regulations*	November 2004
G-302-2.1	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.1 Licensees*	July 2004
G-302-2.2	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.2 Licensees*	July 2004
G-302-2.3	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.3 Licensees*	July 2004
G-302-2.4	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.4 Licensees*	July 2004
G-302-2.5	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.5 Licensees*	July 2004
G-302-3.1	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.1 Licensees*	July 2004
G-302-3.2	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.2 Licensees*	July 2004
G-302-3.4	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.4 Licensees*	July 2004
G-302-3.5	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.5 Licensees*	July 2004
G-303-1.0	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 1.0 Licensees*	July 2004
G-303-2.2	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.2 Licensees*	July 2004
G-303-2.3	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.3 Licensees*	July 2004
G-303-2.4	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.4 Licensees*	July 2004
G-303-2.5	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.5 Licensees*	July 2004
G-303-3.1	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.1 Licensees*	July 2004
G-303-3.2	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.2 Licensees*	July 2004

Document number	Document title	Issued for public consultation
G-303-3.4	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.4 Licensees*	July 2004
G-303-3.5	*CNSC Type II Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 3.5 Licensees*	July 2004
G-303-2.1	*CNSC Type I Inspection of Activities and Devices for Nuclear Substances and Radiation Device Licensees – Group 2.1 Licensees*	July 2004
G-224	*Environmental Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills*	July 2004
S-224	*Environmental Monitoring Program at Class I Nuclear Facilities and Uranium Mines and Mills*	July 2004
G-314	*Implementation of Radiation Protection Programs by Consignors, Carriers and Consignees of Radioactive Material*	March 2004
C-292	*Draft Regulatory Guide – Applying for a Licence – Diagnostic Nuclear Medicine, Therapeutic Nuclear Medicine, Human Research Studies*	April 2002
C-287	*Draft Regulatory Guide – Public Access to Information held at the CNSC*	January 2003
C-138	*Draft Regulatory Guide – Software in Protection and Control Systems*	October 1999
C-006 rev 1	*Draft Regulatory Guide – Requirements for the Safety Analysis of CANDU Nuclear Power Plants*	September 1999
C-200	*Draft Regulatory Guide – Radiation Safety Training for Radioisotope, Medical Accelerator and Transportation Workers*	January 1998
C-006	*Proposed Regulatory Guide – Requirements for the Safety Analysis of CANDU Nuclear Power Plants*	June 1980

3.7 Licensing process

The CNSC licenses about 3,500 operations across Canada, including uranium mines, fuel fabrication facilities, radioisotope production, waste management facilities, nuclear power plants in Ontario, Quebec and New Brunswick, and AECL facilities in Chalk River, Ontario and Whiteshell, Manitoba. Information about the CNSC's licensing process is available at nuclearsafety.gc.ca

Several types of licences are issued. A facility (Class I, II, uranium mines or mills) is licensed during its lifecycle. Licences are required for site preparation, construction, operations, decommissioning and abandonment. An application for a licence, renewal or amendment may trigger other legislation and regulations. For example, an EA under the CEA Act may be a prerequisite to proceeding with a licence application. The CEA Act may require an EA of a project to analyze potential environmental impacts and their severity, possible mitigation measures and any residual impacts. Both the physical and socio-economic environments must be considered in the EA. The range of stakeholder consultations is determined by the severity of the potential environmental impacts.

In addition, the CNSC also licenses the import and export of controlled nuclear substances, equipment, information and nuclear-related dual-use items. Proposed imports and exports are evaluated by CNSC staff to ensure compliance with Canada's nuclear non-proliferation and export policies, international agreements related to safeguards, health, safety and security, as well as the NSCA and its associated regulations.

3.8 Licensing hearings

The NSCA establishes a legislative requirement for the Commission Tribunal to hold public hearings, with respect to exercising its power to license. The NSCA also requires that applicants, licensees and anyone named in or subject to an order must have the opportunity to be heard. Accordingly, the CNSC *Rules of Procedure* set out the requirements for notification of public hearings and publication of decisions from public hearings, as described earlier.

The Commission Tribunal also holds public meetings for its members to consider a wide range of topics related to the nuclear regulatory process and, in certain cases, to make legislative, policy or administrative decisions on matters of particular or general application.

During a public hearing, simultaneous interpretation in one or the other of Canada's official languages (English and French) is provided. The CNSC produces and publishes verbatim transcripts on its Web site and webcasts public hearings whenever possible; the Webcast is archived on the CNSC Web site for three months.

The Commission Tribunal considers applications in public hearings, which are usually one or two days for each applicant or licensee. For a one-day hearing, the Commission Tribunal hears all of the evidence from the applicant, CNSC staff and intervenors in a single hearing session. For a two-day hearing, the first day is reserved to hear the application and the CNSC staff recommendations. The second day is reserved to hear interventions and is typically held 60 days after the first day to permit stakeholders time to review the application and recommendations.

Figure 3.1 illustrates the public hearing timelines:

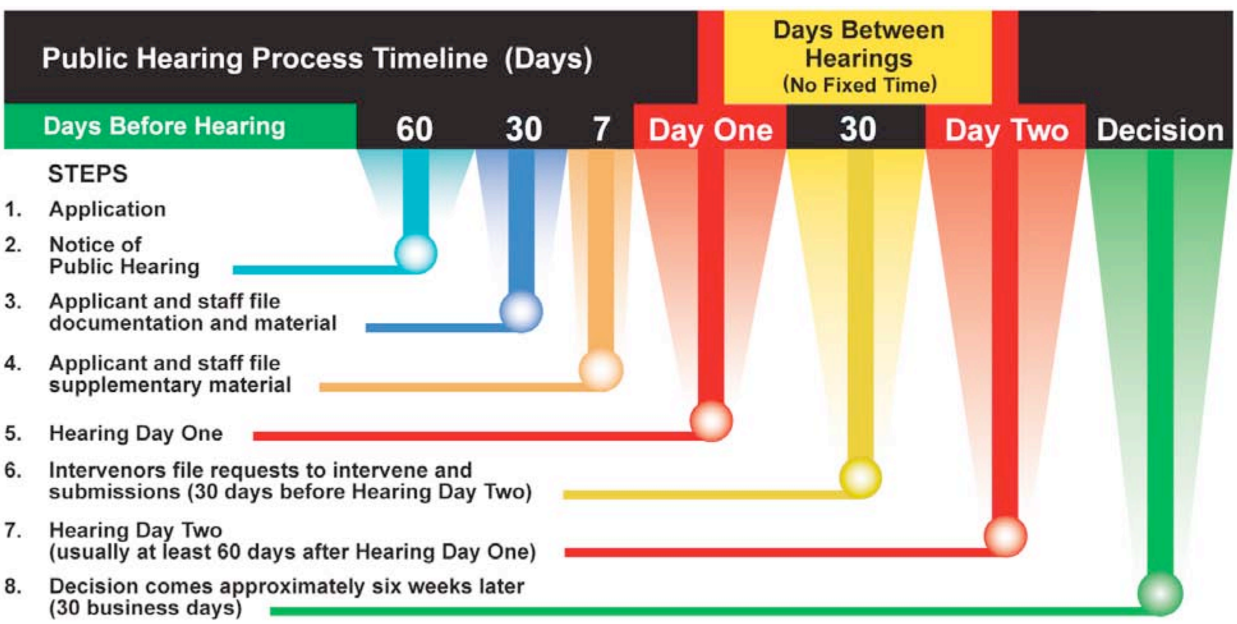

Figure 3.1 – Public hearing process timeline (days)

Hearing Day One: A *Notice of Public Hearing* is published 60 days prior to the hearing date. Applicants and the CNSC staff file the documentation they intend to present at the hearing at least 30 days prior to it. All documents filed by the applicant and staff become public record and are distributed as required (e.g., submissions by staff are provided to the applicant and to any other person who requests them).

Additional information the applicants or staff wish to provide to the tribunal is filed seven days in advance of the hearing. During the hearing, applicants present the information on their application and the CNSC staff present their comments and recommendations to the Commission Tribunal. Its members question both CNSC staff and the applicant regarding the information on the record. No decision is made during the first day of the hearing.

Prior to Hearing Day Two: Anyone wishing to take part in the process can file a request to intervene at least 30 days prior to Hearing Day Two. Documents received from intervenors become public record and are sent to the applicant and staff for review. Supplementary information must be filed seven days prior to the hearing.

Hearing Day Two: As appropriate, the applicant and CNSC staff presents additional information to the Commission Tribunal. Members of the public who have been granted the status of intervenor may attend in person to make their presentations or have their written submissions considered in this public forum. Commission Tribunal members can pose questions to the applicant, the CNSC staff and any intervenors present regarding the submissions made. Participants at the hearing may question each other through the presiding members.

Commission Tribunal Decisions: After Hearing Day Two, the Tribunal deliberates *in camera* (i.e., in a closed session) about the application and all information submitted during the public hearing to reach a decision. Typically, six weeks following the hearing, a notice of decision and a *Record of Proceedings, including Reasons for Decision* are sent to all participants and published on the CNSC Web site (nuclearsafety.gc.ca). Transcripts of the hearing are also posted on the CNSC Web site in the weeks following Hearing Day One and Hearing Day Two.

Abridged Hearings

Abridged hearings are held for less significant licence amendments. They deal with decisions that are more administrative in nature and where there is less public interest in the matter being considered. Abridged hearings may be held in a closed or public forum. The rules of procedure are different for abridged hearings, and can mean shortened notification requirements, reduced time periods and/or limited participation.

3.9 Compliance and the CNSC Compliance Program

Administering licensing decisions of the Commission Tribunal entails a planned and continuous oversight. Whether based on or off site, CNSC staff work on a daily basis to carry out regular inspections, audits and reviews to provide a comprehensive overall and day-to-day picture of operations. This process ensures that the operations are safe and in compliance with the licence as described in section E.6.1.

Confirmation of compliance with licences is managed within the CNSC Compliance Program (CCP). The CCP is a formal compliance verification program that includes promotion, verification and enforcement. These elements of the program are described in section E.6.1.

3.10 Cooperative undertakings

The CNSC works cooperatively with a number of other national and international organizations. At the national level, the CNSC's mandate is clearly outlined by the NSCA, which specifies that nuclear regulatory activities are a federal responsibility. However, there are areas where other federal and provincial departments have legislated parallel or complementary responsibilities. They include security, emergency preparedness and mining.

In addition, to fulfill Canada's international obligations, the CNSC collaborates with various agencies (such as its counterparts in other countries and DFAIT) to ensure that nuclear cooperation is conducted consistently with international agreements and especially with the non-proliferation regime.

Also at the international level, the CNSC's cooperation and involvement in international nuclear organizations includes the IAEA and the Nuclear Energy Agency of the Organisation of Economic Co-operation and Development (OECD). The CNSC's role is to promote Canadian interests and evaluate international recommendations, standards and guides for adoption in the CNSC's regulatory framework.

3.11 The CNSC Outreach Program

The CNSC recognizes open, transparent and timely communications as being central to the work and management of Canada's nuclear regulatory regime. Open and proactive communications ensure that stakeholders receive information and that their views and concerns are taken into account in the formulation, implementation and evaluation of the CNSC policies, programs, services and initiatives. (For information on specific initiatives relating to Aboriginal consultation, refer to section E.8.2.)

The CNSC strives to operate with a high level of transparency in all of its activities. These efforts involve engaging stakeholders through a variety of appropriate consultation processes, effective information sharing and communications. In 2003, the CNSC Executive Committee approved the CNSC Outreach Program Framework. The Framework provides a detailed description of the need for an Outreach Program and the steps that are taken to implement it successfully.

The CNSC uses outreach to communicate scientific, technical and regulatory information to stakeholders concerning the activities of the CNSC and the effects of the uses of nuclear energy and materials on health, security and the environment.

The CNSC's Outreach Program:

- provides the context and framework for outreach activities
- provides tools and materials for existing and new activities
- sets targeted, measurable outcomes
- tracks and continuously seeks to improve the CNSC's performance in doing outreach
- identifies opportunities for new activities
- provides the structure and necessary resources for additional support to CNSC staff in carrying out related activities

3.11.1 Framework for the CNSC's Outreach Program

The CNSC uses outreach to communicate information to stakeholders, consult with them and be aware of issues and concerns they have that relate to the CNSC as the Canadian nuclear regulator or to its regulatory regime.

3.11.2 Stakeholders

In implementing its Outreach Program, the CNSC must address two subgroups of stakeholders within the general stakeholder population:

- Key stakeholders are individuals or groups with whom the CNSC regularly or periodically interacts. They have at least a general knowledge of the CNSC and its roles and responsibilities. These groups include municipalities and residents near key facilities, licensees, non-governmental organizations, industry associations and all levels of government.

- General stakeholders are individuals or groups from the Canadian public in whose interest the CNSC regulates the Canadian nuclear sector but who are largely unaware of the CNSC and its roles and responsibilities.

3.11.3 Definition of outreach

The following definition of outreach was developed to apply to both subgroups of stakeholders:

> "Outreach is a coordinated approach to increasing levels of communication with stakeholders on issues or information of mutual interest, listening to the views received, and acting where appropriate. It includes activities that are over and above licensing and compliance activities required by the NSCA and its associated regulations."

3.11.4 Definition of outreach activity

An outreach activity is an activity that conveys information to or receives information from stakeholders (communication), or actively solicits input from stakeholders (consultation). For the purposes of the CNSC, outreach activities do not include mandated licensing and compliance activities but do include:

- meetings with municipal officials and community groups
- interactions with the public
- public hearings of the Commission Tribunal, particularly when they are held in a local community
- meetings with licensees on non-licence specific issues (e.g., quarterly meetings with the Canadian Nuclear Association (CNA) and Cost Recovery Advisory Group (CRAG) meetings)
- presentations by the president and executives at various seminars and stakeholder meetings
- benchmarking and other exercises with other regulators
- participation in international and national conferences and events
- proactive media relations events
- consultations on environmental assessments

Since the last reporting period, CNSC staff have continued to conduct outreach activities. For example, in June 2010, public information sessions were conducted in Labrador on proposed uranium mining projects. Throughout the latter half of 2010 and the first quarter of 2011, CNSC staff conducted a series of information outreach meetings with several groups in communities situated along the route of the proposed transport of used steam generators from Ontario to Sweden (see section H.4 for more information).

In addition, as part of the CNSC's early regulatory role in the APM process, CNSC staff meets communities and Aboriginal groups who are interested in learning more about the regulatory framework and the licensing process for a deep geological repository. The CNSC has conducted four presentations to interested communities and Aboriginal groups (see section K.5.3 for more information).

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Annex 4 – Spent Fuel Storage Technologies in Canada

4.1 Wet storage technology

Spent fuel discharged from a nuclear reactor is stored initially in wet bays or water pools. The wet bays, together with the cooling and purification systems, provide containment of the spent fuel and associated radioactivity and provide good heat transfer to control fuel temperatures. The water also provides shielding and allows access to the fuel, via remotely operated and automated systems, for handling and examination. The bay structure and structural elements (such as fuel containers and stacking frames) provide mechanical protection.

The walls and floors of CANDU reactor water pools are constructed of carbon steel reinforced concrete that is approximately two metres thick. Inner walls and floors are lined with a watertight liner, consisting of stainless steel, a fibreglass-reinforced epoxy compound or a combination of the two. The bay structure is seismically qualified, so that the structures and bay components maintain their structural form and support function both during and following a design basis event (i.e., an accident such as an earthquake). Other structural design considerations include load factors and load combinations (including thermal loads) for which upper and lower temperature limits have been established.

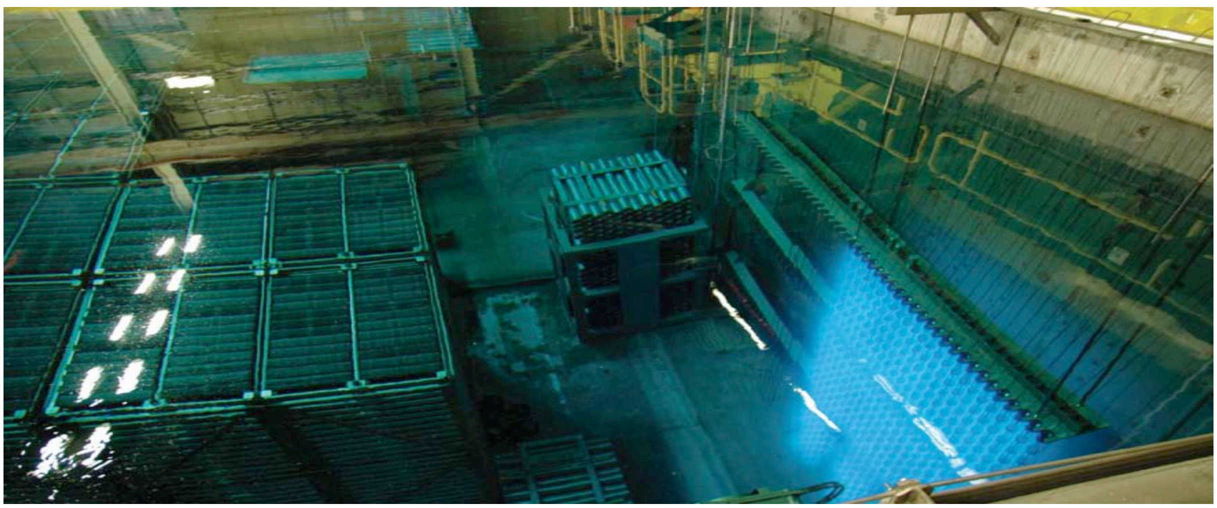

Figure 4.1 – Pool storage at Pickering Nuclear Generating Station

4.1.1 Bay liners

The bays are designed to prevent bay water leaking into the environment through any possible defects in the concrete. The bay's inner liner is the primary barrier against outward leakage. The bays also have a leakage collection system to ensure that any leakage that does occur is captured and conducted to a controlled drainage system. The design has provisions for leak detection and tracing.

4.1.2 Storage in wet bays

A number of designs are used to hold spent fuel for storage in wet bays. OPG has a standardized site-specific, storage-transportation module that stores the fuel compactly. To reduce handling, the storage-transportation module is also suitable for holding the fuel during transportation. Baskets, trays and modules are stacked vertically in the bays in seismically qualified stacking frames.

4.1.3 Water pool chemical control

In all storage bays, water is circulated through cooling and purification circuits. A combination of ion exchange columns, filters and surface skimmers is used to control water purity within design limits. A typical purification system also includes resin traps, sample points and instrumentation to indicate when filters and ion exchange columns are exhausted, as well as when resin traps must be cleaned out. Water-pool chemical control has the following objectives:

- minimize corrosion of metal surfaces
- minimize the level of radioisotopes in the water and reduce radiation fields and radioiodine levels in the bay area
- maintain clarity of the bay water for ease of bay operation

To ensure purity, demineralized water is used.

4.2 Experiences with wet storage

Early operating experiences at both the AECL research reactor spent fuel bays (which have been in operation since 1947) and at the NPD and Douglas Point reactors have provided a basis for the successful operation of the spent fuel bays in the current generation of power reactors. Those experiences, along with the development of high-density storage containers, inter-bay fuel transfers and remote handling mechanisms, have contributed to the establishment of current safe storage techniques.

Good chemical control has been achieved in Canadian spent fuel bays. Radioactivity in the water has been kept to very low or non-detectable levels, resulting in low radiation levels in the bay area. Overall fuel bundle defect rates are low. During early operations, defective fuel was canned (e.g., stored in a sealed cylinder). With more operating experience, canning has been found to be generally unnecessary, due to minimal release of fission products from most defective bundles. In some cases, known defective fuel is held temporarily in the fuel handling system before being passed to the bay. Known defective fuel is generally stored in a designated part of the fuel bay.

As noted above, an epoxy polymer liner is in place at a number of the stations. With extended operating lifetimes and continual exposure to radiation, there has been some radiation-induced deterioration of the liner at the Pickering A Nuclear Generating Station (Pickering A NGS) Primary Bay (where the first epoxy liner was used).

Potential leaks were located and repaired before Pickering A NGS was returned to service after an extended shutdown. Techniques have been developed for underwater repairs that use an underwater-curing epoxy. Extensive repairs were completed in 2002–2003 at various locations in the Pickering A NGS Primary Bay.

4.3 Dry storage technology

There are currently three basic designs used for the dry storage of spent fuel in Canada:

- AECL concrete canister
- AECL Modular Air-Cooled Storage System (MACSTOR™)
- OPG dry storage container

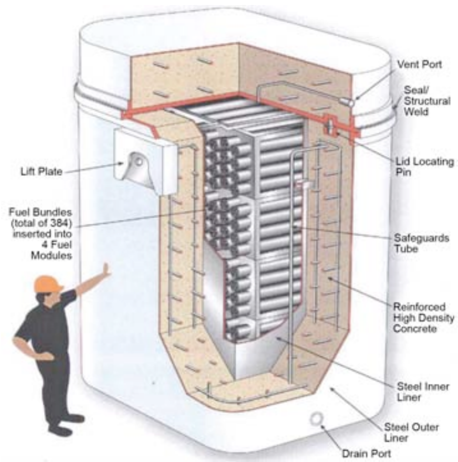

Figure 4.2 – OPG dry storage container

4.3.1 AECL concrete canisters

The AECL Concrete Canister Fuel Storage Program was developed at the Whiteshell Laboratories in the early 1970s to demonstrate that dry storage for irradiated reactor fuel was a feasible alternative to water pool storage. Owing to the success of the demonstration program, concrete canisters were used to store Whiteshell Reactor-1 spent fuel. Thanks to the success of the AECL Concrete Canister Fuel Storage Program, the AECL concrete canister design was used at CRL, the Point Lepreau Generating Station and the partially decommissioned Douglas Point and Gentilly-1 nuclear generating stations.

The main components of the canister system are:

- the fuel basket
- the shielded workstation
- the transfer flask
- the concrete canister itself

The fuel basket is constructed of stainless steel and comes in two sizes. One can hold 54 bundles (used for fuel from Douglas Point, Gentilly-1 and Nuclear Power Demonstration) and one can hold 60 bundles (in use at Point Lepreau). The fuel basket is designed to provide storage for spent fuel that has been in wet storage for six years or more; the fuel basket consists of two assemblies – the basket and the basket cover.

A shielded workstation is equipped to dry a loaded fuel basket and to weld the basket cover to the basket base plate and central post assembly. It is composed of a number of subassemblies used for lifting, washing, drying, seal welding and inspecting the spent fuel baskets. The shielding provided by the workstation is sufficient to reduce the radiation fields and ensure the safety of workers.

The fuel basket transfer flask is used to shield the basket when it is moved from the shielded workstation at the generating station to the dry storage canister at the waste management facility.

The concrete canister is a cylindrical reinforced concrete shell with an internal liner. To provide additional shielding, a two-piece loading plug is used until the canister is filled. Provision is made for IAEA safeguard seals to be placed on top of the canister plug, so that it cannot be removed without breaking the seals.

Two small-diameter pipes allow the air between the liner and the fuel baskets to be monitored in order to confirm the integrity of the confinement barriers. The concrete canisters are supported on reinforced concrete foundations above the water table. Each canister holds six, eight, nine or 10 baskets, depending on the specific needs of the station.

The transfer of spent fuel from the storage bays to dry storage canisters always begins with the oldest fuel. Therefore, the nominal age of the spent fuel in dry storage is usually older than seven years, which adds a measure of conservatism to the assumptions and overall safety of the dry storage of irradiated fuel.

Three barriers (defence-in-depth) ensure the containment of the radioactive products:

- the fuel sheath
- the fuel basket
- the internal liner

4.3.2 AECL MACSTOR™ module

The Modular Air Cooled Storage (MACSTOR™) module is a variant of the canister storage technique. The MACSTOR™ modules are currently installed and being operated at the Gentilly-2 site in Quebec, at the Cernavoda site in Romania and at the Qinshan site in China.

The original design of MACSTOR (MACSTOR-200) is a secure reinforced concrete structure housing 20 vertical steel cylinders, each of which holds 10 sealed baskets of 60 spent fuel bundles. Each module can store 12,000 bundles of spent fuel. Each cylinder is secured to the top slab of the module, and two sampling pipes, which extend to the outside of the MACSTOR™ module, are provided at its base. These pipes allow confirmation of the integrity of confinement. The MACSTOR-200 is used at the Gentilly-2 site in Quebec and the Cernavoda site in Romania.

The newer design, MACSTOR-400, can store twice as much fuel with a marginal increase in construction costs when compared to MACSTOR-200. The MACSTOR 400 houses 40 vertical steel cylinders, each of which will hold 10 sealed baskets of 60 fuel bundles. In total, the module can store 24,000 bundles of spent fuel. The MACSTOR-400 is used at the Qinshan site in China and is being installed at the Cernavoda site in Romania.

The heat of the spent fuel is dissipated primarily by natural convection, through ventilation ports that extend through the concrete walls. The ventilation is provided by 10 large air inlets in each longitudinal wall near the base of the module (five on each side), and by 12 large air outlets located slightly below the top of the module (six on each side). The air inlets and outlets are arranged in a series of baffles to avoid direct gamma radiation.

To enhance cooling, the storage cylinders of the MACSTOR™ module are in direct contact with the air circulating in the module. All the surfaces of the storage cylinders are hot galvanized to protect the storage cylinders from ambient air.

The loading operations for the MACSTOR™ module are identical to those of the concrete canister. Both use the fuel basket, shielded workstation and transfer flask concept. The only essential difference between the two is the storage structure itself.

Figure 4.3 – MACSTOR™ at Gentilly-2

4.3.3 Ontario Power Generation dry storage containers

OPG currently operates three spent fuel dry storage facilities – at the Pickering Waste Management Facility (PWMF), the Western Waste Management Facility (WWMF) and the Darlington Waste Management Facility.

OPG dry storage facilities employ standard dry storage containers. These are massive, transportable containers, with an inner cavity for fuel containment. Each one is designed to hold 384 fuel bundles and weighs approximately 60 tonnes when empty and 70 tonnes when loaded.

The containers are rectangular, with walls of reinforced concrete sandwiched between interior and exterior shells made of carbon steel. The inner liner constitutes the containment boundary, while the outer liner is intended to enhance structural integrity and facilitate decontamination of the surface of the dry storage container. Helium is used as a cover gas in the dry storage container cavity, to protect the fuel bundles from potential oxidation. OPG dry storage facilities are indoor, while the AECL storage facilities are outdoor. For both, there are no anticipated radiological releases under normal operating conditions.

Figure 4.4 – Dry storage containers at the Pickering Waste Management Facility

4.4 Experiences with dry storage

Research programs have assessed the behaviour of spent fuel when stored in dry and moist air conditions and in a helium environment. The programs concluded that CANDU fuel bundles, whether intact or with defects, can be stored in dry storage conditions for up to 100 years or more without losing integrity. Additional research is ongoing.

The experience gained at licensed dry storage facilities, which have been in operation for several years, provides a high level of confidence that CANDU dry storage facilities can be operated safely and without undue risk to workers, the general public and the environment. Dry storage containers have been used successfully and safely at the PWMF since 1996. The safety performance of the facility has been excellent over the entire period. Dose rates have remained below regulatory limits. Collective occupational radiation exposures have been below the predicted amounts by 30 percent or more. Emissions from the processing area have also remained below regulatory limits. All three OPG dry storage facilities operate contamination-free, and there have been no effluent releases resulting from dry storage containers.

Thermal and shielding analyses, carried out for design and safety assessment purposes, have been found to be conservative. Analysis and measurements carried out at the PWMF indicate that the maximum fuel cladding temperature does not exceed 175°C in dry storage. In addition, results of neutron dose rate calculations have demonstrated that, as expected, the dose rates produced by neutrons are negligible compared to those generated by gamma radiation. This result is due to the heavy concrete used as shielding in the dry storage containers.

To verify the results of the thermal analysis, an experimental thermal performance verification program was carried out in the summer of 1998. A dry storage container, instrumented with 24 thermocouples at various locations on the inner and outer liners, was loaded with six-year cooled fuel and placed within an array of dry storage containers containing 10-year cooled fuel. Temperatures were also measured at the interspaces between the dry storage containers, in addition to indoor and outdoor ambient temperature measurements. The results demonstrated the conservatism of the temperatures predicted analytically.

4.5 Spent fuel storage facilities

After a cooling period of six to 10 years in the storage bay (the exact cooling period is site-specific), spent fuel is then transferred to an interim dry storage facility. All transfers of spent fuel to dry storage are conducted under IAEA surveillance. All loaded dry storage containers in interim storage are also under the surveillance of the IAEA through the application of a dual sealing system.

4.5.1 Pickering Nuclear Generating Station

Pickering hosts two NGSs (Pickering A and B). Each station consists of four CANDU pressurized heavy-water reactors. Pickering NGS-A commenced operation in 1971 and continued to operate safely until 1997, when it was placed in voluntary layup as part of what was then Ontario Hydro's nuclear improvement program. In September 2003, Unit 4 was returned to commercial operation. Unit 1 was returned to commercial operation in November 2005. Units 2 and 3 were defuelled, dewatered and placed in safe storage by September 2010.

Pickering NGS-B commenced operation in 1982 and continues to operate today. OPG plans for continued operation of some of the Pickering B units until 2020.

The spent fuel waste generated at both Pickering NGS-A and Pickering NGS-B is stored in the irradiated fuel bays for a minimum of 10 years before it is transferred to the PWMF.

4.5.2 Pickering Waste Management Facility – spent fuel dry storage

OPG's PWMF is located within the protected area of the Pickering NGS. In operation since 1996, the primary purpose of the PWMF is to store spent fuel from the reactors at the Pickering A and B NGS. It is expected that the PWMF will be in operation until at least 10 years after the shutdown of the last Pickering reactor unit.

The spent fuel dry storage area of the PWMF comprises a dry storage container processing building and three storage buildings. The Pickering spent fuel dry storage system is designed to transfer spent fuel from wet storage in the Pickering A and B irradiated fuel bays into a concrete dry storage container designed by OPG. Prior to transfer to the PWMF, each loaded dry storage container is drained, its cavity is vacuum dried, and the container surface is surveyed for loose contamination. If necessary, decontamination is carried out.

Once the dry storage container loaded with spent fuel is received at the PWMF processing building, the transfer clamp and the seal are removed, and the lid is seal-welded to the dry storage container body. The lid weld is subsequently inspected for defects. The dry storage container undergoes final vacuum drying and helium backfilling. Subsequently, the drain port is welded and inspected, and helium leak testing is performed. The dry storage container is surveyed to ensure that no loose contamination is present; in the unlikely event contamination is found, the container and the affected area are decontaminated.

Finally, touch-up paint is applied to scuffs or scrapes on the container's exterior. Prior to being introduced into the storage buildings, IAEA seals are applied to each container. The PWMF can process approximately 50 dry storage containers (or 19,200 spent fuel bundles) per year.

The PWMF can store up to 650 dry storage containers or 249,600 fuel bundles in the two existing storage buildings in the PWMF Phase I. A PWMF Phase II area has been constructed in the east complex as shown in figure 4.5. The PWMF Phase II complex currently contains one spent fuel dry storage building (Storage Building 3) with space for one additional storage building. The two storage buildings in the PWMF Phase II area will eventually have a combined capacity of 1,000 dry storage containers. The PWMF Phase II area operates within its own established protected area.

In 2009, the PWMF (spent fuel dry storage area and re-tube components storage area combined) reported releases of less than 0.0002 GBq to air and 0.15 GBq to water. It is important to note, however, that activity released from the PWMF is included in the total releases reported for the Pickering NGS.

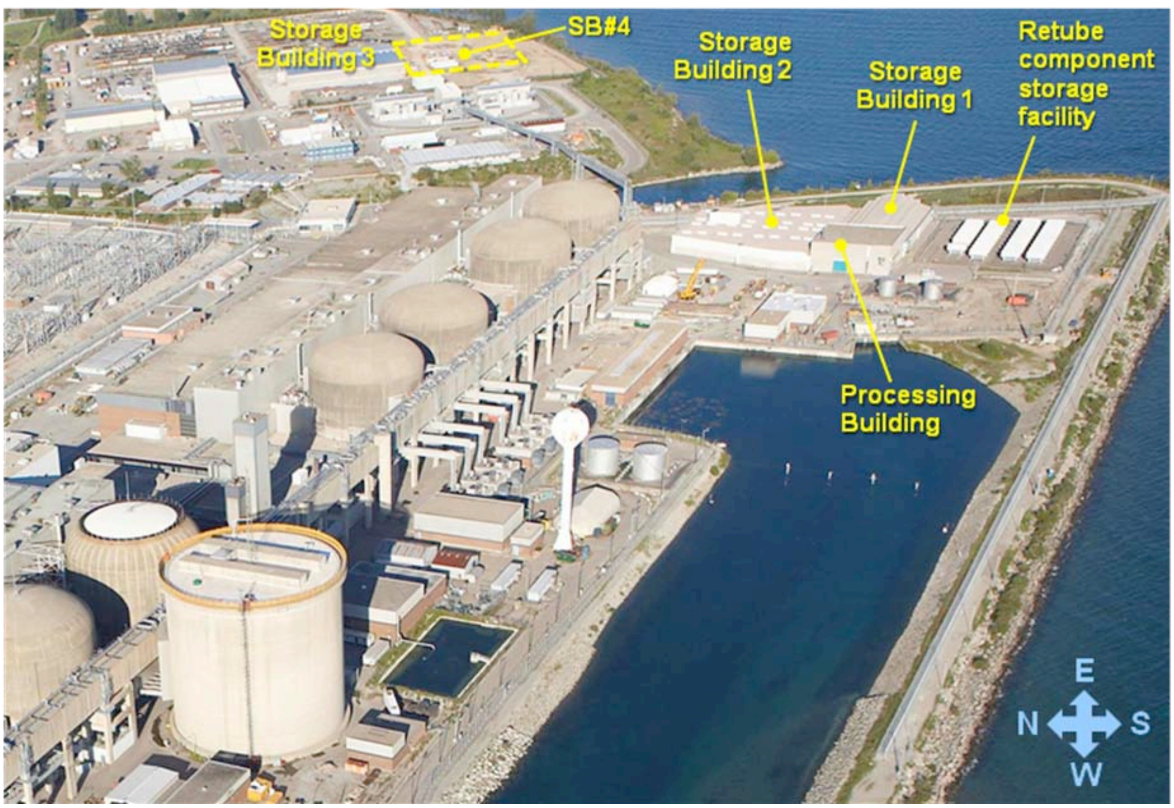

Figure 4.5 – PWMF I (Processing Building, Storage Buildings 1 and 2 and Retube Component Storage Facility) and PWMF II (Storage Building 3 and future Storage Building 4) area

4.5.3 Bruce Nuclear Generating Stations A and B

The Municipality of Kincardine, Ontario, hosts the Bruce nuclear site, which contains two NGSs (Bruce NGS-A and NGS-B). Bruce NGS-A consists of four CANDU pressurized heavy-water reactors. Currently, only Units 3 and 4 are in operation; Units 1 and 2 are being refurbished.

Bruce NGS-B consists of four CANDU heavy-water reactors. This station commenced operation in 1984 and continues to operate today. Bruce Power Inc. leases and operates both Bruce NGS-A and NGS-B.

4.5.4 Western Waste Management Facility – spent fuel dry storage

OPG's Western Used Fuel Dry Storage Facility, which is part of the WWMF, began operations in February 2003. The WWMF Western Used Fuel Dry Storage Facility was designed to provide safe storage for the Bruce NGS-A or NGS-B spent fuel until all of it is transported to an alternative long-term spent fuel storage or disposal facility. It can provide dry storage for about 750,000 fuel bundles produced at Bruce NGS-A and Bruce NGS-B. The spent fuel is stored in dual-purpose concrete dry storage containers, identical to those currently in use at the PWMF. The processing of dry storage containers is carried out in a manner similar to that at the PWMF.

The WWMF can process approximately 130 dry storage containers (or 49,920 spent fuel bundles) per year. OPG is authorized to store up to 750,000 spent fuel bundles, or approximately 2,000 dry storage containers, at the facility.

4.5.5 Darlington Nuclear Generating Station

The Darlington NGS, operated by OPG, consists of four CANDU pressurized heavy-water reactors. The station commenced operation in 1989 and continues to operate today. All of the spent fuel produced at the Darlington NGS is currently stored in the water-filled storage bays. OPG has announced a reinvestment plan which sets the course for refurbishment of the existing Darlington facility to extend its lifetime to approximately 2050. OPG is proceeding with detailed planning for refurbishment.

The spent fuel waste generated at the Darlington NGS is stored in the irradiated fuel bays for a minimum of 10 years before the spent fuel is transferred to the DWMF.

4.5.6 Darlington Waste Management Facility

The Darlington Waste Management Facility (DWMF) is located at the Darlington NGS site. It provides safe storage for the Darlington NGS spent fuel until this fuel is transported to an alternative long-term spent fuel storage or disposal facility.

The current DWMF is made up of a processing building and storage building that was designed to house up to 500 dry storage containers. The facility, however, is designed to provide a storage capacity for up to 576,000 fuel bundles produced at the Darlington NGS after two additional storage buildings are constructed in the future. The spent fuel is stored in dual-purpose concrete dry storage containers, identical to those currently in use at the PWMF and WWMF. The processing of dry storage containers is also identical to the operations at the PWMF and the WWMF. The DWMF can process approximately 60 dry storage containers (or 23,040 spent fuel bundles) per year.

Figure 4.6 – Darlington reactor site with Darlington Waste Management Facility in the foreground

4.5.7 Gentilly-2 Nuclear Power Plant

The Gentilly-2 Nuclear Power Plant, which is operated by Hydro-Québec, houses a CANDU pressurized heavy-water reactor. The station went into service in 1982 and began commercial operation in 1983.

The spent fuel generated here is first stored in a pool in irradiated fuel bays. After a period of cooling in the storage bays, the spent fuel is transferred to the dry storage facility. The spent fuel is transferred into baskets directly in the pool. The loaded baskets are then transferred to a shielded workstation, in which the contents are dried and the basket lids are welded on. Once the work on the baskets has been completed, the baskets are transported to Hydro-Québec's spent fuel dry storage facility.

4.5.8 Hydro-Québec spent fuel dry storage facility

In operation since 1995, the Gentilly-2 spent fuel dry storage facility provides additional storage capacity in CANSTOR modules (an AECL-designed technology, MACSTOR™). This facility has been authorized to build a total of 20 CANSTOR modules, with a total storage capacity of 240,000 spent fuel bundles. By the end of 2010, nine CANSTOR modules had been built and were in service. The eventual number of these modules will depend on a decision made concerning the refurbishment of the reactor.

Currently, the storage baskets are transferred on an as-needed basis, normally between April and December each year. Approximately 4,500 spent fuel bundles are transferred to storage each year. At all times, the licensee makes sure that dose rates at the fence line of these facilities stays within the authorized limit of 2.5 µSv/h.

Figure 4.7 – Gentilly-2 spent fuel dry storage facility (bottom right)

4.5.9 Point Lepreau Nuclear Generating Station

The Point Lepreau Nuclear Generating Station, operated by New Brunswick Power Nuclear Corporation (NB Power), consists of one CANDU pressurized heavy-water reactor. The station commenced operation in 1982. It is currently in safe shutdown with plans to restart early in 2012. The spent fuel generated at the Point Lepreau NGS is initially stored in the irradiated fuel bay and then transferred to Point Lepreau spent fuel dry storage facility, where it is stored in concrete canisters.

4.5.10 Point Lepreau spent fuel dry storage facility

In operation since 1990, the Point Lepreau spent fuel dry storage facility provides additional storage capacity for the Point Lepreau NGS in above ground concrete canisters. The facility is authorized to construct 300 canisters for a total of 180,000 spent fuel bundles. By the end of 2010, the facility had constructed 180 canisters. Approximately 5,000 spent fuel bundles are transferred to dry storage each year that the station operates, depending on the power output of the Point Lepreau nuclear reactor.

The average dose for the year at the spent fuel storage facility perimeter fence was 950.0 µSv, which is equivalent to an average dose rate of 0.10 µSv/h.

The Point Lepreau Generating Station is currently preparing for a major refurbishment outage. This work will enable the station to operate for another 25 to 30 years. To handle the spent fuel resulting from the extended operational life of the station, land was prepared to permit the construction of up to 300 additional canisters, depending on upcoming needs.

Figure 4.8 – Point Lepreau spent fuel dry storage area

4.5.11 Douglas Point spent fuel dry storage facility

The AECL Douglas Point spent fuel dry storage facility is located at the Bruce NGS. The prototype CANDU power reactor at Douglas Point became operational in 1968 and was shut down permanently after 17 years of operation. Decommissioning began in 1986, and approximately 22,256 spent fuel bundles were transported to concrete canisters in late 1987. The concrete canisters are currently in storage-with-surveillance mode. The Dry Fuel Storage Canister Air Sampling program showed gross beta activity levels below 0.35 Bq/canister, gross alpha levels below 0.02 Bq/canister and gross gamma levels below 7.32 Bq/canister in 2010.

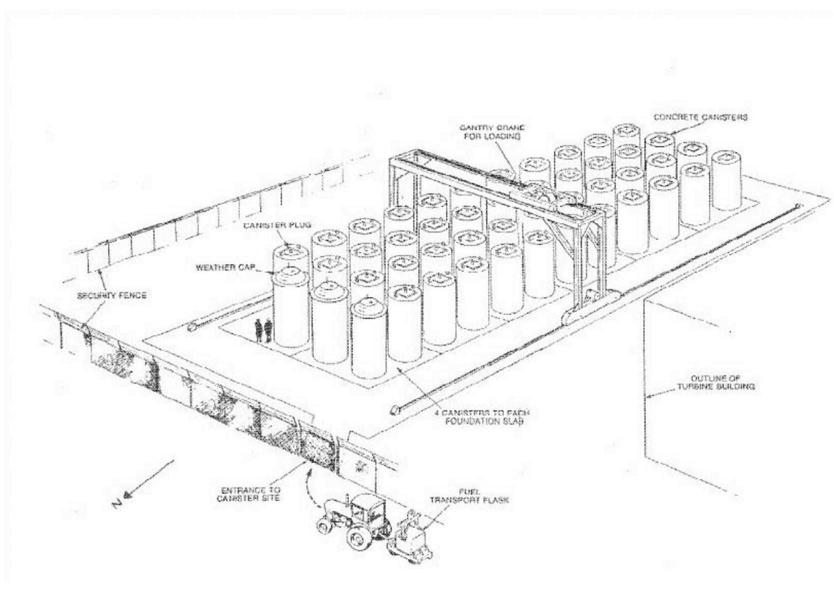

Figure 4.9 – Douglas Point spent fuel dry storage facility

4.5.12 Gentilly-1 spent fuel dry storage facility

The AECL Gentilly-1 Nuclear Power Station became operational in May 1972. It attained full power for two short periods in 1972 and was then operated intermittently for a total of 183 effective full-power days until 1978. In 1984, AECL began a two-year decommissioning program, during which a total of 3,213 spent fuel bundles were transferred to concrete canisters. The concrete canisters are currently in storage-with-surveillance mode. The Dry Fuel Storage Canister Air Sampling program showed gross beta activity levels were below 0.12 Bq/canister, gross alpha levels were less than 0.02 Bq/canister and gross gamma levels were less than 2.33 Bq/canister in 2010.

4.5.13 Chalk River Laboratories – Area G – spent fuel dry storage area

The Waste Management Area G at AECL CRL is a spent fuel dry storage area that contains concrete canisters as described in section 4.3.1. The NPD was a demonstration reactor operated by Ontario Hydro (now OPG) from 1962 until 1987, when it was decommissioned. As part of the decommissioning program, the spent fuel was transferred to concrete canisters located at the AECL CRL spent fuel dry storage area. At this site, AECL has stored 68 full and partial spent fuel bundles from Bruce, Pickering and Douglas Point, as well as 4,886 fuel bundles from the NPD reactor, in 12 dry storage concrete canisters. The concrete canisters are currently in storage-with-surveillance mode.

Two concrete canisters were constructed on the existing concrete support pad to store calcined waste from the processing of radioisotopes separated in the new processing facility at CRL. These canisters are in the extended shutdown state, matching the other Dedicated Isotope Facility systems. Construction of the canisters is not completed.

4.5.14 Whiteshell Laboratories (WL) Spent Fuel Storage Facility

Whiteshell Laboratories (WL) was established at Pinawa, Manitoba in the early 1960s to carry out nuclear research and development activities for higher-temperature versions of the CANDU reactor. The initial focus of research was the Whiteshell Reactor-1 Organic Cooled Reactor, which began operation in 1965. Whiteshell Reactor-1 continued to operate until 1985.

The Concrete Canister Storage Facility Program, or Whiteshell spent fuel storage facility, was developed in the early 1970s to demonstrate that dry storage was a feasible alternative to water pool storage for irradiated reactor fuel.

Because of the success of the demonstration program, the Concrete Canisters Storage Facility (CCSF) was built to store all remaining Whiteshell Reactor-1 (WR-1) spent fuel. In addition, a number of spent fuel bundles from CANDU stations are stored in the WL facility after undergoing post-irradiation examinations in the WL shielded facilities. The facility provides storage for 2,268 irradiated fuel bundles originating from both the WR-1 operation and CANDU reactor. Some spent fuel waste from operations prior to the 1975 canister development program is stored in standpipes in the WMA. (Further details on the Whiteshell decommissioning program can be found in annex 7.1.)

Figure 4.10 – Whiteshell Laboratories Concrete Canister Storage Facility (CCSF)

4.5.15 NRU Research Reactor

The NRU Research Reactor is a thermal neutron, heterogeneous, heavy-water moderated and cooled reactor. It was designed for operation with natural uranium metal fuel rods and converted to operation with enriched driver fuel rods in 1964. Gradual conversion to LEU fuel began in 1991.

Initial storage of the spent fuel rods is in water filled bays located within the NRU. After an appropriate time to allow for radioactive decay and cooling, the spent fuel is generally transferred to tile holes at Waste Management Area B at CRL. The tile holes are also used to store the spent fuel from the NRX reactor, which was shut down in 1992.

4.5.16 McMaster Nuclear Reactor

The McMaster Nuclear Reactor (MNR) is a pool-type reactor, with a core of enriched uranium fuel moderated and cooled by light water. The reactor operates at powers up to five MW. The MNR was converted from highly enriched uranium (HEU) fuel to low-enriched uranium (LEU) fuel during 2006–2007. The original HEU fuel was returned to Savannah River in the United States. The LEU fuel was manufactured in France. The MNR is the only Canadian medium-flux reactor in a university environment. The MNR's neutrons are used in nuclear physics, biology, chemistry, earth sciences, medicine and nuclear medicine. Any spent fuel at the McMaster Nuclear Reactor can be stored in a water environment.

Annex 5 – Radioactive Waste Management Facilities

5.1 Radioactive waste management methods

All radioactive wastes produced in Canada are placed into storage with surveillance, pending the establishment of long-term waste management facilities. At existing waste management facilities, various storage structures are currently in use:

- in-ground burial
- low-level storage buildings
- modular above ground storage buildings
- Quonset huts
- tile holes
- in-ground containers
- concrete bunkers

5.1.1 Pickering Waste Management Facility – re-tube components storage

The Pickering Waste Management Facility consists of the spent fuel dry storage area (see annex 4.5.10) and a storage area, called the re-tube components storage area (RCSA), which stores reactor core component waste from re-tube activities at the Pickering NGS-A. The RCSA is located within the protected area of the Pickering NGSs and is operating in storage-with-surveillance mode, meaning that it is closed to new waste unless it receives prior written approval from the CNSC.

The RCSA uses dry storage modules (DSMs) to store the re-tube components. The RCSA was designed to accommodate 38 DSMs, cylindrical casks made from reinforced heavy concrete. The design of the DSMs provides adequate shielding to meet dose rate requirements outside the facility and keep worker dose rates ALARA. At present, the RCSA consists of 34 loaded DSMs, two empty DSMs and empty space for two additional DSMs.

The RCSA is covered in an impermeable membrane and provides a low-maintenance surface. A drainage system directs the runoff water from the storage area to the Pickering NGS-B outfall. Catch basins permit the periodic sampling of the water.

Figure 5.1 – Pickering Waste Management Facility, with RCSA (left) and spent fuel dry storage area (right)

5.1.2 Western Waste Management Facility – low- and intermediate-level waste storage

The Western Waste Management Facility (WWMF) is owned and operated by OPG at the Bruce Power site near Kincardine, Ontario. The WWMF consists of two distinct areas:

- a low-and intermediate-level radioactive waste storage area
- a spent fuel dry storage area (refer to annex 4.5.4)

The low- and intermediate-level radioactive waste storage area provides safe handling, treatment and storage of radioactive materials produced at NGSs (Pickering A and B, Darlington, Bruce A and B) and other facilities currently or previously operated by OPG or its predecessor Ontario Hydro. The low- and intermediate-level radioactive waste storage area consists of various buildings, such as the Waste Volume Reduction Building (WVRB) and the Transportation Package Maintenance Building (TPMB). The storage structures used in this facility consist of low-level waste storage buildings, refurbishment waste storage buildings, quadricells, in-ground containers, trenches and tile holes.

The WVRB can receive low-level radioactive wastes and sort them into processable and non-processable streams. It can further process some of the waste by using compaction or incineration prior to storage. The WVRB consists of the following main areas:

- The **radioactive waste incinerator area** contains the radioactive waste incinerator, associated equipment and an active drainage sump.

- The **compaction area** contains a box compactor and a civil maintenance shop. Control and mechanical maintenance shops are located at the TPMB to carry out repairs and equipment maintenance.

- The **material handling, storage and sorting area** provides for material movement, sorting and temporary storage of incoming and processed wastes. Access to the incinerator and compaction areas is included.

- The **control room** houses the main work control centre. All low- and intermediate-waste storage area systems and services alarms are monitored in this room.

- **Truck bays** establish a weather-protected area for the receipt and unloading of low-level wastes.

- **Ventilation equipment areas** contain air intake filters, intake fans, heating coils, air exhaust filters and exhaust fans. Radioactive airborne effluent monitors, for the building ventilation and radioactive incinerator exhaust, are also located in this area.

- **Electrical and storage rooms** provide housing for electrical switchgear and MCCs, and storage for non-waste products.

OPG has developed derived release limits (DRLs) for airborne radioactive releases from the radioactive incinerator and active ventilation in the WVRB and TPMB and for releases to surface and subsurface drainage at the site. The non-radioactive effluents must conform to the Certificate of Approval (Air) for the WWMF site issued by the Ontario Ministry of Environment. Currently, radioactive and non-radioactive effluents are all below regulatory requirements.

The safe handling, processing and storage of radioactive waste at the WWMF requires a combination of design features, procedures, policies and monitoring programs. Required programs focus on radiation protection, occupational health and safety, environmental protection and monitoring for individual areas, as well as the overall facility.

The low- and intermediate-level waste storage area of the WWMF typically receives about 450 cubic metres of radioactive waste per month. The actual amount can vary widely, depending on maintenance activities at the various nuclear power plants. The waste is subsequently processed, when possible, and placed into the appropriate storage structure.

Two refurbishment waste storage buildings have been constructed within the developed part of the low- and intermediate-level waste storage area. These buildings store the waste that arises from the refurbishment of Bruce NGS-A Units 1 and 2. One of these building contains the re-tube components in specially designed concrete and steel boxes, and the other houses the steam generators. The construction schedule for the future refurbishment waste storage structures will be based on need and, therefore, on the refurbishment plans developed for the nuclear power plants by the power reactor licensee.

In 2009, the WWMF (spent fuel dry storage area and the low- and intermediate-level radioactive waste storage area combined) released 4.95E+13 Bq of tritium, 4.44E+04 Bq particulate beta/gamma, 6.45E+04 Bq iodine-131 and 4.52E+09 Bq carbon-14 to air. Releases to water were 8.82E+10 Bq tritium and 7.97E+07Bq gross beta.

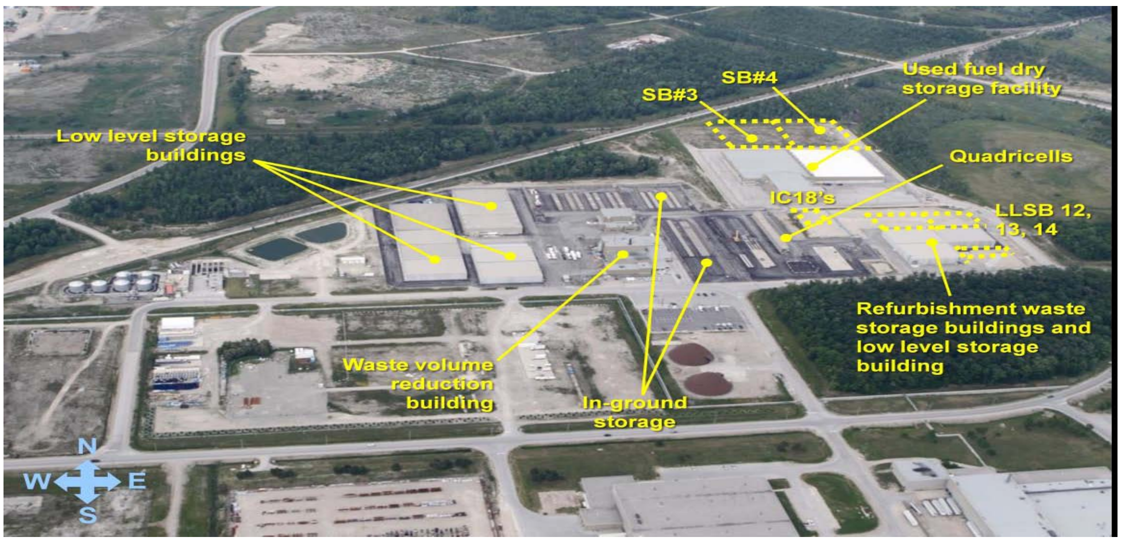

Figure 5.2 – Western Waste Management Facility

5.1.3 Radioactive Waste Operations Site 1

Radioactive Waste Operations Site 1 (RWOS 1) is owned and maintained by OPG at the Bruce nuclear site. The facility provides for the storage of low- and intermediate-level waste produced at the Douglas Point Nuclear Generating Station. Wastes are stored in reinforced concrete trenches with concrete covers.

The facility, which has been operated in storage-with-surveillance mode since the mid-1970s, is closed to new wastes. OPG monitors and maintains the site and structures, and no new waste can be added without the prior written approval of the CNSC.

5.1.4 Hydro-Québec Waste Management Facility

The Hydro-Québec Waste Management Facility consists of a spent fuel dry storage area and a low-level radioactive waste management area (WMA). The low-level radioactive WMA provides for the safe storage of radioactive materials produced at the Gentilly-2 Nuclear Power Plant. The low-level radioactive WMA consists of several types of reinforced concrete bunkers.

The Type A bunker is used for the storage of high-level radioactive waste such as filters. Type B is used for the storage of intermediate-level radioactive waste, while Type C is used for the storage of low-level radioactive waste.

The low-level radioactive WMA receives approximately 25 cubic metres of radioactive waste per year. Samples of surface runoff from the radioactive WMA, collected and analyzed in 2007, have shown that the tritium concentrations varied between 280 Bq/L and 1,500 Bq/L. The average dose rate for 2007 at the radioactive WMA perimeter fence was 0.07 µSv/h.

In 2007, the CNSC approved Hydro-Québec's request to build additional waste management structures. This project received a favourable CEA Act decision in December 2006. The new Solid Radioactive Waste Management Facility (SRWMF) is being developed in four phases. This new facility will provide additional concrete bunkers to store low- and intermediate-level radioactive waste and filters. Phase 1 has been in operation since January 2009. Construction of Phase 2 has been completed and is expected to be in operation in 2011.

Two new types of concrete structures have been added to the SRWMF. These structures are re-tube waste canisters (for the high-level refurbishment waste) and used resin storage enclosures. The SRWMF continues to be under regulatory review.

Figure 5.3 – Gentilly-2 spent fuel dry storage area and low-level radioactive WMA

5.1.5 Point Lepreau Waste Management Facility

The Point Lepreau Solid Radioactive Waste Management Facility (SRWMF) includes a Phase I Area for the safe storage of radioactive materials produced at the Point Lepreau Generating Station (PLGS) and a Phase II Area for the storage of spent fuel (described in annex 4.5.10). Phase III was completed in 2007 to accommodate the reactor refurbishment waste.

The Phase I Area contains the following storage structures:

- **Vaults**: These concrete structures are used to store the bulk of low-level wastes. Almost all the waste stored in the vaults is expected to decay to an insignificant level by the end of the structure's design life. There are approximately 2,133 cubic metres of storage in the four vault structures. Each vault has four equal compartments.

- **Quadricell**: The quadricell structures are designed to contain intermediate-level waste, such as spent ion exchange resins and filters from reactor systems and contaminated system components. Currently, there are approximately 144 cubic metres of quadricell storage available in a total of nine quadricells; these quadricells are currently empty.

- **Filter**: The filter storage structures are used for storing filters from heat transport purification, active drainage, gland seal supply, moderator purification, and spent fuel bay and fuelling machine systems. These structures are contained within one of the vaults mentioned above.

The Phase I Area received an average of less than 1.0 cubic metre of radioactive waste per month in 2010.

Samples of surface runoff from the Phase I Area, collected and analyzed in the fourth quarter of 2010, have shown that tritium concentrations varied between 87 and 710 Bq/L. The average dose for the year at the Phase I Area perimeter fence was 971.9 µSv, which translates to an average dose rate of 0.11 µSv/h.

The Phase III Area contains the following storage structures:

- **Vaults**: These concrete structures are used to store the bulk of low-level waste from the reactor refurbishment. There are approximately 890 cubic metres of storage space in the two vault structures. Currently, there are approximately 734.66 cubic metres of vault storage being stored.

- **Retube canisters**: These concrete structures are used to store intermediate-level waste from the refurbishment of the PLGS reactor (primarily reactor components). There are approximately 165 cubic metres of storage in the five structures. Currently, there are approximately 139.54 cubic metres of retube canister storage being stored.

The average dose per year at the Phase III Area perimeter fence was 1,157.2 µSv, which translates into an average dose rate of 0.13 µSv/h.

Figure 5.4 – Point Lepreau re-tube waste canisters

5.1.6 Radioactive waste management at decommissioned reactor sites

The Douglas Point, Gentilly-1 and NPD reactors are shut down, partially decommissioned and in the storage-with-surveillance phase. As these facilities contain radioactive materials, including radioactive wastes from decommissioning activities, they are presently licensed as waste management facilities. The storage-with-surveillance phase is currently envisaged to be 30 years or longer. A major factor influencing the length of the phase is the availability of long-term waste management facilities. (Annex 7 provides further information on the decommissioning activities at each of these sites.)

5.1.6.1 Douglas Point Waste Management Facility

The AECL Douglas Point Waste Management Facility (DPWMF) is located on the Bruce nuclear site in Kincardine, Ontario. The prototype CANDU power reactor was shut down permanently in 1984 after 17 years of operation. Decommissioning began in 1986, and the spent fuel bundles were transported to concrete canisters in late 1987.

Stored waste consists of activated corrosion products and fission products. The waste is stored in the reactor and service buildings. The sources of each waste type are as follows:

- induced radioactivity in reactor components and the biological shield
- radioactive corrosion products and fission products deposited on the drained heat transport and moderator surfaces
- ion exchange resin from both the heat transport and moderator systems stored in underground tanks
- contaminated soil stored in the service building
- drums of contaminated steel from fuel storage trays
- intermediate-level waste stored in the fuel transfer tunnel leading from the reactor building to the receiving bay

In 2010, DPWMF released 2.75E+11 Bq of tritium and 3.40 Bq of carbon-14 from the HEPA-filtered ventilation system for the reactor building during 675 hours of operation. The total liquid tritium release was 3.34E+10 Bq. The total liquid carbon-14 release was 1.12E+09 Bq from the facility.

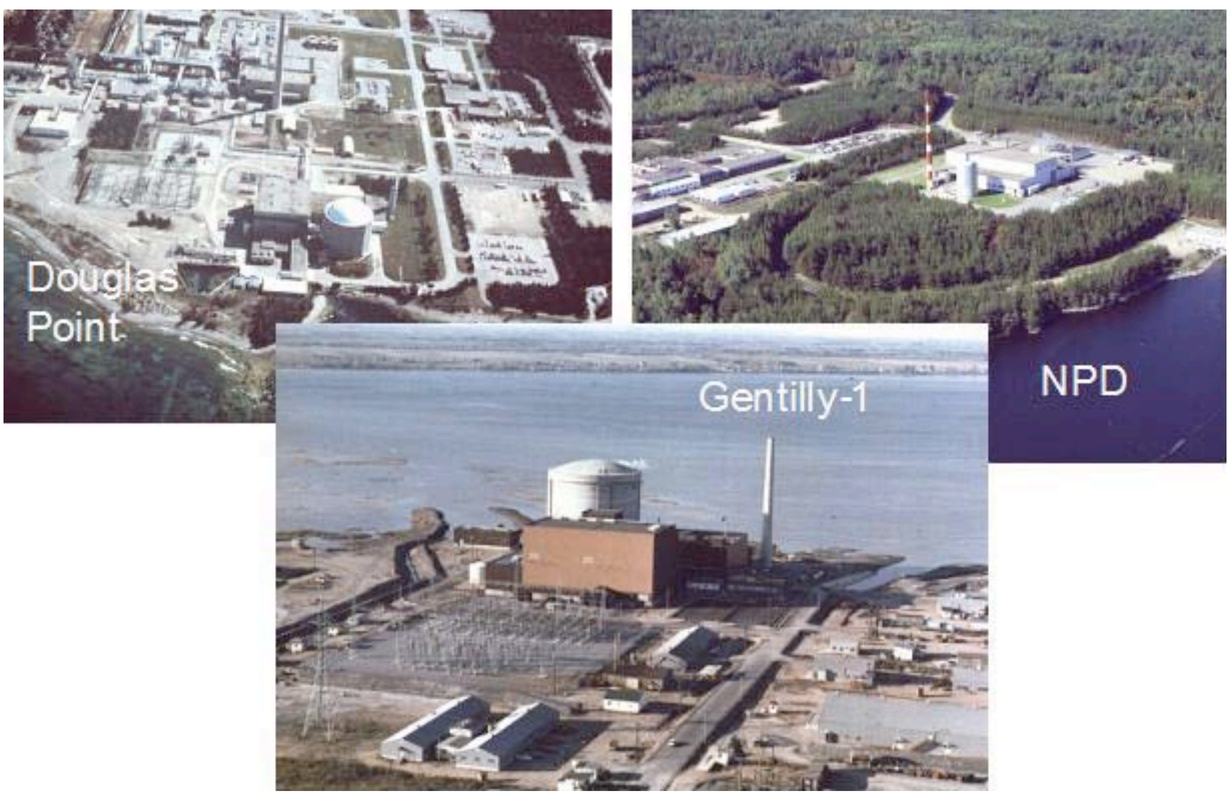

Figure 5.5 – Douglas Point, NPD and Gentilly-1 facilities

5.1.6.2 Gentilly-1 Waste Management Facility

The AECL Gentilly-1 Waste Management Facility (G1WMF) is situated within Hydro-Québec's Gentilly-2 Nuclear Power Plant boundary. The CANDU-BLW-250 Gentilly-1 Nuclear Power Station began operation in May 1972 and attained full power for two short periods during that same year. It was operated intermittently for a total of 183 effective full-power days until 1978, when it was determined that some modifications and considerable repairs would be required. Consequently, it was in a layup state from 1980 to 1984, when a decommissioning program was initiated to bring the Gentilly-1 station to a safe sustainable shutdown state that permitted storage-with-surveillance.

The G1WMF consists of specified areas within the turbine and service buildings, the whole reactor building, the resin storage area and the spent fuel storage canister room.

Stored waste consists of activated corrosion products and fission products. The sources of each waste type area are as follows:

- induced radioactivity in reactor components and the biological shield
- radioactive corrosion products and fission products deposited on the drained heat transport and moderator system surfaces
- contaminated soil
- ion exchange resin from the heat transport and moderator systems
- containers of dry low-level contaminated equipment and material that resulted from operation and earlier decommissioning activities

There are no airborne releases from the G1WMF. In 2010, 7.33E+04 Bq of activity beta/gamma were released from the facility liquid sump to the Hydro-Québec power reactor active liquid discharge system.

5.1.6.3 Nuclear Power Demonstration Waste Management Facility

Located in Rolphton, Ontario, the AECL Nuclear Power Demonstration Waste Management Facility (NPDWMF) contains the decommissioned NPD Nuclear Generating Station. The station operated from 1962 until 1987, when Ontario Hydro (now OPG), with assistance from AECL, decommissioned it to a static state interim storage condition. After the static state was achieved, Ontario Hydro turned over control of the NPDWMF to AECL in September 1988. Since then, various non-nuclear ancillary facilities, such as the administration wing, training centre, pumphouse and two large warehouses, were demolished and the refuse was removed from the site for reuse, recycling or waste. The fuel bundles were transferred to the CRL waste management area for storage.

The NPDWMF is divided into nuclear and non-nuclear areas. Stored waste consists of induced radioactive, activated corrosion products and some fission products. The confined residual radioactivity in the NPD after removal of the irradiated fuel and heavy water consists of:

- induced radioactivity in the reactor components and biological shield (i.e., the concrete walls surrounding the reactor)
- radioactive corrosion products in the drained heat transports and moderator systems
- small amounts of radioactivity in auxiliary systems, components and materials stored in the nuclear area of the facility

In 2010, the airborne emissions were 1.00E + 11 Bq for tritium and 1.89E + 05Bq for gross beta. There were no liquid effluent releases during 2010, but the average liquid releases between 2005 and 2009 were 2.80E+11Bq for tritium, 1.10E+07 Bq for carbon-14, 4.20E+06 Bq for gross beta and 2.30E + 06Bq for gross gamma.

5.1.7 AECL Nuclear Research and Test Establishment Facilities

AECL currently has two research facilities in Canada – one at AECL CRL in Ontario, which is operational, and the other at the AECL WL in Manitoba, which is currently undergoing decommissioning. (Annex 7 provides further information on decommissioning activities.) The radioactive wastes produced at these two sites are stored in waste management facilities at each site.

5.1.7.1 Chalk River Laboratories

The Chalk River Laboratories (CRL) site is located in Renfrew County, Ontario, on the shore of the Ottawa River, 160 kilometres northwest of Ottawa. The site, which has a total area of about 4,000 hectares, is situated within the boundaries of the Corporation of the Town of Deep River. The Ottawa River, which flows northwest to southeast, forms the northeastern boundary of the site. The Petawawa Military Reserve abuts the CRL property to the southeast. The Village of Chalk River, in the Municipality of Laurentian Hills, lies immediately to the southwest of the site.

The CRL site was established in the mid-1940s and has a history of various nuclear operations and facilities, primarily related to research. Most of the nuclear and associated support facilities and buildings on the site are located within a relatively small industrial plant site area, adjacent to the Ottawa River near the southeast end of the property. Various waste management areas for radioactive and non-radioactive wastes are located within the CRL property, along the southwest to northeast corridor. The CRL WMAs provide some fee-based waste management for institutions such as universities, hospitals and industrial users that have no other means to manage their wastes.

The CRL WMAs manage eight types of waste:

- **CRL nuclear reactor operation wastes**, which include fuel and reactor components, reactor fluid cleanup materials (e.g., resins and filters), trash and other materials, contaminated with radioactivity as a result of routine operations
- **CRL fuel fabrication facility wastes**, which include zirconium dioxide and graphite crucibles used to cast billets, filters, and other trash such as gloves, coveralls and wipes
- **CRL isotope production wastes**, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- **CRL isotope usage wastes**, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- **CRL hot cell operations wastes**, which include cleaning materials contaminated air filters, contaminated equipment and discarded irradiated samples
- **CRL decontamination and decommissioning wastes**, which include a variety of contaminated wastes with variable physical and chemical properties, as well as radiological properties
- **CRL remediation wastes**, which include solidified waste arising from the treatment of contaminated soil and groundwater
- **CRL and offsite miscellaneous wastes**, which include radioactive wastes that do not readily fall within the other classes of wastes described above (e.g., wastes from radioisotope laboratories and workshops, and other materials such as contaminated soil)

Liquid wastes, such as scintillation cocktails, radiological-contaminated lubricating oils, wastes contaminated by polychlorinated biphenyl (PCB) and isotope production wastes are also handled by the CRL waste management operations. Approximately 15 to 20 cubic metres of these types of waste are received into the WMAs per year, including wastes received from offsite waste generators, and are disposed of using commercial disposal services.

In addition, active aqueous wastes generated at the CRL site are treated at the Waste Treatment Centre (WTC). After treatment through a liquid waste evaporator, the treated effluent is released to the process sewer, which eventually discharges to the Ottawa River.

5.1.7.1.1 Waste Management Area A

The first emplacement of radioactive waste at the CRL site took place in 1946, into what is now referred to as Waste Management Area (WMA) A. These emplacements took the form of direct disposal of solids and liquids into excavated sand trenches. The scale of operations was modest and unrecorded until 1952, when the cleanup from the NRX accident generated large quantities of radioactive waste (which included the NRX calandria) that had to be managed quickly and safely. At that time, approximately 4,500 cubic metres of aqueous waste, containing 330 TBq (9,000 Ci) of mixed fission products, was poured into excavated trenches. This action was followed by smaller dispersals (6.3 TBq and 34 TBq of mixed fission products) in 1954 and 1955, respectively. The active liquid disposal tank received bottled liquids and, based on recorded observations, it is assumed the bottles were intentionally broken at the time of emplacement. The active liquid disposal tank was estimated to have received about 3.7×10^{13} Bq of strontium-90 and about 100 grams of plutonium. Waste is no longer accepted for emplacement in WMA A.

WMA A is on the western flank of a sand ridge. Three aquifers have been identified in the vicinity of WMA A: lower sand, middle sand and upper sand. Groundwater flow is initially to the south. As the aquifer sands thicken, the flow direction bends to the south-southeast. The wastes are believed to be above the water table in WMA A, but infiltration has transported contaminants into the groundwater, which creates a contaminated plume with an area extent of 38,000 square metres. Groundwater monitoring data collected to date have encountered total beta, gross alpha and strontium-90 in some of the sample wells. The groundwater plume is subject to periodic investigations to monitor migration of the plume and identify any deviations from expected conditions. Routine groundwater monitoring around the perimeter of WMA A (i.e., near the source of the plume) indicates stable or improving conditions, in that the contamination levels in the groundwater around the perimeter are generally either remaining at similar concentrations or gradually declining with time.

5.1.7.1.2 Waste Management Area B

Waste Management Area B was established in 1953 to succeed WMA A as the site for solid waste management. The site is located on a sand-covered upland, approximately 750 metres west of WMA A. Early waste storage practices for LLW were the same as those used in WMA A – namely, emplacement in unlined trenches and capped with sandy fill, in what is now the northern portion of the site. Additionally, numerous special burials of components and materials occurred.

Asphalt-lined and capped trenches were used for solid ILW from 1955 to 1959, when they were superseded by concrete bunkers constructed below grade but above the water table in the site's sand. The use of sand trenches in WMA B for LLW was discontinued in 1963 in favour of concrete bunkers and WMA C.

Concrete structures were used to store solid waste packages that did not meet sand trench acceptance criteria, but did not require a significant amount of shielding either. Early concrete bunkers were rectangular. These were superseded in 1977 by cylindrical structures, which are still used.

Cylindrical bunkers are formed by using removable metal forms to create corrugated reinforced concrete walls on a concrete pad. The maximum volume of a cylindrical concrete bunker is 110 cubic metres, but typical volumes of stored waste average about 60 cubic metres.

High-level wastes are also stored in WMA B, in engineered facilities known as tile holes. Tile holes are used to store radioactive material that requires more shielding than can be provided in concrete bunkers. Stored materials include irradiated fuel, hot cell waste, experimental fuel bundles, unusable radioisotopes, spent resin columns, active exhaust system filters and fission product waste from the molybdenum-99 production process. A new tile hole array at WMA B is being constructed and will go into operation in 2011.

There are several groundwater contaminant plumes extending from WMA B. One plume, on the east side, contains organic compounds (e.g., 1,1,1-trichloroethane, chloroform, trichloroethylene) that emanate from the unlined sand trenches at the north end of the site. Referred to as the solvent plume, this plume is subject to periodic investigations to monitor contaminant migration and identify any deviations from expected conditions. Routine groundwater monitoring around the northeast perimeter of WMA B (i.e., near the source of the plume) indicates stable conditions, in that the contamination levels in the groundwater at the perimeter remain at similar concentrations over time.

The second plume emanates from the northwest corner of the WMA B and is dominated by strontium-90. The source of this plume is the western section of the unlined sand trenches. Routine groundwater monitoring around the northwest perimeter of WMA B (i.e., near the source of the plume) indicates improving conditions, in that the contamination levels in the groundwater at the perimeter decrease over time. The effects of this contaminant migration are mitigated by a plume treatment system known as the Spring B Treatment Plant. This automated treatment facility removes strontium-90 from surface water and groundwater, where the plume flow path discharges to the biosphere in a series of springs. This treatment system removes a significant fraction of the strontium-90 activity in the influent. In 2010, the Spring B Treatment Plant treated 4.0E+05 litres of groundwater, removing 0.83 GBq of strontium and reducing input concentrations from 2,000 Bq/L (avg.) to 8.7 Bq/L (avg.).

Tritium is another contaminant observed in the groundwater at WMA B. Routine groundwater monitoring around the WMA indicates that the tritium contamination levels remain stable over time. A number of different types of waste storage structures within WMA B are considered the source of this contamination.

Figure 5.6 – Waste Management Area B at the CRL site

5.1.7.1.3 Waste Management Area C

Waste management area C was established in 1963 to receive low-level wastes with hazardous half-life less than 150 years, and wastes that could not be confirmed to be uncontaminated. Early operations consisted of emplacements in parallel trenches separated by intervening wedge-shaped stripes of undisturbed sand. In 1982, this system was changed to a “continuous trench” method to make more efficient use of the available space. In 1983, part of the original parallel trenches was covered with an impermeable membrane of high-density polyethylene.

The WMA C extension was constructed adjacent to the south end of WMA C in 1993 and began accepting wastes in 1995. As the continuous trench and/or its extension was backfilled and landscaped, material from the suspect soil stockpile was used for grading purposes to ensure that the surface of WMA C was suitable for travel by heavy equipment. Material placed in the soil stockpile satisfied specific acceptance criteria.

Besides the sand trench waste, inactive acid, solvent and organic liquid waste were also placed in specific sections of the trenches or in special pits located along the western edge of the area – although this practice was discontinued. Contaminated sewage sludge was also emplaced in the sand trenches until late 2004.

Since 2006, additional WMA C waste inventory, including sewage sludge, is restricted to interim above ground storage of sealed containers. The new Bulk Materials Landfill (BML) was completed in 2010, and the sewage sludge from WMA C was transferred to WMA J in late 2010. All other materials stored on the surface of WMA C are being removed in preparation for installation of an engineered cover over WMA C.

Groundwater monitoring data at WMA C indicates that a plume is emanating from this area. The primary contaminant is tritium, although organic compounds are also observed at elevated concentrations in some boreholes. Routine groundwater monitoring around the WMA C indicates that the tritium contamination levels remain stable over time.

5.1.7.1.4 Waste Management Area D

WMA D was established in 1976 to store obsolete or surplus equipment and components that are known or suspected to be contaminated but do not require enclosure (pipes, vessels, heat exchangers, etc.). It also stores closed marine containers holding drums of contaminated oils and liquid scintillation cocktails. These latter items pose more of a short-term chemical hazard than a radiological hazard. Mixed and hazardous wastes are now routinely disposed of through commercial service agreements.

The site consists of a fenced compound that encloses a gravel-surfaced area in which the components are placed. If the components have surface contamination, they must be packaged appropriately for the package to be free of surface contamination. The LLRWMO maintains two buildings for the storage of slightly contaminated material from non-AECL sites. All storage in WMA D is above ground. No burials are authorized in this area.

5.1.7.1.5 Waste Management Area E

WMA E is an area that received suspect and slightly contaminated soils and building materials, and other bulk soils and building debris from approximately 1977 to 1984. The waste materials were used to construct a roadway in WMA E, which was intended to become a waste management area for suspect contaminated materials. This site was to be used in place of WMA C for this type of waste. The plan to create this site was terminated when concerns were raised about the location.

5.1.7.1.6 Waste Management Area F

WMA F was established in 1976 to accommodate contaminated soils and slag from Port Hope, Albion Hills and Ottawa – all located in Ontario. The stored materials are known to contain low levels of radium-226, uranium and arsenic. Emplacement was completed in 1979, and the site is now considered closed, although it is subject to monitoring and surveillance to assess possible migration of radioactive and chemical contaminants.

5.1.7.1.7 Waste Management Area G

WMA G was established in 1988 to store the entire inventory of irradiated fuel from the NPD prototype CANDU power reactor in above ground concrete canisters. Two additional concrete canisters were constructed on the existing concrete support pad to store calcined waste, which will be created by the processing of radioisotopes separated in the new processing facility at CRL. These two canisters are in the extended shutdown state, as are the other Dedicated Isotope Facility systems.

5.1.7.1.8 Waste Management Area H

WMA H began operating in 2002. It is the location for the modular above ground storage (MAGS) structures and the shielded modular above ground storage (SMAGS) structures. Dry low-level wastes are packaged and, in some instances, compacted in steel containers prior to storage in MAGS and SMAGS. The first of six SMAGS structures has been completed, and a licence amendment was issued by the CNSC to allow operation. Construction of the second SMAGS was completed in 2010. An additional four SMAGS structures will be built at intervals of three to four years. These structures will provide storage capacity for the next 20 to 30 years.

Figure 5.7 – MAGS structure in Waste Management Area H

5.1.7.1.9 Waste Management Area J

Construction of the new Bulk Materials Landfill (BML) located in WMA J at CRL was completed in 2010. The BML is designed for the long-term management of the dewatered sewage sludge produced at the Sewage Treatment Plant at CRL. The facility consists of an engineered landfill lined with impermeable layers of geotextile and semi-permeable layers of clay. The leachate from the waste is collected and sent for further processing following analysis. Once all phases (a total of four) are complete, the BML will be able to accommodate 100 years of sewage sludge generated at CRL and will ensure proper long-term management of the waste in an environmentally responsible manner. Dewatered sewage sludge has been stored in roll-off containers in WMA C since 2004, and the contents of these containers were safely emplaced into the BML in late 2010.

5.1.7.1.10 Liquid dispersal area

Development of the liquid dispersal area commenced in 1953 when the first of several infiltration pits was established to receive active liquids via pipeline from the NRX rod bays. The pits are located on a small dune in an area bounded on the east and south by wetlands and by WMA A on the west.

Reactor Pit #1 was a natural closed depression used between 1953 and 1956 for radioactive aqueous solutions. Dispersals included an estimated 74 TBq of strontium-90, along with a wide variety of other fission products, and approximately 100 grams of plutonium (or other alpha emitters expressed as plutonium). Between 1956 and 1998, the pit was backfilled with solid materials that included contaminated equipment and vehicles previously stored in WMA A plus potentially contaminated soils from excavations in the active area.

Reactor Pit #2 was established in 1956 to succeed Reactor Pit #1. A pipeline was used to transfer NRX rod bay water. Samples of water from the holding tank were analyzed for soluble and total alpha, soluble and total beta particles, strontium-90, tritium, cesium-137 and uranium.

The chemical pit was also established in 1956 to receive radioactive aqueous wastes from active laboratories on site (other than the reactors). Its construction is similar to that of Reactor Pit #2 – namely, an excavation backfilled with gravel and supplied by a pipeline.

The last facility in the liquid dispersal area is the Laundry Pit, which was installed in 1956. As its name implies, the Laundry Pit was used for waste water from the active area laundry and the decontamination centre but was only employed for that purpose for a year. The recorded inventory is 100 GBq of mixed fission products and 0.1 g of plutonium-239.

The liquid dispersal area has not been used since 2000, and there are no plans for future use of this area. Two groundwater plumes emanate from the liquid dispersal area, as would be expected for dispersal facilities. One plume from the reactor pits contains tritium as the only nuclide released in significant quantities. Routine groundwater monitoring around the reactor pits shows that the tritium contamination levels have significantly decreased since dispersal operations were halted. This groundwater monitoring shows the presence of other radiological contaminants but at low concentrations that are declining over time.

The second plume emanates from the chemical pit, with the contaminant of primary concern being strontium-90. Routine groundwater monitoring around the chemical pit indicates improving conditions – in that the contamination levels in the groundwater are decreasing. The effects of this contaminant migration are mitigated by a plume treatment system known as the chemical pit treatment plant. This pump and chemical treatment facility removes strontium-90 from groundwater collected from four collection wells that are spaced across the width of the plume near the pit. This treatment system removes a significant fraction of the strontium-90 activity in the influent. In 2010, the chemical pit treatment plant treated 6.0E+05 litres of groundwater, removing 0.95 GBq of strontium-90 and reducing input concentrations from 1.600 Bq/L (avg.) to 8.3 Bq/L (avg.).

5.1.7.1.11 Acid, chemical and solvent pits

Three small pits are located north of WMA C and are collectively known as the acid, chemical and solvent (ACS) pits. Constructed in 1982 and in operation until 1987, the pits were individually used for inactive chemical, acid and solvent wastes. The acid pit received about 11,000 litres of liquid wastes (hydrochloric, sulphuric and nitric acids) and a small amount of solid wastes (potassium carbonate powder, acid batteries and citric acid). The solvent pit received approximately 5,000 litres of mixed solvents, oils, varsol and acetone, while the chemical ACS pit received smaller volumes of wastes.

5.1.7.1.12 Waste Tank Farm

The Waste Tank Farm contains seven underground stainless steel tanks that store high-and intermediate-level radioactive liquid waste. The first series of three tanks contain ion exchange regeneration solutions from fuel rod storage bays. One of the three tanks is empty and provides a transfer destination for the contents of either of the other two tanks should they develop a leak.

The second series of four tanks contains acid concentrate, mainly resulting from fuel reprocessing between 1949 and 1956. The last transfer of solutions to any of the storage tanks at the waste tank farm occurred in 1968; no solutions have been added since then. One of the four tanks is empty and serves as a backup in the event that one of the other tanks leaks.

5.1.7.1.13 Ammonium Nitrate Decomposition Plant

The Ammonium Nitrate Decomposition Plant was built in 1953 and was used to decompose the ammonium nitrate in liquid wastes from the fuel processing plant. The plant was shut down in 1954 following several leak events (releases) and was subsequently dismantled with much of the equipment being buried *in situ*.

As would be expected for this type of facility, a contaminant plume emanates from the nitrate plant compound, with the contaminant of primary concern being strontium-90. Routine groundwater monitoring at the perimeter of the compound indicates stable conditions – in that contamination levels in the groundwater remain stable over time.

The effects of this contaminant migration are mitigated by a plume treatment system, known as the wall and curtain treatment system, which operates passively by using a clinoptilite zone installed in the ground next to an impermeable barrier that extends across the plume flowpath. This passive treatment system removes a significant fraction of the strontium-90 activity in the influent. In 2010, the system treated 1.27E+07 litres of groundwater, preventing the discharge of 4.7 GBq of strontium-90 and reducing input concentrations from 366 Bq/L (avg.) to less than 1 Bq/L (avg.). Since 1998, the treatment system has prevented the discharge of 5.5E+10 Bq of strontium-90.

5.1.7.1.14 Thorium Nitrate Pit

In 1955, about 20 cubic metres of liquid waste from a uranium-233 extraction plant on the CRL site was discharged into a pit. The solution contained 200 kilograms of thorium nitrate, 4,600 kilograms of ammonium nitrate, 10 grams of uranium-233, and 1.85 E+11 Bq each of strontium-90, cesium-137 and cerium-144. The pit was filled with lime to neutralize the acid and precipitate the thorium, and was then covered with soil.

5.1.7.1.15 Glass block experiments

In 1958, a set of 25 hemispheres of glass (two kilograms each) of mixed fission products was buried below the water table as part of a program to investigate methods for converting high-level radioactive liquid solutions into a solid. A second set of 25 blocks of aged fission products was buried in 1960. The burials were designed to test how well the glassified wastes would retain the incorporated fission products if exposed to leaching in a natural groundwater environment. The glass blocks have since been recovered and transferred to secure storage in the waste management areas.

5.1.7.1.16 Bulk storage area

The bulk storage area was used prior to 1973 to store large pieces of equipment from the control area. Significant cleanup efforts are now underway in this area.

5.1.7.1.17 Emissions

The operation of the CRL WMAs results in the release of radioactive and non-radioactive contaminants into the environment. Most of the existing releases are historic. They result from discontinued practices such as dispersal of intermediate-level liquid waste and sand trench disposal of intermediate solid and liquid wastes. The releases contaminated onsite land, groundwater and surface water, and also resulted in offsite releases of contaminants to the Ottawa River.

The contaminant concentrations in offsite water bodies, however, are well below the standards set for both drinking water and the protection of aquatic life. DRLs have been established for airborne and liquid effluents released from the CRL site. CRL has developed administrative levels set at a fraction of the DRL and close to the normal operating levels. These administrative levels are used to provide timely warning that a higher than expected release has occurred and that the situation will be investigated promptly.

5.1.7.1.18 CRL Waste Treatment Centre (WTC)

The CRL Waste Treatment Centre (WTC) treats wet solid wastes and liquid wastes from Chalk River Laboratories facilities that are contaminated or suspected of being contaminated by radioactivity. The WTC also treats small volumes of liquid radioactive waste received by CRL from offsite waste generators.

The wet solid wastes are baled (after compacting, if possible) and transferred for storage in concrete bunkers in WMA B. Between 50 and 150 bales measuring 0.4 cubic metres are produced per year. In addition to those quantities, the WTC generates solid waste internally. This waste includes disposable clothing, paper and cleaning materials, and is compacted (where possible), baled and stored in WMA B bunkers. Liquid waste is treated in variable amounts per year, ranging from 1,500 and 4,000 cubic metres per year. These wastes consist of decontamination centre waste, chemical active drain system waste and reactor active drain waste. Treatment facilities include a liquid waste evaporator (LWE), which concentrates the waste, and a liquid waste immobilization system (LWIS), which immobilizes the concentrated liquid in a bitumen matrix in drums that are then stored in WMA B.

Atmospheric releases of radionuclides from the WTC occur via roof vents. Roof vents are monitored for such things as particulate gross alpha activity, particulate gross beta activity, tritium oxide and iodine-131. Treated liquid effluent from the WTC is discharged to the process outfall after sampling for gross alpha, gross beta and tritium oxide. The liquid effluent is also regularly monitored for suspended solids, total phosphorus, nitrates, pH, conductivity, organic carbon, chemical oxygen demand, solvent extractable, metals, volatile organics and semi-volatiles.

5.1.7.1.19 Whiteshell Laboratories

Whiteshell Laboratories is a nuclear research and test establishment located in Manitoba on the east bank of the Winnipeg River, about 100 kilometres northeast of Winnipeg. Comprising a number of nuclear and non-nuclear facilities and activities, the major facilities on site include the Whiteshell Reactor-1 (WR-1), the shielded facilities, research laboratories, and liquid and solid radioactive waste management areas and facilities, including the Concrete Canister Storage Facility (CCSF) complex for the dry storage of research reactor fuel. WL is currently undergoing decommissioning. (Annex 7.1 provides further information on these decommissioning activities.)

The one waste management area (WMA) is located approximately 1.5 kilometres northeast of the main WL site (2.7 kilometres by road). The area is approximately 148 by 312 metres, representing 4.6 hectares. The WMA, which has been in operation since 1963, provides storage for low- and intermediate- level radioactive wastes. The following facilities are located within the WMA:

- an organic incinerator
- LLW storage bunkers
- LLW unlined earth trenches
- LLW/ILW storage bunkers
- ILW in-ground concrete bunkers
- HLW/ILW in-ground concrete standpipes (similar to the CRL tile holes described in section 5.1.7.1.2)
- liquid waste storage tanks

The Concrete Canister Storage Facility, described in annex 4.5.14, is located next to the WMA.

The WL site is near the northeast boundary of the plains area of Manitoba. The WMA site is located about 10 metres above the normal Winnipeg River level, and is well above any recorded flood levels (river levels are also controlled by nearby hydroelectric dams). The Winnipeg River flows through an area underlain by granite and granitic gneisses of the Precambrian Shield. The area is the transitional zone between the coniferous forest of the Canadian Shield and the aspen parklands of the Prairies.

The WMA soil cover consists of 5.5 metres of highly plastic medium-brown clays above 4.6 metres of medium-plastic light-brown clay. The upper clay exhibits pronounced volume changes depending on moisture content and is susceptible to frost heave. Both clays are very impermeable. A stable glacial till deposit underlies the entire area at a depth of approximately 10.5 metres. The glacial till is compact and has a high bearing strength. The granitic Lac du Bonnet batholith lies below the till at a depth of approximately 12 metres.

Hydrologically, the WMA is located in a groundwater discharge zone, which means that the groundwater flow is predominantly upward from the underground aquifer to the surface. The depth of WMA excavations is limited to ensure that the impermeable clay layers are not penetrated.

The incineration facility is used to incinerate waste laboratory solvents, and was formerly used to incinerate the organic coolant waste arising from the operation, shutdown and cleanup of the WR-1 reactor.

From 1963 to 1985, LLW was buried in unlined trenches approximately 6 metres wide by 4 metres deep, and with lengths up to 60 metres. Trenches were covered with at least 1.5 metres of excavated material after they were filled. There are 25 filled trenches located in the WMA. Trench storage of LLW was discontinued in 1985 in favour of engineered above ground LLW storage bunkers. The LLW bunkers are constructed of concrete, with overall dimensions of 26.4 metres long by 6.6 metres wide by 5.2 metres high, with a wall thickness of 0.3 metres, which comes to a total of 805 cubic metres of storage space each. Future WMA plans are to construct shielded modular above ground storage (SMAGS) structures (discussed in section 5.1.7.1.8) for the storage of future decommissioning LLW wastes.

In-ground or partially in-ground bunkers are used to store ILW wastes. Possessing a variety of dimensions, these bunkers are constructed of reinforced concrete, with a wall thickness of 0.25 metres. In-ground, concrete standpipes (similar to the CRL tile holes described in section 5.1.7.1.2) were used at WL from 1963 to the mid-1970s (when the use of above ground concrete canisters commenced) to provide storage for HLW/ILW packages. The standpipes are constructed of reinforced concrete, 0.2 metres thick, with a 0.3-metre integral base lined with galvanized steel pipes. A removable concrete shielding plug, about 0.9 metres thick, provides access.

5.1.8 Monserco Limited

Monserco Limited, in operation since 1978, operates a radioactive waste processing facility in Brampton, Ontario. In this facility, radioactive wastes (typically from hospitals, universities, research institutes and industrial firms) are sorted and packaged. Wastes may be processed on site by minimization techniques, and by delay and decay. Monserco also ships low-level contaminated waste, or slightly contaminated metals, directly to the United States for incineration or recycling.

The company in the United States may return the material to Monserco unchanged if the company decides it cannot be processed. The resultant ash from incineration is returned for disposal to Monserco. Monserco then ships the ash to CRL radioactive waste management facility for long-term management or returns it to the original client (waste producer). Levels of radionuclides monitored from the exhaust stack have always been less than specified investigation levels.

Monserco also handles spent sealed sources and used liquid scintillation vials and cocktails. Sealed sources are shipped to AECL’s CRL radioactive waste facility for the long-term management. Monserco also operates a radioactive waste and source pickup service in Montreal, Quebec. These wastes and sources are transported to the Brampton facility for processing and shipment.

5.1.9 Cameco Blind River Refinery/Port Hope Conversion Facility/Port Hope Fuel Fabrication Facility waste and by-product management

Conserving resources and recycling of waste materials is an important part of operations – for both environmental and economic reasons. At the Cameco Blind River Refinery, nitrogen oxide air emissions are recovered and converted to nitric acid for reuse. At the Port Hope Conversion Facility, ongoing recycling programs include in-plant recovery of hydrofluoric acid from air emissions for recycling, and the creation and sale of an ammonium nitrate by-product for use as commercial fertilizer. At the Port Hope Fuel Fabrication Facility, scrap generated from fuel pellet manufacturing is recovered.

There are several process streams in the refining and conversion processes that result in materials that contain economically attractive quantities of natural uranium. These recyclable products are suitable for use as alternate feed for uranium mills and are sent on for further processing to recover their uranium content.

The Blind River and Port Hope waste management programs collect, clean, monitor and, if necessary, cut to acceptable sizes all scrap material to the extent practicable before releasing it to commercial recycling agencies. Material that cannot be recycled, or does not meet strict release guidelines, is either compacted or incinerated to reduce volume, then drummed for storage on site or, in some instances, processed further and combined with the uranium-bearing recyclable products noted above. The stored non-recyclable material that cannot be cleaned is primarily insulation, sand, soil and some scrap metal. These materials will remain in storage until future recycling or disposal routes are identified.

Cameco is the licensee for two large historic waste management facilities in the Port Hope area: the Welcome Waste Management Facility in the Municipality of Port Hope and the Port Granby Waste Management Facility in the Municipality of Clarington. These facilities, which were established in 1948 and 1955 respectively, together contain roughly 1 million cubic metres of low-level radioactive waste and contaminated soils. Both facilities have been closed to any additional waste emplacements for many years, pre-dating the formation of Cameco. The long-term management of these facilities will be addressed through the Port Hope Area Initiative. In addition, the Government of Canada has agreed to accommodate 150,000 cubic metres of wastes from the Cameco Port Hope Conversion Facility, arising from early operations of that site, also within the framework of the Port Hope Area Initiative. These wastes include drummed radioactive wastes, contaminated soils and decommissioning wastes.

Figure 5.8 – Cameco Bind River Refinery

Annex 6 – Uranium Mine and Mill Facilities

6.1 Background

Owned by Eldorado Gold Mines (a private company), the first radium mine in Canada began operating in 1933 at Port Radium in the Northwest Territories. Uranium ore concentrate was sent to Port Hope, Ontario, where radium was extracted. At that time, uranium had little or no commercial value, and the focus was on the ore's radium-226 content. The Port Radium Mine produced ore for radium until 1940 and reopened in 1942 to supply the demand for uranium from defence programs in the United Kingdom and the United States.

In 1943, Canada, the United Kingdom and the United States instituted a ban on private exploration and development of mines to extract radioactive materials. The Government of Canada also nationalized Eldorado Gold Mines in 1943, and established the federal Crown Corporation Eldorado Mining and Refining, which had a monopoly on all uranium prospecting and development. Canada subsequently lifted the ban on private exploration in 1948.

In 1949, Eldorado Mining and Refining began the development of a uranium mine in the Beaverlodge area of northern Saskatchewan, and, in 1953, milling the ore on site commenced. The Gunnar and Lorado uranium mines and mills began operating in the same area in 1955 and 1957, respectively. Several other small satellite mines also opened in the area in the 1950s, sending ore for processing to either Eldorado or the Lorado mills.

In Ontario, 15 uranium mines began production between 1955 and 1960 in the Elliot Lake and Bancroft areas. Ten of the production centres in the Elliot Lake area and three in the Bancroft area produced tailings. The last of these mines ceased operations and was decommissioned in the 1990s. (These former mining and milling sites are discussed in annex 8.)

At present, all active uranium mines are located in Saskatchewan. Uranium mining is ongoing at Rabbit Lake, McClean Lake and McArthur River, and waste rock is currently being managed (see annex 7.6). The Cigar Lake mine is currently under construction. Uranium mills and operational tailings management facilities exist at McClean Lake, Rabbit Lake and Key Lake. Non-operational tailings management areas are located at Rabbit Lake, Key Lake and Cluff Lake. (See figure B.3 for the locations of operating and inactive uranium mining and milling sites in Canada.)

6.2 Province of Saskatchewan

Saskatchewan is the only province in Canada with operating uranium mines. In the past, mine and mill operators have requested harmonization in areas such as inspections and reporting requirements, involving the Saskatchewan Ministry of Environment, Saskatchewan Ministry of Advanced Education, Employment and Labour and the CNSC. An agreement currently exists between the CNSC and the Government of Saskatchewan to encourage greater administrative efficiency in regulating the uranium industry. The agreement lays the groundwork for the two groups to coordinate and harmonize their respective regulatory regimes.

6.3 Operational tailings and waste rock management strategy

6.3.1 Overview

About one-quarter of the world's primary uranium production comes from uranium deposits in the Athabasca Basin in northern Saskatchewan. These deposits include:

- the current production sites of Rabbit Lake, Key Lake, McClean Lake and McArthur River
- sites of planned future production at Cigar Lake, Midwest and Millennium

The newer sites include the highest grade uranium ore bodies in the world (at McArthur River and Cigar Lake), averaging about 20 percent uranium. Some of these ores in the Athabasca Basin have high nickel and arsenic content (up to five and one percent, respectively), which introduces additional considerations into the management of tailings and waste rock resulting from mining and milling these ores.

Past production centres, which are no longer actively producing uranium, include:

- the Uranium City district mines and mills of Gunnar, Lorado and Beaverlodge
- the decommissioned Cluff Lake site, where production was terminated at the end of 2002

6.3.2 Tailings management strategy

Mills with tailings management facilities (TMFs) are located at Rabbit Lake, Key Lake and McClean Lake. There is no mill at the McArthur River mine, because the ore is transported to Key Lake for processing. Similarly, mills are not planned at either Cigar Lake or Midwest. Ores will be transported to McClean Lake for initial processing, with final processing activities for Cigar Lake uranium solution to be divided between McClean Lake and Rabbit Lake.

All three sites currently use the same basic approach: previously mined open pits have been converted to engineered disposal systems for tailings. Although there are certain differences in detail, two basic principles underlie the containment of the tailings and their potential radionuclide and heavy metal contaminants:

- **Hydraulic containment during the operational phase**: As a result of dewatering during mining, the water level in the pit at the start of tailings placement is well below the natural groundwater level in the area. This dewatering creates a cone of depression in the groundwater system, resulting in the natural flow being directed toward the pit from every direction. This hydraulic containment feature is maintained throughout the operational life of the tailings facility by maintaining the pit in a partially dewatered state. Since water has to be pumped continuously from the pit, current water treatment technology results in high-quality effluent suitable for discharge to surface water.

- **Passive long-term containment, using the hydraulic conductivity contrast between the tailings and their surrounding geologic materials**: Long-term environmental protection is achieved through control of the tailings' geochemical and geotechnical characteristics during tailings preparation and placement. This control creates future passive physical controls for groundwater movement in the system, which will exist after the decommissioning of operational facilities.

The tailings contain a significant fraction of fine-grained materials (chemical precipitates formed during the ore processing reactions). Tailings consolidation occurs during operation and will be completed during the initial decommissioning steps. The outcome is that the consolidated tailings have a very low hydraulic conductivity. When surrounded by a material with a much higher hydraulic conductivity, the natural groundwater path is around the impermeable plug of tailings.

Potential contaminant transport from the tailings is controlled by diffusion from the outer surface of the tailings mass; this is a slow process, with minimal advective contaminant flux, and a consequently high level of groundwater protection. Potential contaminant transport is further minimized by the geochemical properties of the tailings. Reagents are added during tailings preparation to precipitate dissolved elements such as radium, nickel and arsenic to stable insoluble forms, which enables long-term concentrations in the tailings' pore water to remain low.

A constructed permeable zone around the tailings may be installed (in the form of sand and gravel) while the tailings are placed, as is done at Rabbit Lake. Alternatively, the permeable zone may exist naturally, as is the case at McClean Lake and Key Lake. This natural permeable zone allows for subaqueous placement of tailings, which has advantages in terms of radiation protection and prevention of ice formation with the tailings mass. At McClean Lake, the sandstone formation surrounding the tailings has a hydraulic conductivity contrast of more than a factor of 100 relative to the tailings.

Extensive characterizations of the natural geologic formations and groundwater system, as well as the tailings' properties, are used to acquire reliable data for the computer models used to predict long-term environmental performance based on the fundamental principles governing the system. This performance will be confirmed during the life of the operation and through the post-decommissioning monitoring, which will be continued until stable conditions are achieved and for as long as desired thereafter.

Section 6.4 of this annex provides site-specific details for the Athabasca Basin tailings facilities. The development of these facilities began nearly 30 years ago, and their favourable operational experience and design evolutions – based on that experience – provide confidence in their performance, both now and in the future.

6.3.3 Waste rock management strategy

In addition to tailings from the milling process, uranium production results in large volumes of waste rock being removed before miners can access and mine the ore. The segregation of these materials according to their future management requirements is now a core management strategy. Material excavated from open pits is classified into three main categories: clean waste (both overburden and waste rock), special waste (containing sub-economic mineralization), and ore.

6.3.3.1 Clean waste

This term refers to waste materials that are benign with respect to future environmental impact and that can be disposed in surface stockpiles or used on site for construction purposes. These different types of materials are described below:

- **Surficial soils with high organic content**: When practical depths are present, a thin layer of surface soil is stripped and separately stockpiled for replacement as the future surface soil layer during site reclamation activities.

- **Overburden soils**: A few metres of glacial till (typically around 10 metres) are present before the underlying sandstone rock is encountered. This material is either stockpiled separately for future use as fill during reclamation or used as the base for clean waste rock stockpiles.

- **Waste rock**: The Athabasca Basin is a sandstone basin that overlies the Precambrian Shield basement rock. The sandstone depth is shallow around the Basin perimeter, and increases to as much as 1,200 metres toward the centre of the Basin. Depths up to about 200 metres are practical for open pit mining, so that the sites at and near the Basin perimeter primarily feature this mining method.

- **Large volumes (depending on the depth) of unmineralized sandstone**: This material is mined to reach the ore body and is stockpiled on the surface near the pit, and the stockpiles, minus whatever amount has been used for construction purposes, are subsequently reclaimed and vegetated. As mining approaches the ore body, a zone of altered (partially mineralized) rock is present. Both this halo of altered rock, and the basement rock below it, may contain small amounts of uneconomic uranium and/or various metals such as nickel or arsenic.

In some instances, because it contains sulphide, there is the potential for acidic leachate when the rock is exposed to moisture and oxygen from the atmosphere. This phenomenon of acid rock drainage (ARD) is common to many types of mining. Sophisticated methods are now available to segregate those amounts of waste rock, which represent a potential environmental risk – due to either ARD and/or dissolved contaminants in leachate – if left on the surface for the long term.

This material, referred to as “special waste”, is managed differently from the environmentally benign waste rock. The segregation methods include borehole logging, collection and analyses of borehole samples prior to mining, and analyses of samples during mining. In addition to a retrospective laboratory analysis, qualified geological interpretation of the mining faces reinforced with real-time analyses made with an ore radiometric scanner are used to segregate each truckload – according to uranium content – as ore, special waste or waste rock, and direct it to the appropriate stockpile.

Since uranium ore deposits are in secular equilibrium with its progeny, good correlations can be made between radioactivity of the ore and its uranium content. The latest technical development is the application of a handheld, portable scanner that uses X-ray fluorescence to perform field characterization for arsenic. This method has recently been tested at McClean Lake, and became operational for the mining of the most recent open pit there.

Volumes of waste rock are much smaller for underground mining, but the same general considerations apply. Clean waste materials are stockpiled and used for construction or reclamation purposes. Any surplus amounts can be stockpiled, and the stockpiles reclaimed and vegetated. Special waste is either used as aggregate and underground backfill, or is returned underground to other mined areas or transferred to sites with mills or mined-out open pits.

6.3.3.2 Special waste

As noted above, waste rock near ore bodies is potentially problematic. Because it has some halo mineralization around the ore deposit, it therefore potentially generates acid in some instances and/or becomes a source of contaminated leachates when exposed to an atmosphere containing oxygen. Disposal of this special waste in mined-out pits and flooding, to cut off the oxygen supply from the atmosphere and stop oxidation reactions, is now a widely recognized solution, provided that the pit is suitable for the long-term management of the risk. If not, engineered covers present an *in situ* solution to impede the interaction of oxygen and moisture with the special waste. As it is mined, the special waste is segregated and temporarily stored on the surface on lined pads, with drainage collection systems for collection and treatment of runoff water. After mining activities have ended, the special waste is backhauled into the mined-out pit (see figure 6.4). At a large pit with two or more zones, the direct transfer of special waste from the mining zone to a mined-out zone is practical. Typically, any waste material with uranium content greater than either 300ppm triuranium octoxide (U_3O_8) or 0.025 percent (250ppm) uranium is classed as special waste.

Similar to tailings facilities, extensive characterizations of natural geologic formations, groundwater system and waste rock properties are used to acquire reliable data for the computer models used to predict long-term performance. This performance is confirmed by post-decommissioning monitoring, which will be continued until stable conditions are achieved, and for as long as desired thereafter.

6.3.3.3 Ore

Typically, all material grading greater than 0.085 percent uranium has been classified as ore and stockpiled to be fed to the mill. The cut-off grade for the mill may vary depending on market conditions for uranium.

6.3.4 Waste water treatment and effluent discharge

All mine and mill facilities provide water treatment systems to manage contaminated water collected from their tailings disposal facilities, as well as water inflows collected during open pit or underground mining, and problematic seepages from waste rock piles. The treatment processes vary from flow through to batch discharge systems and largely rely on conventional physical settling and chemical precipitation methods found in the general metal mining industry. Typically, these sites have a single point of final discharge into the receiving environment; however, the Key Lake operation has two discharge points. Uranium mines and mills also treat for radionuclides. Specifically, focus is placed on treatment for radium-226, using barium chloride precipitation. In the case of Rabbit Lake, additional treatment has been incorporated to reduce uranium levels in effluent discharge. The quality of effluent is controlled by regulatory approved codes of practice, as well as by effluent quality regulation.

In northern Saskatchewan, effluent quality regulation ensures that Saskatchewan Surface Water Quality Objectives (SSWQO) are maintained in the receiving environment downstream of the operations. If the effluent is found acceptable (i.e., in compliance with regulatory limits), it is released to the environment. Otherwise, the effluent is recycled to the water treatment plants or mill for reprocessing. In 2010, the total volume of treated waste water that met SSWQO requirements and was subsequently discharged to the receiving environment was 14,999,068 cubic metres from five active uranium mining and or milling sites in northern Saskatchewan.

Table 6.1 – Active uranium mining/milling site waste water volumes meeting SSWQO requirements in 2010

Active uranium mining and or milling site in northern Saskatchewan	Total volume of waste water that met SSWQO Requirements
AREVA – McClean Lake	2,082,553 m^3
Cameco – Rabbit Lake	4,468,584 m^3
Cameco – Cigar Lake	393,219 m^3
Cameco – McArthur River	1,870,816 m^3
Cameco – Key Lake (Horsefly Lake)	4,978,504 m^3
Cameco – Key Lake (Wolf Lake)	1,205,392 m^3
Total	**14,999,068 m^3**

To reduce the impact of effluent discharges to the receiving environment, the uranium mining and milling facilities have developed ecological risk models to evaluate the impacts of treated effluent discharges. The prime concerns resulting from this work are chronic, not acute, and relate to control of metals, not radionuclides. The control of nickel and arsenic loading has been a core focus; however, more recently, attention has turned to molybdenum and selenium loadings. This broader spectrum of contaminants of concern has led to efforts to develop and install the next generation of treatment technology based on the use of membrane technology.

As such, a large reverse osmosis plant has been installed at the Key Lake facility. Additional application of this technology is expected at other northern Saskatchewan facilities, particularly for mining as opposed to milling effluent components, in which the low ionic content of the effluent makes membrane technology less difficult.

6.4 Waste management facilities

6.4.1 Key Lake

6.4.1.1 Tailings management

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

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

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

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

Through the use of a tremie pipe system, tailings are deposited under the water cover, providing benefits in terms of placement and attenuation of radon emissions. In this system, tailings are placed in the mined-out pit by using what is termed “a natural surround” containment strategy. Tailings and residual water on the surface are removed during tailings placement, both by the drainage blanket and by surrounding groundwater wells. The residual water extracted from the tailings mass is collected for treatment. The consolidated tailings form a low-permeability mass relative to the higher-permeability area surrounding the tailings.

After decommissioning, groundwater will follow the path of least resistance (i.e., around the tailings rather than through them), which minimizes environmental impacts. At the end of 2010, the Deilmann TMF contained 4,082,300 tonnes (dry weight) of tailings.

Figure 6.1 – Deilmann Tailings Management Facility at Key Lake

6.4.1.2 Waste rock management

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

To reduce the decommissioning liability associated with the Deilmann North waste rock pile, approximately 1.3 million cubic metres of nickel-rich waste rock were excavated and disposed of in the Gaertner pit.

6.4.1.3 Contaminated industrial wastes

Contaminated industrial wastes are either recycled or landfilled in the AGTMF. Leachates from these materials are collected by the AGTMF’s seepage collection system and returned to the mill for process make-up water, or treated and released to the environment. It is estimated that 7,380 cubic metres of uncompacted waste were placed at this site in 2010.

6.4.2 Rabbit Lake

6.4.2.1 Tailings management

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

The original Rabbit Lake open-pit mine was converted to a tailings management facility in 1986 by using pervious surround technology. Since its commissioning, the Rabbit Lake in-pit tailings management facility (RLITMF) has been used as a tailings repository for ore from the Rabbit Lake, B-zone, D-zone, A-zone and Eagle Point mines. At the end of 2010, the RLITMF contained 7,438,860 tonnes (dry weight) of tailings.

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

Figure 6.2 (a) – Rabbit Lake In-pit Tailings Management Facility

Figure 6.2 (b) – Rabbit Lake In-pit Tailings Management Facility

6.4.2.2 Waste rock management

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

Current projections are that no waste rock will remain on the surface at Eagle Point after the mining and backfilling of mined-out stopes is complete. The D-zone waste rock pile consists of 200,000 cubic metres of primarily lake-bottom sediments and organics. This material may eventually be used as cover material for the B-zone waste rock pile. The A-zone waste-rock pile (28,307 cubic metres of clean waste) has been flattened and contoured. The B-zone waste pile contains an estimated 5.6 million cubic metres of waste material stored on a pile covering an area of 25 hectares. Contaminated runoff and seepage from this pile is collected and treated prior to release into the environment. All the special waste from the A-zone (69,749 cubic metres), B-zone (100,000 cubic metres) and D-zone (131,000 cubic metres) open-pit mines was returned to the pits and covered with layers of waste rock and/or clean till before the mined-out pits were allowed to flood.

There are approximately 6.7 million cubic metres of predominantly sandstone, with some basement rock and overburden tills, stored on the West #5 waste rock pile adjacent to the RLITMF. Mineralized waste is stored on four piles (1.8 million cubic metres) adjacent to the Rabbit Lake Mill. Runoff and seepage from these areas are collected in the RLITMF.

6.4.2.3 Contaminated industrial wastes

Radioactive and other contaminated materials from the Eagle Point Mine and Rabbit Lake Mill are disposed of in the contaminated landfill site located on the west side of the RLAGTMF. It is estimated that 4,740 cubic metres of uncompacted waste were placed at this site in 2010.

6.4.3 McClean Lake

6.4.3.1 Tailings management

McClean Lake was the first new uranium mill built in North America in 15 years. The mill and TMF are state-of-the-art efforts in worker and environmental protection for processing high-grade uranium ore. Open-pit mining of the initial ore body (John Everett Bates – JEB) began in 1995. After the ore was removed and stockpiled, the pit was developed as a TMF. The design of the TMF has been optimized for performance, both during operation and for the long term, by employing key features such as:

- production of thickened tailings within the mill process (addition of lime, barium chloride and ferric sulphate) to remove potential environmental contaminants from solution and yield geotechnically and geochemically stable tailings
- transport of the tailings from the mill to the TMF through a continuously monitored pipe-in-pipe containment system
- final sub-aqueous tailings placement within the mined-out JEB pit for long-term, secure containment in a belowground facility
- use of natural surround as the optimum approach for long-term groundwater diversion around the consolidated tailings plug
- subaqueous tremie placement, from a floating barge, of the thickened tailings below a water cover in the pit; this method minimizes segregation of fine and coarse material, prevents the freezing of the tailings and enhances radiation protection due to the attenuation of radon emissions by the water cover
- use of dewatering wells around the entire pit perimeter to minimize clean groundwater inflow while maintaining hydraulic containment during operations – that is, the water levels are maintained such that groundwater flow is toward the pit
- a bottom filter drain feeding a dewatering drift and raise wells to allow collection and treatment of discharged pore water during tailings consolidation
- recycling of pit water by a floating barge and a pipe-in-pipe handling system
- complete backfilling of the pit, upon decommissioning, with clean waste rock and a till cap

At the end of 2010, the JEB TMF contained 1,826,000 tonnes (dry weight) of tailings.

Figure 6.3 (a) – JEB Tailings Management Facility at McClean Lake

Figure 6.3 (b) – JEB Tailings Management Facility at McClean Lake

6.4.3.2 Waste rock management

Open-pit mining at McClean Lake has progressed from one pit to the next, and has included the JEB, Sue C, Sue A, Sue E and Sue B pits. The Sue B pit was the last open pit and mining was completed on November 26, 2008. Since the completion of Sue B, open pit mining has not occurred at McClean Lake.

Figure 6.4 (a) – Sue mining area at McClean Lake

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

Figure 6.4 (b) –Sue mining area at McClean Lake

All wastes (exclusive of the overburden) from the Sue A pit were also deposited into the mined-out Sue C pit. This approach was conservative, due to the uncertainty regarding segregating special waste based on its arsenic content. An X-ray fluorescence (XRF) method, which was successfully tested during Sue A mining, can segregate special waste based on acid-generating potential (using a simple laboratory test), radiological content (using the ore scanner) and a key non-radiological contaminant (arsenic, using an XRF scanner). Special waste from Sue E was also placed in the mined-out Sue C pit, while clean waste was placed in a separate Sue E waste rock stockpile. All material removed from the Sue B pit was classified as special waste and placed in the mined-out Sue E pit below an elevation of 400 metres above sea level. The total waste rock inventory at McClean Lake at the end of 2010 was 51.7 million tonnes of clean material (primarily waste rock) and 10.2 million tonnes of mineralized waste rock (special waste).

6.4.3.3 Contaminated industrial wastes

Chemically or radiologically contaminated waste materials originate from the mining, milling and water treatment areas of the McClean Lake operation. All the contaminated material is collected in yellow dumpsters, distributed around the site and deposited in the landfill for chemically and radiologically contaminated materials at the perimeter of the TMF. This landfill is within the hydraulic containment area of the JEB TMF. During final site decommissioning, these materials will be excavated and deposited in the JEB TMF. The existing contaminated waste temporary landfill was expanded in September 2008. This extension encompassed an area of approximately 2,089 cubic metres. The area averaged three metres in depth, providing an additional 6,267 cubic metres of storage space. From the end of 2007 to the end of 2010, approximately 2,128 cubic metres of waste was placed in the landfill.

6.4.4 Cigar Lake

6.4.4.1 Tailings management

Cigar Lake does not have a mill and does not produce tailings.

6.4.4.2 Waste rock management

There are five waste rock storage pads in operation at Cigar Lake. The current inventories result from test mining activities conducted at the site. Waste rock volumes are expected to increase substantially over the next few years as the construction of the operating mine is completed. The waste rock is classified as either clean waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock are temporarily stored on engineered lined containment storage pads. Leachate from these pads is contained and collected for treatment in the mine water treatment plant. When possible, clean or benign waste rock is used as fill or construction material on site. While some potentially acid-reactive waste rock may be used as backfill in the mine, the majority of this material is expected to be eventually transported to the McClean Lake mine site for disposal in a mined-out pit.

6.4.4.3 Contaminated industrial wastes

This waste rock storage pile is stockpile B, one of the stockpiles used to store potentially acid reactive waste rock, described in section 6.4.4.2, at Cigar Lake.

6.4.5 McArthur River

6.4.5.1 Tailings management

McArthur River does not have a mill and does not produce tailings.

6.4.5.2 Waste rock management

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

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

6.4.5.3 Contaminated industrial wastes

A transfer area, located adjacent to the mine headframe, is used to sort and temporarily store contaminated material. The contaminated material is shipped to the Key Lake operation, where it is disposed of in the AGTMF.

Annex 7 – Decommissioning Activities

7.1 AECL Whiteshell Laboratories

7.1.1 Background

Whiteshell Laboratories (WL) has provided research facilities for the Canadian nuclear sector since the early 1960s. In 1997, AECL decided to discontinue research programs and operations at the facility, and the Government of Canada concurred with the decision in 1998. In 1999, AECL began to prepare plans for the safe and effective decommissioning of the WL.

The Whiteshell Laboratories is a nuclear research and test establishment located in Manitoba on the east bank of the Winnipeg River about 100 kilometres northeast of Winnipeg, about 10 kilometres west of Pinawa and nine kilometres upstream from Lac du Bonnet. The major structures located on the site include a WR-1 reactor, the shielded facilities, research laboratories, and liquid and solid radioactive waste management areas and facilities, including the Concrete Canister Storage Facility (CCSF) for the dry storage of spent research reactor fuel.

The WL is currently licensed under a nuclear research and test establishment decommissioning licence. This licence authorized AECL to operate and undertake decommissioning activities at the facility until December 31, 2008. Since the 3rd National Report, an application was made by AECL for the renewal of the licence. This was a renewal of the initial six-year licence that expired on December 31, 2008. The Commission Tribunal renewed the decommissioning licence until December 31, 2018.

During the initial six-year period of the decommissioning licence (2002-2008), the decommissioning activities focused on the shutdown and decontamination of nuclear and radioisotope laboratory buildings and facilities. Also during this period, two nuclear facilities, the Van de Graaff Accelerator and the Neutron Generator, were completely decommissioned.

Major activities completed since the 3rd National Report include preparations to demolish the principal radioisotope laboratory building, development of plans for the standpipe remediation, and the design and construction of enabling facilities, including a waste clearance facility and a waste handling facility. Major activities planned for the balance of the current licensing period (until December 31, 2018) include the demolition of the radioisotope laboratory building and the re-establishment of the functions of the existing site liquid-waste treatment, active laundry and decontamination facilities into updated facilities; decommissioning their existing buildings will follow. Also included is remediation and expansion of waste storage facilities in the waste management area (WMA), reconfiguration of the site infrastructure service systems, completion of the pre-project standpipe work to define the preferred remediation option, and demolition of redundant non-nuclear service buildings. Activities planned for subsequent licensing periods include the final decommissioning of the WR-1 reactor, WMA storage structures, the shielded facilities and the enabling facilities.

Figure 7.1 – Aerial view of Whiteshell Laboratories main site

7.1.2 Underground Research Laboratory (URL)

The Underground Research Laboratory (URL), located approximately 15 kilometres northeast of AECL's Whiteshell Laboratories in Manitoba, was an underground, experimental facility used for research into controlled blasting techniques, rock mechanics and hydrological studies associated with potential deep underground disposal of spent fuel and the behaviour of various materials under the conditions of storage in deep-rock formations. No spent fuel or high-level radioactive materials were ever placed in the URL.

Two underground radioisotope laboratories (using low levels of tracer isotopes) were licensed by the CNSC under its *Nuclear Substances and Radiation Devices Regulations* (NSRDR). These laboratories were closed and decontaminated several years ago. CNSC staff confirmed this during an inspection conducted prior to the revocation of the CNSC's operating licence in 2003. The URL, therefore, no longer contains CNSC licensed laboratories and requires no further radiological decommissioning. The present URL Closure Project is much more closely related to a mine shutdown than a nuclear decommissioning project, and is following the requirements of Manitoba's *Mines and Minerals Act* and related regulations. Natural Resources Canada conducted an environmental assessment of the URL Closure Project under the *Canadian Environmental Assessment Act*. The decision page for the URL environmental assessment was finalized in February 2009, and NRCan "is of the opinion that the project is not likely to cause significant adverse environmental effects with the implementation of appropriate mitigation measures".

Placement of the concrete bulkheads on the URL shaft and ventilation raise surface openings during October 2010 safely concluded the underground portion of work in the URL Closure Project and achieved the URL safe sustainable closure state. The primary requirement for achieving this state was the sealing of selected boreholes, ventilation raise and main shaft. Final URL site closure will follow a minimum three-year period of site environmental and post-closure borehole hydraulic and geochemical monitoring. Once the monitoring period has ended, the 22 post-closure boreholes can be sealed and the URL surface facilities either removed or designated for re-use. At that point, provincial regulatory approval must be secured in order for AECL to abandon the URL site.

7.2 AECL Gentilly-1 Waste Management Facility

The Gentilly-1 Waste Management Facility consists of a permanently shut down, partially decommissioned prototype reactor and associated structures and ancillaries. This facility is presently in the long-term storage-with-surveillance phase of a deferred decommissioning program. Located on the south bank of the St. Lawrence River about 15 kilometres east of Trois-Rivières, Quebec, the Gentilly complex accommodates both the Gentilly-1 Waste Management Facility and the Gentilly-2 Nuclear Power Plant, a CANDU 600-Mw unit.

The Gentilly-1 Nuclear Power Station consists of a CANDU-BLW-250 reactor and was put into service in May 1972. It attained full power for two short periods in 1972 and operated intermittently for a total of 183 effective full-power days until 1978, when it was determined that certain modifications and considerable repairs would be required. The station was put into a layup state in 1980, and the decision not to rehabilitate the station was made in 1982.

The main components of the Gentilly-1 Nuclear Power Station were the reactor core, heat transport system, turbines and shielding. The reactor was heavy-water moderated, cooled by light water and fuelled with natural uranium in the form of zircaloy-clad uranium dioxide pellets. The reactor vessel was a vertical cylinder that contained a heavy-water moderator and was traversed by 308 pressure tubes and surrounding calandria tubes. The heat produced by the reactor fuel (mostly by boiling) was removed by the light-water coolant and then pumped through inlet and outlet headers and feeder pipes in a closed circuit. The steam generated by the reactor core was separated from the liquid coolant in the steam drum before being delivered to the turbine generator.

The decision to permanently shut down the reactor was made in 1984. A two-year decommissioning program began in April of that year to bring the Gentilly-1 Nuclear Power Station to an interim safe and sustainable shutdown state that is equivalent to storage with surveillance. The moderator (heavy water) was drained and shipped to other operating sites. Non-radioactive hazardous materials, such as combustible and flammable materials, laboratory supplies and oils, were identified and removed. The transfer of spent fuel from wet storage in the reactor pool to dry storage in the purpose-built canister storage area was completed in 1986. Major and minor decontamination activities (disassembly, decontamination and consolidation) were completed as required. All major radioactive or radioactively contaminated components not shipped to other licensed facilities were consolidated on site in either the reactor building or turbine building. Areas that possess significant residual contamination or radioactive materials have been reduced to a few locations. Radiological surveys were performed at the completion of each decommissioning activity.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period of storage-with-surveillance. Final decommissioning occurs in Phase 3. The Gentilly-1WMF has completed Phase 1 and is currently in Phase 2.

7.3 AECL Douglas Point Waste Management Facility

The Douglas Point Waste Management Facility (DPWMF) is located at the site of the former Douglas Point Nuclear Generating Station (DPNGS) situated on the Bruce nuclear site. The DPNGS, which consists of a 200-MW CANDU reactor, was put into service in 1968. It was owned by AECL and operated by Ontario Hydro until 1984. During this operational period, the station generated 17 x 10^9 kWh of electricity and attained a capacity of 87.3 percent.

The main components of the DPNGS were the reactor, heat transport system, turbines and power-generating equipment. The reactor was heavy-water moderated, cooled by pressurized heavy water and fuelled with natural uranium. The reactor core contained 306 horizontal fuel-containing pressure tubes and was surrounded by the heavy-water moderator. The heat transport system pumps circulated the pressurized heavy water through the reactor coolant tubes to eight boilers, where the heat was transferred to the boiler steam and water system. The reactor primarily used heavy concrete, steel and water as shielding to protect the surrounding area from radiation during operation. Steam generated in the boilers was transferred to the turbine for power generation.

The DPNGS was permanently shut down on May 5, 1984, and placed in an interim, safe and sustainable shutdown state. This interim state is referred to as the storage-with-surveillance state. The DPNGS then became the Douglas Point Waste Management Facility.

Following the shutdown of the reactor, the primary heat transport and moderator medium (heavy water) was drained and shipped to other operating sites. The booster rods were removed and shipped to the CRL for storage in February 1985. Non-radioactive hazardous materials, such as combustible and flammable materials, laboratory supplies and oils, were identified and removed. The transfer of spent fuel from wet storage in the reactor pool to a dedicated dry storage facility was completed in 1987. Major and minor decontamination activities (disassembly, decontamination and consolidation) were completed as required. All major radioactive or radioactively contaminated components that were not shipped to other facilities licensed to receive them were consolidated on site. Areas that possessed significant residual contamination or radioactive materials have been reduced to a few locations, and radiological surveys were performed at the completion of each decommissioning activity.

The DPWMF is presently in the storage-with-surveillance phase of a deferred decommissioning program. For decommissioning purposes, the DPWMF is divided into three planning envelopes. Envelope A consists primarily of nominally uncontaminated buildings and structures, which may be decommissioned at any time, with health, safety and environmental concerns taken into account. Envelope B consists primarily of contaminated buildings, which will be decommissioned after allowing for a period of radioactive decay and after long-term waste management facilities become available. Envelope C includes the spent fuel canister area.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period of storage-with-surveillance. Final decommissioning occurs in Phase 3. The DPWMF has completed Phase 1 and is currently in Phase 2.

7.4 AECL Nuclear Power Demonstration Waste Management Facility

The Nuclear Power Demonstration Waste Management Facility (NPDWMF) consists of a permanently shutdown, partially decommissioned demonstration CANDU reactor and associated structures and ancillaries. The facility, which is presently in the interim storage-with-surveillance phase of a deferred decommissioning program, is located on the west bank of the Ottawa River in Ontario, some 25 kilometres upstream from AECL CRL and 15 kilometres from the Town of Deep River. The NPD NGS, consisting of a 20-MW CANDU pressurized-water reactor, was placed in service in October 1962 and operated by Ontario Hydro (now OPG) until May 1987. In 1988, operating and compliance responsibilities were transferred from Ontario Hydro to AECL, and the facility became the NPDWMF.

The facility produced electrical power for the Ontario Hydro grid, trained people for the commercial nuclear power plants of Ontario Hydro, and performed experiments in process systems concepts to be incorporated in the design of the commercial nuclear power plants. During this operations period, the station generated 3×10^9 kWh of electricity at a net electrical capacity factor of 65 percent.

The main components of the NPD NGS were the reactor, heat transport system, turbine and electrical power generator equipment. The reactor was heavy-water moderated, cooled by pressurized heavy water and fuelled with natural uranium. The reactor core contained 132 horizontal fuel containing pressure tubes and was surrounded by a heavy-water moderator. The heat transport system pumps circulated the hot pressurized heavy water through the reactor coolant tubes to a heat exchanger/boiler unit, where the heat was transferred to the boiler steam and water system. The reactor, boiler and auxiliary systems were installed below ground and were surrounded by concrete shielding to protect the surrounding accessible areas from radiation during operation. Steam generated in the boilers was transferred to the turbine/generator for electrical power generation.

The NPD NGS was permanently shut down on May 24, 1987, and placed into an interim, safe and sustainable shutdown phase. This interim storage period is referred to as the storage-with-surveillance phase. Following the shutdown of the reactor, the heavy water from the primary heat transport and moderator systems was drained and shipped off site. The reactor was defuelled and the fuel bundles were transferred to CRL. Demineralizer system equipment was removed from the various nuclear process systems and transferred to CRL. Major and minor decontamination activities were completed as required. The facility was functionally divided into nuclear and non-nuclear areas, with any equipment or structures either radioactive or radioactively contaminated confined to the nuclear area. All cross connections between the two areas were blocked off, sealed or permanently locked.

A three-phase approach has been established for reactor decommissioning. Phase 1 brings the facility to a safe, sustainable shutdown state. Phase 2 is a period of storage-with-surveillance. Final decommissioning occurs in Phase 3. The NPDWMF has completed Phase 1 and is currently in Phase 2.

7.5 AECL Chalk River Laboratories decommissioning activities

7.5.1 Pool Test Reactor

The Pool Test Reactor (PTR) was a type of reactor with fuel elements suspended in a pool of water that served as the reflector, moderator and coolant. It was a low-power research reactor (less than 100 W), designed and built to conduct reactivity studies on irradiated fuel samples and to determine the cross-section of fission products. PTR usage then shifted to testing and calibration of self-powered flux detectors on a commercial basis.

The PTR began operating in 1957 and was permanently shut down in 1990. The fuel was removed and placed in a tile hole at the CRL site. Since then, the PTR has been monitored and kept under surveillance, and is currently in a safe shutdown state. The decommissioning objective is to return the area to the site landlord for use as general active laboratory space at CRL.

The PTR consists of a pool that is approximately 4.5 metres square by six metres deep, and contains about 125,000 litres of water. Specific decommissioning activities undertaken with regard to the PTR include:

- removing the PTR equipment: aluminum-graphite reflectors, fission chamber, core plate and support, oscillator mechanism, core tube support brackets, control rod drive system and control rod support
- draining and drying the pool
- removing the deionized water supply and purification system from the pool
- removing all electrical components associated with the facility, including meters, switches and panels, with wiring to be removed to clear termination points
- removing all signs and fixtures associated with the facility from walls, floor and ceiling
- segregating and transferring all waste generated by the decommissioning project to Waste Management Operations for storage and disposal as appropriate

The decommissioning is scheduled to begin after regulatory approval and is expected to last less than one year. The CNSC and NRCan approved the environmental assessment for this project in 2007. Lessons learned from the emptying of the NRX fuel rod bay will be incorporated into PTR planning documents. The detailed decommissioning plan and other planning documents will be written and submitted to the CNSC for approval prior to PTR decommissioning. An application for decommissioning approval is expected during 2011, with decommissioning estimated to be completed by 2012.

The decommissioning of the PTR facility is planned in three phases.

- Phase 1 brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state.

The PTR facility decommissioning is currently in Phase 2.

7.5.2 Plutonium Recovery Laboratory

The Plutonium Recovery Laboratory was constructed in 1947 and was in operation from 1949 to 1957. During that period, it was designed to extract plutonium isotopes from enriched fuels used in research reactors. Following shutdown in 1957, the majority of the processing equipment was flushed, decontaminated and removed. The only process systems remaining are the fuel dissolver tanks, rod lifting mechanisms and basement sumps.

This facility has a footprint of about 514 square metres. Actual decommissioning activities are expected to be initiated in the next 10 years, after regulatory approval to decommission. Decommissioning is to be carried out in three phases.

- Phase 1, carried out over a 3-year period, brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state, and will be completed within an estimated two-year period.

The Plutonium Recovery Laboratory decommissioning is currently in Phase 2.

7.5.3 Plutonium Tower

The Plutonium Tower was used to develop means to extract plutonium from fuel rods irradiated in the NRX reactor and was operated for a few years in the late 1940s. The building was permanently shut down in 1954. All process equipment was removed from the building, and an initial cleanup was carried out. Further decontamination and dismantling was carried out in the 1980s.

The Plutonium Tower building is 19.2 metres high and has a footprint of about 28 square metres. All process equipment was removed from this building. Other decommissioning activities include:

- conducting a confirmatory radiological survey of the concrete tower interior, annexes and underground pipe chase to update the hazard status
- isolating process and service lines entering the building from neighbouring interconnected buildings
- demolishing the annexes, concrete tower, building structure and footings/foundations
- segregating solid wastes and transferring them to appropriate waste management facilities at the CRL site
- removing any contaminated soil and backfilling from the area, as required

Decommissioning activities are expected to begin once regulatory approval has been granted. The removal of the Plutonium Tower is expected to take approximately one year. An environmental assessment, which is currently being reviewed by the CNSC and NRCan pursuant to the *Canadian Environmental Assessment Act* and a detailed decommissioning plan, is expected to be completed in 2011.

The decommissioning of the Plutonium Tower facility is planned in three phases.

- Phase 1 brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state.

The Plutonium Tower is currently in Phase 2 decommissioning.

7.5.4 Waste Water Evaporator

The Waste Water Evaporator, which was constructed in 1952, was used to process and treat radioactive liquid wastes produced by the NRX fuel reprocessing work conducted between 1952 and 1958. Some evaporation activities were also carried out between 1958 and 1967 to concentrate about 450 cubic metres of stored process wastes remaining from earlier fuel processing. The facility was shut down in 1971.

The Waste Water Evaporator has a footprint of about 130 square metres. One of the seven tanks is suspected to hold about 100 litres of radioactive liquid waste, while two other tanks are suspected to contain a small quantity of dried contaminated sludge.

Decommissioning activities for this building include:

- isolating process and service lines entering the building from neighbouring interconnected buildings
- removing, treating and storing any liquid wastes from the tank, process lines and equipment
- decontaminating process equipment, processing cells and other components in the building to remove contamination
- removing process equipment, processing cell, building structure and footing/foundations
- segregating solid wastes and transferring them to appropriate waste management facilities at the CRL site
- removing any contaminated soil surrounding the building to a distance of one metre from the building footprint, and backfilling the area as required

Actual decommissioning activities will be initiated in the next 10 years, after regulatory approval to decommission the facility. Removal of the Waste Water Evaporator is expected to take one year. An environmental assessment, which is currently being performed pursuant to the *Canadian Environmental Assessment Act* and a detailed decommissioning plan, will be completed in 2011.

The decommissioning of the Waste Water Evaporator facility is planned in three phases.

- Phase 1 will bring the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state.

The Waste Water Evaporator Facility decommissioning is currently in Phase 1.

7.5.5 National Research Experimental (NRX) Reactor

The NRX reactor, Canada's first large-scale research reactor, commenced operation in 1947 and played a major role in developing the CANDU reactor. The reactor was used extensively for the testing of fuels and materials, and for nuclear physics research in support of the Canadian nuclear power program.

The reactor is a vertical assembly of permanent tubes kept in a calandria, which contain the reactor fuel assemblies. The reactor is heavy-water-moderated and light-water-cooled, and has a power rating of 42 MW. After approximately 250,000 hours of operating time, the NRX reactor was shut down on January 29, 1992.

The NRX reactor facility is divided into three planning envelopes: the NRX reactor, the fuel storage bays and the ancillary buildings. The decommissioning of the NRX reactor is planned in three phases.

- Phase 1 brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the NRX reactor through a series of decommissioning work packages and achievement of the final end state.

The NRX decommissioning process began with the permanent shutdown of the NRX reactor facility. Shutdown operations for the NRX reactor and ancillary buildings have been completed. And the Phase 1 activities to establish a safe sustainable storage-with-surveillance state for the fuel storage bays are currently under review for completeness.

The NRX fuel bays consist of A and B bays. The A bay's fuel was removed in the late 1990s after the facility was shut down – after which the A bay cleaning commenced. An environmental assessment was completed and approved by the CNSC in 2007. The CNSC then approved two advanced decommissioning work packages to remove water from the A and B bays, and to remove approximately 30 metres of wooden building structure over the bays, creating a fire separation between the bays and NRX reactor. As a result, the A bay was cleaned and emptied in 2007, followed by the removal of approximately 30 metres of superstructure over a section of empty bays.

The B bay consists of a network of water-filled and sand/water-filled bays that were connected to the A bay in the early 1950s. Work was undertaken in the late 1950s to isolate the B bays from the A bay by using a series of concrete dividing walls. Sections of the B bays were drained and filled with sand, while the remaining sections were re-filled with water. Emptying the B bays will commence once final work is completed on the A bay. Lessons learned from decommissioning the A bay will be incorporated in the planning for the B bays.

The decommissioning of the NRX facility is planned in three phases.

- Phase 1 brings the facility to a safe sustainable shutdown state, suitable for an ensuing period of storage with surveillance.
- Phase 2 is the storage-with-surveillance period.
- Phase 3 is the removal of the facility through a series of decommissioning work packages and achievement of the final end state.

Decommissioning of the NRX, building B204 A and B bays and associated facilities are currently in Phase 2.

7.6 Cluff Lake Project

The Cluff Lake Project, owned and operated by AREVA, began in 1981 and was completed at the end of 2002, when ore reserves were depleted. More than 62 million pounds of U_3O_8 was produced over the 22-year life of the project. Site facilities included the mill and tailings management area (TMA), four open-pit and two underground mines, the camp for workers and site infrastructure. Cluff Lake was the first of the northern Saskatchewan uranium mines to move into decommissioning. The decommissioning licence was received from the CNSC in July 2004, after five years of public consultation, environmental assessment and regulatory review, and marked the completion of the planning phase of work to return the site to a natural state. The objective is to return the site as closely as practical to its original state in a manner that both protects the environment and allows traditional uses such as fishing, trapping and hunting to be carried out safely.

Site staff and contractors carried out decommissioning work between 2004 and 2006, with revegetation of restored areas carrying into 2007. An extensive follow-up monitoring program to assess the performance of the decommissioned site is now underway. A small number of staff remains on site to carry out the monitoring program and provide minor maintenance at restored areas. Ultimately, when all stakeholders judge the performance of the decommissioned site satisfactory, it is expected that the site will be transferred to the Government of Saskatchewan through the institutional control framework established by the *Reclaimed Industrial Sites Act* (see section H.10.3).

The following sections briefly describe the main decommissioning activities.

7.6.1 Mill area

Decommissioning the mill involved two phases, which were completed in 2004 and 2005. The mill demolition work was broadly similar to demolition of other similarly sized industrial facilities, with special measures needed to protect workers from residual contamination and industrial hazards and to prevent the spread of contaminants into the environment. Only two inactive warehouses remain. These warehouses are used for storage and equipment repair during the post-closure monitoring period. Waste materials were disposed in one of the open pits at the site, together with much larger volumes of waste rock. Following the mill demolition, till material was placed throughout the former mill area to serve as a growth medium for native wood species planted at the site and to ensure that radiological clearance levels were achieved throughout the area.

Figures 7.2 (a) and (b) – (a) A photograph of the Cluff Lake mill areas during operation, and (b) a photograph of the area following decommissioning but prior to the revegetation becoming established

7.6.2 Tailings management area

The TMA at Cluff Lake is a surface impoundment, constructed using a series of engineered dams and dikes and extending over about 70 hectares. It formerly consisted of a solids containment area, water-decantation area and water-treatment facilities. Thickened tailings were pumped to the solids containment area, where consolidation and liquid decantation occurred. The decant water, together with waste water from other sources, was piped to a two-stage water treatment facility for radium-226 precipitation. Currently, the TMA is surrounded by two diversion ditches, which divert runoff from the upstream drainage basin around the TMA to the downstream water body.

Decommissioning of the TMA was initiated by covering the tailings with till in stages to promote consolidation. When consolidation was complete, the TMA cover was contoured to provide positive drainage, using locally available till with a minimum cover thickness of one metre, and then revegetated. The surface contour and vegetated cover promote runoff of rainfall and snowmelt, as well as evapotranspiration of moisture to the atmosphere, which minimizes net infiltration through the tailings. Extensive characterization of the tailings and the site's geology and hydrogeology has been performed to acquire reliable data on which to base the assessment of long-term performance. One of the objectives of the follow-up monitoring program is to verify the key assumptions used in the long-term performance assessment. Seven nested piezometers were installed in the TMA in 2010 in order to collect additional hydrogeological data for comparison with the key assumptions.

Figures 7.3 (a) and (b) – Photographs show the Cluff Lake TMA during operation and after decommissioning but prior to the revegetation becoming established.

7.6.3 Mining area

Mining involved four open pits and two underground mines. One open pit (“D” pit) and its associated pile of waste rock were reclaimed in the mid 1980s. Water quality data from the flooded pit shows stable, acceptable surface water quality, and native species of vegetation have been re-established on the waste rock pile.

Two open pits have been used for the disposal of waste rock, with one of these two pits also used to accept industrial waste during operations and decommissioning. This waste included the mill demolition waste.

The major decommissioning activities consisted of:

- dismantling and disposing of all above ground structures
- sealing all access openings (ramps, ventilation shafts) to the two underground mines, and allowing them to flood naturally
- relocating waste rock to complete the backfilling of one open pit (Claude pit), then re-contouring and establishing vegetation on these areas
- removing a portion of – and then re-contouring – the waste rock within another open pit (Dominique-Janine North (DJN) pit) and then allowing this pit and the contiguous Dominique-Janine Extension (DJX) pit to flood to the natural level to eventually form a small lake that meets surface water quality criteria
- reclaiming the remaining Claude waste rock pile by re-sloping for long-term stability, compacting the waste rock surface, covering with till and establishing a vegetation cover
- re-contouring and establishing native vegetation on all disturbed areas

Extensive characterization of the waste rock, the geologic formations in the area and the site hydrogeology has been performed to acquire reliable data for the assessment of long-term performance. One of the objectives of the post-closure monitoring program is to verify the key assumptions used in the assessment of long-term performance. Eleven nested piezometers were installed in the Claude pit in 2010 in order to collect additional hydrogeological data for comparison to the key assumptions.

(a) – DJ operational (b) – DJ decommissioned (c) – “D” pit approximately 20 years after decommissioning

Figures 7.4 (a), (b) and (c) – Photographs show one of the Cluff Lake mining areas (DJ) during operations and after decommissioning but prior to revegetation becoming established.

7.7 Bruce Heavy Water Plant

The Bruce Heavy Water Plant (BHWP) was a Class 1B nuclear facility contained within the boundaries of the Bruce nuclear site located in Tiverton, Ontario. It began producing heavy water in 1973 and continued until the last production facilities were shut down in 1998. Decommissioning of some of the older production systems began in 1993.

The demolition of the BHWP was completed in 2006. All contaminated soil has been remediated, and the project is in a three-year period of end-state environmental monitoring, after which it will be possible for the licensee to apply for a licence to abandon.

Figure 7.5 – Demolition of the Bruce Heavy Water Plant site

7.8 Dalhousie University Slowpoke Reactor

Dalhousie University's SLOWPOKE-2 Reactor (DUSR) facility was part of Dalhousie's Trace Analysis Research Centre. In November 2004, the CNSC received a notice from Dalhousie University of its intention to defuel and decommission the DUSR facility. At that time, Dalhousie University had provided a brief outline of the project to initiate the environmental assessment (EA) process. The EA process was subsequently put on hold at the request of the proponent on June 2, 2006. On December 2009, Dalhousie University notified the CNSC of its intention to proceed with decommissioning, and the CNSC restarted the EA process.

Before the Commission Tribunal was able to make a licensing decision regarding the proposed project, pursuant to the *Nuclear Safety and Control Act* (NSCA) it had to make a decision, in accordance with the *Canadian Environmental Assessment Act* (CEA Act), on an environmental assessment (EA) of the proposal. In December 2010, the CNSC held a hearing and approved the proposed *Environmental Assessment Guidelines for the Proposal Decommission the Dalhousie University SLOWPOKE-2 Reactor in Halifax, Nova Scotia*.

In January 2011, a hearing was held for Dalhousie University's application to the CNSC for a decommissioning licence. The licence was granted and is currently valid from January 20, 2011 to December 31, 2015. Concurrently, the Commission Tribunal revoked the non-power operating licence for the Dalhousie University SLOWPOKE-2 Reactor Facility.

DUSR has hired AECL as the sole contractor to conduct the decommissioning activities of the DUSR facility. The AECL activities on the DUSR Decommissioning Project are executed through AECL CANDU services, within the CANDU Reactor Division. As of March 31, 2011, the following decommissioning activities have occurred:

- preparation of the rooms in the building where the reactor is located, by removal of all items not required for the defuelling and decommissioning process
- preliminary surveys to identify areas with potential radioactive contamination
- defuelling of the reactor and transfer of the fuel
- dismantling of the reactor components and identifying radioactive, contaminated, hazardous, and clean components
- packaging and transportation of all radioactive, contaminated, hazardous, and clean components
- packaging and transportation of all radioactive components for authorized disposal or storage
- disposal of other radioactive and non-radioactive wastes
- decontamination of the site to render it free of residual radioactive contamination

CNSC staff verified these decommissioning activities during a compliance inspection in March 2011. The next stage of the licensing process is to consider an application for a licence to abandon.

Figure 7.6 – Decommissioning of Dalhousie University's SLOWPOKE-2 Reactor

Annex 8 – Inactive Uranium Mines and Mills Tailings Management Areas

8.1 Introduction

There are 20 tailings management sites that have resulted from the operation of uranium mines in Canada: 14 in Ontario, four in Saskatchewan and two in the Northwest Territories. (A map of their locations is included in figure B.3.)

8.1.1 Saskatchewan

There are three inactive uranium tailings sites in Saskatchewan: Beaverlodge, Lorado and Gunnar. In addition to these sites, AREVA's Cluff Lake mining facility is currently being decommissioned (see annex 7.6).

8.1.1.1 Beaverlodge

Cameco holds a waste facility operating licence for the decommissioned Beaverlodge uranium mine located near Uranium City in the northwest corner of Saskatchewan. Mining of ore at this site began in 1950 and milling in 1953, with both activities continuing until closure in 1982. Decommissioning began in 1982 and was completed in 1985. Since then, the site has been in a monitoring and maintenance phase. All mine structures have been removed from the site; all but one of the open pits has been completely backfilled; and mine shafts have been capped and decommissioned according to Joint Regulatory Group requirements.

All of the control structures associated with this site are passive. Three small water-level control structures exist but there are no effluent treatment plants. There are roads, waste rock piles and tailings management areas that are subject to inspection programs and local and area-wide environmental monitoring programs.

The Beaverlodge site has three tailings management areas (TMAs), which contain 5.8 million tonnes of tailings and 4.3 million tonnes of uranium tailings disposed of underground – for a total of 10.1 million tonnes of lower-grade uranium mine tailings. In addition, there are approximately 5.1 million tonnes of waste rock on the site.

At decommissioning in 1982, the site consisted of 73 separate properties that covered approximately 744 hectares. There were 17 different mining areas; 10,161,000 tonnes of ore were recovered that averaged 0.25 percent uranium (0.10 to 0.43 percent ranges). The Saskatchewan *Reclaimed Industrial Sites Act* later came into effect and created an institutional control framework for the long-term provincial management of post-decommission properties. As a result, five of the 73 Beaverlodge properties were exempt from CNSC licensing and entered into this framework in 2009. However, these properties were not part of the overall radiological waste inventory considered in this report.

Figure 8.1 – Beaverlodge former mill area

8.1.1.2 Gunnar and Lorado

On April 2, 2007, the Governments of Canada and Saskatchewan announced the first phase of the cleanup of closed uranium mine and mill sites in northern Saskatchewan (principally Gunnar and Lorado). Private sector companies that no longer exist operated these facilities from the 1950s until the early 1960s. When the sites were closed, the regulatory framework in place was not sufficient to ensure an appropriate containment and treatment of the waste, which led to environmental impacts on local soils and lakes. The total cleanup cost, which the Governments of Canada and Saskatchewan will share, will be $24.6 million.

The Gunnar mine site is located on the southern tip of the Crackingstone Peninsula along the North shore of Lake Athabasca, approximately 25 kilometres southwest of Uranium City, Saskatchewan (see figure 8.3). The Gunnar mine site has been closed since 1964, and has not been adequately decommissioned.

On June 15, 2007, a comprehensive environmental assessment for the Gunnar project began pursuant to the provisions of the *Canadian Environmental Assessment Act*. The federal authorities responsible for the assessment are the CNSC (responsible for issuing the licence for the project) and Natural Resources Canada (responsible for partially funding the project). An environmental assessment is also being conducted by the Government of Saskatchewan, in accordance with the terms of the Canada–Saskatchewan Agreement on Environmental Assessment Cooperation.

In the summer of 2010, the cleanup of the Gunnar mine and mill site began in order to remove hazards that pose immediate risks to the health and safety of the public. All buildings and structures that failed a structural safety assessment are expected to be taken down by no later than October 31, 2011.

The Lorado Uranium Mining Ltd. mill site is located north of Lake Athabasca in the northwest corner of Saskatchewan, approximately eight kilometres southwest of Uranium City (see figure 8.2). EnCana West Limited (EWL) had been identified as the owner of the land on which a portion of the unconfined tailings from the Lorado milling operation exists. The remainder of the site is provincial Crown land. In 2008, EWL negotiated an agreement with the Government of Saskatchewan. EWL has paid a significant amount of money in exchange for the Saskatchewan to assume current and future control and responsibility of the site. Work related to the remediation of the Lorado site will require the CNSC licensing and joint regulatory approvals.

In the meantime, measures to prevent radioactive tailings from becoming airborne and to limit public access to the tailings area at Lorado are expected to be in place by late spring 2011.

Figure 8.2 – Lorado tailings site

Figure 8.3 – Aerial view of Gunnar mine site

8.1.2 Northwest Territories

There are two licensed closed uranium mine and tailings sites in the Northwest Territories: Port Radium Mine and Rayrock Mine.

8.1.2.1 Port Radium

The Port Radium site is located in the Northwest Territories at Echo Bay on the eastern shores of Great Bear Lake, about 265 kilometres east of the Déné community of Déline at the edge of the Artic Circle. Mining at the Port Radium site occurred from 1932 to 1940, from 1942 to 1960 and from 1964 to 1982 – in the last instance, to recover silver. The site covers approximately 12 hectares and is estimated to contain 1.7 million tons of uranium and silver tailings. The site was partially decommissioned in 1984, according to the standards of the day. In 2006, the Government of Canada reached an agreement with the local community and completed the remediation of the site in 2007 under a CNSC licence.

Indian and Northern Affairs Canada (INAC) will continue performance and environmental monitoring and reporting under the licence. Radiological results for Port Radium Sampling in 2009 are summarized as:

- < 0.005 Bq/L for radium-226
- < 0.71 Bq/L for lead-210
- < 0.013 Bq/L for polonium-210
- < 0.01 Bq/L for thorium-230

These levels are below the discharge limits specified in the licence conditions, and below the Canadian Water Quality Guidelines and Health Canada's drinking water criteria.

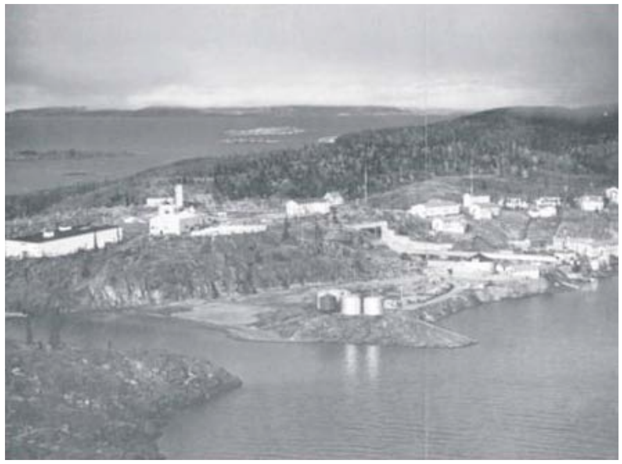

Figure 8.4 (a) – Aerial view (1950s) of Port Radium Mine

Figure 8.4 (b) – Aerial view (2002) of Port Radium Mine

8.1.2.2 Rayrock

Uranium mining and milling occurred at the Rayrock site from 1957 until 1959, when it was abandoned. Following an environmental assessment and the issuance of an AECB licence (reissued as a CNSC licence in 2001), INAC decommissioned and rehabilitated the Rayrock site (including the capping of the tailings) in 1996. Performance monitoring and reporting of the results have been ongoing since 1996.

INAC sampled surface water for 2009 and reported the following radiological concentrations at the final point of control:

- 0.07 Bq/L for lead-210
- 0.03 Bq/L for polonium-210
- 0.16 Bq/L for radium-226
- 0.01 q/L for thorium-228
- 0.38 Bq/L for thorium-230
- 0.01 Bq/L for thorium-232
- 0.2 Bq/L for uranium-234
- 0.0028 Bq/L for uranium-235
- 0.0034 Bq/L for uranium-238

For the 2009 sampling period, many of the radionuclide concentrations were below detection limits, and in all cases below the Canadian Water Quality Guidelines and Health Canada's drinking water criteria.

Figure 8.5 – Rayrock Mine

8.1.3 Ontario

8.1.3.1 Elliot Lake area

There are 12 inactive uranium mine sites and 10 uranium TMAs in and around Elliot Lake, Ontario. All of the Elliot Lake uranium mines were brought into production between 1955 and 1958. By 1970, five of the mines had been shut down; by 1992, most had ceased operations. Decommissioning of the last of the Elliot Lake uranium mines – Stanleigh, Quirke, Panel, Stanrock and Denison mine sites – was essentially complete by the end of 1999. Currently, all of the sites have been substantively decommissioned, with all mine features capped or blocked, all facility structures demolished, and all sites landscaped and revegetated.

The uranium ore in the Elliot Lake area is classified as low grade (containing less than 0.1 percent U_3O_8). It also contains pyrite and uranium decay products such as radium-226. When exposed to oxygen and water, the tailings become acid-generating, and may mobilize contaminants. Most of the Elliot Lake TMAs, therefore, have some degree of effluent treatment system associated with each site. All of the TMAs have been closed, and all construction activities related to the containment structures have been completed. Currently, the mining companies conduct site-specific and regional environmental monitoring programs, operate the effluent treatment plants, and inspect and maintain the sites.

Rio Algom Ltd. is responsible for the Quirke, Panel, Spanish American, Stanleigh, Lacnor, Nordic, Buckles, Pronto and Milliken mine sites and their associated TMAs, while Denison Mines Inc. is responsible for the Denison, Stanrock and Can-Met mine sites and their TMAs.

Decommissioning of uranium mines and mills is governed by the *Uranium Mine and Mills Regulations* under the NSCA. Two of the mine sites – Denison and Stanrock – currently have the CNSC uranium mine decommissioning licences in effect.

In 2004, Rio Algom Ltd. consolidated all of its Elliot Lake mine sites under one CNSC licence: a waste facility operating licence governed by the *Class 1 Nuclear Facility Regulations* under the NSCA.

8.1.3.1.1 Effluent treatment and environmental monitoring

In Elliot Lake, the TMAs use a mixture of both dry and wet covers. Four of the TMAs – Lacnor, Nordic, Pronto and Stanrock – are engineered with dry covers, and vegetation has been established over the tailings at all of these sites. Active water treatment is required at all of the dry TMAs to correct for acid generation and radium dissolution in the effluent streams, according to the predicted performance for the dry tailings covers. It is expected that water treatment will be required for many more years to come at these sites, as the acid-generating potential of the tailings becomes slowly exhausted due to surface water infiltration and oxidation of the tailings.

The other TMAs – Quirke, Panel, Stanleigh, Spanish American and Denison – are all water covered, and most require some form of active water treatment. However, the extent of treatment required is greatly reduced over that of the effluents resulting from the dry cover TMAs (the water covers minimize exposure to oxygen and the resulting generation of acid). Many of these sites currently require only minimal treatment, and it is expected that the effluent treatment plants will not be required for the length of time predicted at the sites with dry covers.

With respect to environmental monitoring, the licensees have implemented two programs at their TMAs: the TMA Operational Monitoring Program (TOMP) and the Source Area Monitoring Program (SAMP). The first collects data to track TMA performance and supports decisions regarding the management and discharge compliance of the TMAs. The second program was developed to monitor the nature and quantities of contaminant releases to the watershed.

In addition to these measures, both Rio Algom Ltd. and Denison Mines Inc. have jointly implemented two watershed-wide programs, referred to as the Serpent River Watershed Monitoring Program (SRWMP) and the In-Basin Monitoring Program.

The SRWMP is designed to evaluate the effects of all mine discharges and water-level changes on the receiving watershed, focusing on water and sediment quality, benthos, fish health, and radiation and metal doses to humans and wildlife. The Serpent River watershed comprises more than 70 lakes and nine sub-watersheds, which cover an area of 1,376 square kilometres and drain into Lake Huron via the Serpent River.

The In-Basin Monitoring Program, a companion program to the SRWMP, focuses on the risks to biota feeding at the TMAs, by monitoring the physical, chemical and ecological conditions at the TMAs, including ecological changes. Both programs run in five-year cycles. The first cycle was completed in 1999; the second cycle summary report was completed in 2007; the third cycle results were combined with results from the TOMP and the SAMP in one consolidated *State of the Environment Report* in 2011.

The CNSC licenses the Rio Algom Ltd. and Denison Mines Inc. mine sites for possession, care and maintenance of nuclear substances that are found in the TMAs. There are no emissions from the TMAs, except for surface water runoff. TMA waters are treated as required by the licensees, prior to release, and meet the discharge limits that are set in each individual licence. After being treated, they discharge into the Serpent River watershed, which further dilutes them until they ultimately discharge into Lake Huron via the Serpent River. Biological effects monitoring programs have indicated some impairment of the lake's bottom-living benthic invertebrate community in the initial receiving water bodies but no significant impairment of the downstream watershed.

These sites will continue to require monitoring and active management until effluents meet discharge criteria without treatment. These sites will then require some form of ongoing (permanent) care and maintenance.

8.1.3.1.2 Community involvement

With respect to community involvement, the mining companies maintain a public presence in Elliot Lake, offering facility tours, a Web site, and a public information program that keeps the community and city council updated with respect to ongoing activities at the sites. The Serpent River Region Environmental Committee (SRREC), a local environmental committee, attends facility inspections along with the CNSC and the Joint Regulatory Group (which represent the other federal and provincial regulators that have an interest in the Elliot Lake operations). Over the last several years, CNSC staff have conducted outreach activities in Elliot Lake, hosted open houses and attended a public forum hosted by the SRREC.

Figure 8.6 (a) – Aerial view of the Stanleigh Mine site prior to decommissioning

Figure 8.6 (b) – Aerial view of the Stanleigh Mine site after decommissioning

8.1.3.2 Agnew Lake

The Agnew Lake Mine, located about 25 kilometres northwest of Nairn Centre, Ontario, ceased operation in 1983. The uranium mine site was decommissioned and monitored by Kerr Addison Mines from 1983 until 1988. The site was then turned over to the Province of Ontario in the early 1990s. The Ontario Ministry of Northern Development and Mines holds a CNSC waste nuclear substance licence for the Agnew Lake TMA. CNSC staff conduct a compliance inspection of the Agnew Lake Mine once every three years. The Ministry of Northern Development and Mines reported the following 2010 sampling results for the radiological surface water at the final point of control:

- < 0.01 Bq/L for radium-226
- 0.1 Bq/L for lead-210
- < 0.01 Bq/L for polonium-210
- < 0.01 Bq/L for thorium-230

These levels are below the Ontario Provincial Water Quality Objectives (PWQO).

8.1.3.3 Bancroft area

Uranium tailings management sites also exist at the Madawaska, Dyno and Bicroft mines in the area surrounding Bancroft, Ontario. The Madawaska Mine has been inactive since 1983, while operations at the Dyno and Bicroft sites ceased in the early 1960s.

8.1.3.3.1 Dyno Idle Mine site

The Dyno Idle Mine property is located at Farrel Lake, about 30 kilometres southwest of Bancroft, Ontario. The mill circuit at Dyno operated between April 1958 and April 1960. The property consists of an abandoned, sealed underground uranium mine; a mill, which has been largely demolished; a tailings area; one dam; and various roadways. The site is managed and monitored by EWL Management Ltd., which holds a CNSC waste nuclear substance licence for the Dyno Idle Mine site.

During the sampling period of 2010, EWL Management Ltd. provided the following results for the radiological surface water at the final point of control:

- Uranium concentrations during the spring and fall of 2010 were 0.0013 mg/L and 0.0011 mg/L, respectively. Both values were below the PWQO for uranium (0.005 mg/L) and within the range of values reported for 2002–2009 (< 0.001 to 0.0016 mg/L).

- Radium-226 concentrations during the spring and fall of 2010 were 0.08 Bq/L and 0.09 Bq/L, respectively. Both values were below the PWQO for radium-226 (0.06 Bq/L) and within the lower end of the range of values reported for 2002–2009 (< 0.01 to 0.36 Bq/L).

- Thorium-230 concentrations during the spring and fall of 2010 were < 0.005 Bq/L and < 0.005 Bq/L, respectively, and are at the low end of the range of values reported for 2002–2009 (< 0.005 to 0.026 Bq/L).

- Polonium-210 concentrations during the spring and fall of 2010 were 0.012 Bq/L and 0.005 Bq/L, respectively, and are within the range of values reported for 2002–2009 (< 0.005 to 0.02 Bq/L).

- Lead-210 concentrations during the spring and fall of 2010 were < 0.02 Bq/L and < 0.02 Bq/L, respectively, and are within the range of values reported for 2002–2009 (< 0.02 to 0.06 Bq/L).

Figure 8.7 – Main tailings dam Dyno Mine site

8.1.3.3.2 Madawaska Mine site

The Madawaska Mine property is located six kilometres southwest of the town of Bancroft, Ontario on Highway 28. Initial mining and milling operations at Madawaska (Faraday) Mine ran from 1957 until 1964, and again from 1976 to 1982. Reclamation activities were carried out from 1983 to 1992. The CNSC is currently re-evaluating the licensing requirements for the Madawaska site. The site is currently being safely managed by EnCana West Limited. CNSC staff inspects the site annually.

During the sampling period of 2010, EWL Management Ltd. provided the following results for the radiological surface water at the final point of control:

- Uranium concentrations during the spring and fall of 2010 were 0.035 mg/L and 0.037 mg/L, respectively, and are within the range of concentrations measured from 1983–2009 (0.006 to 0.053 mg/L). Concentrations of uranium measured during the spring and fall of 2010 are above the PWQO (0.005 mg/L), which is consistent with the data collected from 1983–2009.

- Radium-226 concentrations during the spring and fall of 2010 were 0.046 Bq/L and 0.065 Bq/L, respectively, and are within the range of concentrations measured during 1983–2009 (0.01 to 0.14 mg/L). As with historic monitoring data, the concentrations measured during 2010 are below the PWQO for radium-226 (0.6 Bq/L), which is consistent with the data collected from 1983–2009.

- Thorium-230 concentrations during the spring and fall of 2010 were below the analytical detection limit of 0.005 Bq/L. Concentrations of thorium-230 reported in 2010 are similar to the concentrations reported in previous years (< 0.005 to 0.05 Bq/L)

- Lead-210 concentrations during the spring and fall of 2010 were < 0.02 Bq/L and 0.02 Bq/L, respectively. Concentrations of lead-210 reported in 2010 are within the range reported in previous years (< 0.02 to 0.06 Bq/L)

- Polonium-210 concentrations during the spring and fall of 2010 were 0.007 Bq/L and < 0.005 Bq/L, respectively. Concentrations of polonium-210 reported in 2010 are within the range reported in previous years (<0.005–0.06 Bq/L)

8.1.3.3.3 Bicroft Tailings Storage Facility

The uranium tailings stored in the Bicroft Tailings Storage Facility resulted from processing low-grade uranium ore at the Bicroft mine from 1956 to 1962. Remediation work has included vegetation of exposed tailings in 1980 and upgrading of dams in 1990 and 1997. In 2005, the Barrick Gold Corporation (Barrick) was issued a waste nuclear substance licence for the Bicroft Mine. The effluents discharge results generally meet the PWQO’s results, with a few exceptions. As part of its licence application, therefore, Barrick conducted a Screening Level Human Health and Ecological Risk Assessment (SLHHERA) to demonstrate that there is no unreasonable risk to health, safety and the environment, and to support a five-year surface water-sampling program. In 2010, the results for the radiological surface water at the final point of control were 1.3 Bq/L for radium-226 and 17 ppb for uranium.

Figure 8.8 – South Tailings Basin Spillway at Bicroft Tailings Storage Facility

8.2 Contaminated lands

8.2.1 Contaminated land under institutional control – Consolidated cells

The six consolidated cells containing historic contaminated soils have been characterized for contaminant concentrations. All of the cells have contaminant concentrations below the unconditional clearance levels set out in the *Nuclear Safety and Radiation Devices Regulations*. The disposition of these sites is still the responsibility of the federal government, but they are no longer regulated under the NSCA.

8.2.2 Historic contaminated lands

8.2.2.1 Fort Fitzgerald

From the early 1930s to the 1950s, uranium ore was transported by the Northern Transportation Route (NTR) from Port Radium on Great Bear Lake, Northwest Territories to the railhead at Waterways (now Fort McMurray, Alberta). Contaminated sites at Fort Fitzgerald exist within 100 metres of the river's edge. As part of the NTR, the sites were used as docks and boat launches. Radiological surveys were conducted in 2004, 2005 and 2006. Data from all the surveys were summarized in 2006, and the material volume was updated to approximately 10,000 cubic metres.

8.2.2.2 Sahtu Region

The Sahtu Region contaminated sites exist in isolated locations along the Great Bear River and at one remote end of Great Bear Lake in the Northwest Territories. Clean-up activities conducted by the LLRWMO at one site removed the highest-grade material, and brought readings down to below background levels. In 2003, the 10 sites along the Great Bear River were characterized; only two sites require the care of institutional controls by the Sahtu Land and Water Board and INAC. The results of the characterization were provided to the communities of Déline and Tulita. Further characterization work is planned for 2011 to identify the volume of contaminated soil at the site.

The landowners and administrators of these Northwest Territories sites have been informed of the radiological contamination and are aware of the requirement for restrictions on construction activities at the sites. They also know about the need to contact the CNSC if construction activities were ever to occur.

8.2.2.3 Toronto, Ontario

Toronto-area contaminated sites include radium-contaminated soils on lands owned by the Province of Ontario and private landowners. Contaminated sites also included radium contamination fixed to structural elements in privately owned buildings.

The contaminated soils are generally covered or occur in areas of low use (primarily open space). Since the last reporting period, the former fenced scrap metal yard underwent characterization by the Ontario Realty Corporation for both radiological and non-radiological contaminants. The CNSC determined that the radiological contaminants were naturally occurring nuclear substances (NONS). Subsequently, this property is no longer under CNSC oversight.

The owners of the private properties are aware of these control measures, and the tenants are restricted from construction activities that would compromise these safeguards. The owners are also aware of the process that requires the CNSC to be contacted and given the opportunity to assess any proposed construction or land-use changes. The CNSC maintains contact with the owners/managers of the sites, through visits and phone conversations, and conducts site visits once every three years.

8.2.2.4 Port Hope Area Initiative for the long-term management of historic low-level radioactive wastes

On March 29, 2001, an agreement was signed between the Government of Canada (represented by the Minister of Natural Resources) and the communities of Port Hope, Hope Township and Clarington for the construction of long-term waste management facilities for historic low-level radioactive wastes and for the cleanup of contaminated sites in the Port Hope area. The wastes consist of about 2 million cubic metres of LLW and contaminated soils, containing radium-226, uranium and arsenic as the primary contaminants.

With this agreement, the Government of Canada began an initiative – the Port Hope Area Initiative – to evaluate and implement a long-term solution for the management of the wastes from the Port Hope area sites. This initiative has been divided into two projects that accord with municipal boundaries. The Port Hope Project entails the cleanup and long-term management of wastes from various contaminated sites in the Municipality of Port Hope – formerly the Town of Port Hope and Hope Township. The Port Granby Project involves the implementation of a long-term management approach for radioactive wastes at the existing Port Granby Waste Management Facility in the Municipality of Clarington.

Single-purpose-built facilities are being planned to manage the wastes from each cleanup project: the Port Hope Long-Term Waste Management Facility (PHLTWMF) and the Port Granby Long-Term Waste Management Facility (PGLTWMF). The PHLTWMF, with an estimated design capacity of 1.8 million cubic metres, is planned to accept a variety of wastes from the area. These include wastes from the major unlicensed sites in the Municipality of Port Hope, such as the Alexander Street ravine, the waterworks, the viaducts area, the Mill Street south site, the landfill and the harbour. Other wastes, such as contaminated roadways and soils from private properties, will also to be included, along with wastes from Cameco's Welcome Waste Management Facility and specified historic wastes from the Cameco conversion facility. Wastes from consolidation sites and temporary storage sites within the community that are being temporarily managed by the LLRWMO will also be included, along with non-radiologically contaminated industrial wastes, as requested by the municipality and provided for in the agreement.

The PHLTWMF is planned for an expanded site at the existing Welcome Waste Management Facility located in the Municipality of Port Hope, which currently contains an estimated 500,000 cubic metres of low-level wastes and contaminated soils. An environmental assessment process has been completed for this project. On October 16, 2009, the Commission Tribunal issued a licence to AECL for the Port Hope Project. The next step is to have the Port Granby Project come before the Commission Tribunal for a licensing decision. These projects are moving forward in a phased approach. Both projects are approaching the end of the planning phase (Phase 1).

The PGLTWMF, with an estimated design capacity of 600,000 cubic metres, is being planned to accept wastes only from the existing Port Granby Waste Management Facility, which is currently owned and operated by Cameco and located in the Municipality of Clarington. The site considered for these wastes is immediately northwest of the existing facility and away from the Lake Ontario shoreline. An environmental assessment process has been completed for this project. The implementation phase of this project is expected to last for six years, once the environmental assessment and licensing process is completed. Long-term monitoring and surveillance will follow this phase.

Figure 8.9 – Port Granby concept diagram

8.2.2.5 Port Hope contaminated sites

A number of contaminated sites have been identified in the Municipality of Port Hope. Some of these sites are known as major unlicensed sites, others are known as small-scale sites, and there are also some licensed and unlicensed temporary storage and consolidation sites. Although many of these sites are not currently licensed by the CNSC, the CNSC is aware of them and is comfortable with how they are being managed. The sites are safe for casual access, pending implementation of the Port Hope Area Initiative, which will remediate them once the long-term waste management facilities for the project have been developed.

The major sites are generally well known by the community and municipality, and will not be further developed until the historic waste deposits can be removed to an appropriate storage facility. Small pockets of contaminated soils, however, also exist on roadways and municipal road allowances, and on municipal, private and commercial properties. These sites are known collectively as small-scale sites.

The development of these sites (which may include common activities such as road repair, infrastructure repair and maintenance, property regrading/landscaping, and private or commercial property development or renovation) is accommodated under the Construction Monitoring Program, an administrative program between the LLRWMO and the Municipality of Port Hope.

The municipality forwards projects that require municipal building permits to the LLRWMO for review and action. This action often results in a radiological monitoring of excavated materials in construction areas. If contaminated soils that need to be removed are identified, they are accepted at the Pine Street Extension Temporary Storage Site, a CNSC-licensed storage facility. The project may then continue as planned. The LLRWMO also accepts applications to the program directly from residents for projects that do not require building permits.

Larger projects, which may negatively impact upon the LLRWMO's ability to receive wastes at its temporary storage site (it currently has a receiving capacity of approximately 5,200 cubic metres), are accommodated through the construction of small purpose-built consolidation or storage sites. In the long term, through the PHAI, the objective is to consolidate this material within the purpose-built Port Hope Long-Term Waste Management Facility.

List of Acronyms

ACR	Advanced CANDU Reactor
AECA	*Atomic Energy Control Act*
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
AGTMF	above ground tailings management facility
ALARA	as low as reasonably achievable
ALI	annual limit on intake
APM	Adaptive Phased Management
AREVA	AREVA Resources Canada Inc.
ASDR	L'aire de stockage des déchets radioactifs (radioactive waste storage area)
ASME	American Society of Mechanical Engineers
BLW	Boiling Light-Water
Cameco	Cameco Corporation
CANDU	Canadian Deuterium-Uranium
CANSTOR	CANDU Storage
CCP	CNSC Compliance Program
CEA Act	*Canadian Environmental Assessment Act*
CEA Agency	Canadian Environmental Assessment Agency
CEPA	*Canadian Environmental Protection Act*
CLEAN	Contaminated Lands Evaluation and Assessment Network
CNSC	Canadian Nuclear Safety Commission
CRAG	Cost Recovery Advisory Group
CRL	Chalk River Laboratories
CSA	Canadian Standards Association
CURE	Canadian Uranium Regulatory Examination
D&WM	Atomic Energy of Canada Limited – Decommissioning & Waste Management organizational unit
DEL	derived emission limit
DFAIT	Department of Foreign Affairs and International Trade; also referred to as Foreign Affairs and International Trade Canada
DGR	Deep Geologic Repository
DJX	Dominique–Janine Extension
DJN	Dominique–Janine North
DO	designated officer
DPNGS	Douglas Point Nuclear Generating Station
DPWMF	Douglas Point Waste Management Facility
DRL	derived release limit
DSM	dry storage module
EA	environmental assessment
EASR	EA Study Report
EC	Environment Canada
EIS	environmental impact statement
EMS	environmental management system
EOC	Emergency Operations Centre
EP	emergency preparedness
FA	Federal Authority
FA	*Fisheries Act*
FNEP	Federal Nuclear Emergency Plan
FPS	Fuel Packaging and Storage
GNSCR	*General Nuclear Safety and Control Regulations*
G1WMF	Gentilly-1 Waste Management Facility
GWMF	Geologic Waste Management Facility
HADD	harmful alteration, disruption or destruction
HC	Health Canada
HEPA	high-efficiency particulate air

HEU	highly enriched uranium
HQ	Hydro-Québec
HLW	high-level radioactive waste
IAEA	International Atomic Energy Agency
IAEA BSS	*International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*
IAS	independent assessment study
ICP	Institutional Control Program
ICRP	International Commission on Radiological Protection
ICWP	Institutional Control Working Group
ILW	intermediate-level radioactive waste
ILW-LL	long-lived intermediate-level radioactive waste
ILW-SL	short-lived intermediate-level radioactive waste
INAC	Indian and Northern Affairs Canada
IRRS	Integrated Regulatory Review Services
JEB	John Everett Bates
JRG	Joint Regulatory Group
LEU	low-enriched uranium
L&ILW	low- and intermediate-level radioactive waste
LLRWMO	Low-Level Radioactive Waste Management Office
LLW	low-level radioactive waste
LWE	liquid waste evaporator
LWTS	Liquid Waste Transfer and Storage
MACSTOR	Modular Air-Cooled Storage
MAGS	modular above ground storage
MNR	McMaster Nuclear Reactor
MPMO	Major Projects Management Office – Natural Resources Canada
NB EMO	New Brunswick Emergency Measures Organization
NB Power	New Brunswick Power Corporation
NCA	Nuclear Cooperation Agreement
NEA	*Nuclear Energy Act*; Nuclear Energy Agency
NEM	Nuclear Emergency Management
NFWA	*Nuclear Fuel Waste Act*
NGS	nuclear generating station
NGO	non-governmental organization
NLA	*Nuclear Liability Act*
NLLP	Nuclear Legacy Liabilities Program
NNIECR	*Nuclear Non-proliferation Import and Export Control Regulations*
NONS	naturally occurring nuclear substances
NPD	Nuclear Power Demonstration
NPP	nuclear power plant
NRCan	Natural Resources Canada
NRU	National Research Universal
NRX	National Research Experimental
NSCA	*Nuclear Safety and Control Act*
NS EMO	Nova Scotia Emergency Measures Organization
NSERC	Natural Sciences and Engineering Research Council
NSR	*Nuclear Security Regulations*
NSRDR	*Nuclear Substances and Radiation Devices Regulations*
NSSR	National Sealed Source Registry
NTR	Northern Transportation Route
NWMO	Nuclear Waste Management Organization
OMOE	Ontario Ministry of the Environment
OPG	Ontario Power Generation
OP&P	operating policies and principles
OSCQ	Organisation de la sécurité civile du Québec

PCB	polychlorinated biphenyl
PGLTWMF	Port Granby Long-Term Waste Management Facility
PHAI	Port Hope Area Initiative
PHLTWMF	Port Hope Long-Term Waste Management Facility
PTNSR	*Packaging and Transport of Nuclear Substances Regulations*
PTR	Pool Test Reactor
PWQO	Ontario Provincial Water Quality Objectives
RA	responsible authority
RCSA	re-tube components storage area
RMC	Royal Military College
RPR	*Radiation Protection Regulations*
RWOS 1	Radioactive Waste Operations Site 1
SaskEMO	Saskatchewan Emergency Management Organization
SLHHERA	Screening Level Human Health and Ecological Risk Assessment
SMAGS	shielded above ground storage
SRECC	Serpent River Region Environmental Committee
SSAC	Canada's State System of Accounting for and Control of Nuclear Materials
SSTS	Sealed Source Tracking System
SRWMF	Solid Radioactive Waste Management Facility
TC	Transport Canada
the Code	Code of Conduct on the Safety and Security of Radioactive Sources
the IAEA Guidance	Guidance on the Import and Export of Radioactive Sources
TLD	thermoluminescent dosimeter
TMA	tailings management area
TMF	tailings management facility
TPMB	Transportation Package Maintenance Building (Western Waste Management Facility)
TRIUMF	TriUniversity Meson Facility
UMMR	*Uranium Mines and Mills Regulations*
UNENE	University Network of Excellence in Nuclear Engineering
URL	Underground Research Laboratory
VLLW	very-low-level radioactive waste
VSLLW	very-short-lived low-level radioactive waste
WFOL	waste facility operating licence
WL	Whiteshell Laboratories
WMF	waste management facility
WR-1	Whiteshell Reactor-1
WTC	Waste Treatment Centre
WVRB	Waste Volume Reduction Building (Western Waste Management Facility)
WWMF	Western Waste Management Facility
XRF	X-ray fluorescence
ZED-2	Zero Energy Deuterium-2