CANADIAN NATIONAL REPORT

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

SEVENTH REPORT
OCTOBER 2020

THE FOLLOWING ORGANIZATIONS CONTRIBUTED TO THE REPORT:

Government of Canada (Canadian Nuclear Safety Commission and Natural Resources Canada),
Atomic Energy of Canada Limited, the Nuclear Waste Management Organization,
Ontario Power Generation Inc., Bruce Power, New Brunswick Power, Hydro-Québec,
Cameco Corporation, Orano, Nordion Inc., and BWX Technologies Inc.

Preface

The *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* (Joint Convention or Convention) is the only international legally-binding instrument that addresses the safety of spent fuel and radioactive waste management on a global scale. The Contracting Parties to the Joint Convention have made a commitment to apply stringent safety measures, prepare a national report on the measures applied and submit it for review by the other Contracting Parties. As well, they will actively participate in the review meetings of the Contracting Parties.

The Joint Convention was adopted on September 5, 1997, at a diplomatic conference convened by the IAEA in Vienna, Austria. The Convention was opened for signature on September 29, 1997, and entered into force on June 18, 2001. Canada was one of the first countries to ratify the Joint Convention on May 7, 1998.

The Joint Convention is an incentive convention which seeks to promote a high level of safety in the management of spent fuel and radioactive waste through a peer review process, every three years.

The objectives of the Joint Convention are to:

- achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management
- ensure that there are effective defenses against potential hazards in the course of such activities
- prevent accidents with radiological consequences and mitigate these consequences should they occur at any stage of spent fuel or radioactive waste management

The Joint Convention applies to:

- spent fuel arising from the operation of civilian nuclear reactors
- radioactive waste arising from civilian applications
- uranium mining and milling wastes
- discharges from regulated activities
- specific provisions on disused sealed sources

The structure of the Convention (as outlined in the Articles of the Joint Convention INFCIRC/546, dated December 24, 1997) is as follows:

- Objectives, Definitions and Scope of Application (Articles 1 to 3)
- Specific Safety Provisions (Articles 4 to 17)
    - Articles 4 to 10: Safety of Spent Fuel Management
    - Articles 11 to 17: Safety of Radioactive Waste Management
- General Safety Provisions (Articles 18 to 26)
- Miscellaneous Provisions (Articles 27 and 28)
- Meetings of the Contracting Parties (Articles 29 to 37)
- Final Clauses and other Provisions (Articles 38 to 44)

The International Atomic Energy Agency (IAEA) serves as the Secretariat for the Joint Convention. The responsibility of implementing the obligations of the Convention on behalf of the Government of Canada has been delegated to the Canadian Nuclear Safety Commission (CNSC).

This report is Canada’s Seventh National Report for the Joint Convention. The review period for the report is from April 1, 2017, to March 31, 2020. The radioactive waste inventory is reported as of December 31, 2019. The following organizations contributed to the development of this report: the CNSC, Natural Resources Canada, Atomic Energy of Canada Limited, the Nuclear Waste Management Organization, Ontario Power Generation Inc., Bruce Power, New Brunswick Power, Hydro-Québec, Cameco Corporation, Orano, Nordion Inc. and BWX Technologies Inc.

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Executive Summary

1.0 Introduction

Canada's Seventh National Report demonstrates how Canada continued to meet its obligations under the articles of the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* during the reporting period, from April 1, 2017, to March 31, 2020. This report is a collaboration between the Canadian Nuclear Safety Commission (CNSC), federal government departments and industry. It focuses specifically on the progress of long-term management initiatives for spent fuel and radioactive wastes in Canada, revisions and updates to Canada's Sixth National Report, as well as comments and issues raised at the Sixth Review Meeting which took place in May 2018.

2.0 2019 Integrated Regulatory Review Service mission to Canada

In September 2019, the CNSC hosted an International Atomic Energy Agency (IAEA) Integrated Regulatory Review Service (IRRS) mission to Canada. The scope of the 2019 mission included all activities and facilities licensed by the CNSC, including the regulation of waste management activities. The 2019 IRRS mission confirmed that the CNSC has a strong regulatory framework and continues to ensure the safe operation of nuclear facilities in Canada. The mission to Canada also provided valuable insights; the CNSC and other Canadian federal departments were presented with suggestions, recommendations and a number of good practices to further improve Canada's oversight of the nuclear industry, including the CNSC's regulatory framework.

The CNSC developed an action plan to address the findings of the 2019 IRRS mission. On February 18, 2020, the CNSC publicly shared Canada's response to each recommendation, suggestion and good practice. These actions show Canada's commitment to addressing the findings of the 2019 IRRS mission, and they will be used to determine whether recommendations and suggestions have been fully addressed prior to the IRRS follow-up mission. The CNSC will continue to share progress related to continuous improvement initiatives resulting from the 2019 IRRS mission in an open and transparent manner. For further information, see section K.5.1.

3.0 Canada's key highlights and current priorities

The following emerged from the Sixth Review Meeting as Canada's current priorities and planned measures to improve safety:

- the modernization of the waste and decommissioning regulatory framework

  As part of its ongoing modernization of the regulatory framework, the CNSC is currently completing the development or update of five regulatory documents related to radioactive waste management and decommissioning, including:

  - REGDOC-1.2.1, *Guidance on Deep Geological Repository Site Characterization*
  - REGDOC-2.11.1, *Waste Management, Volume I: Management of Radioactive Waste*
  - REGDOC-2.11.1, *Waste Management, Volume III: Safety Case for Disposal of Radioactive Waste, Version 2*
  - REGDOC-2.11.2, *Decommissioning*
  - REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*

  These regulatory documents are slated for publication in the 2020–21 fiscal year. For further information, see section K.2.1.

- the implementation of the *Impact Assessment Act*

  The Government of Canada brought in new rules to protect the environment, recognize and respect Indigenous rights, and strengthen the economy through the new *Impact Assessment Act* (IAA), which came into force on August 28, 2019. The impact assessment process is led by the Impact Assessment Agency of Canada (IAAC) and serves as a planning tool that takes into consideration the whole range of environmental, health, social and economic effects of projects. This regime shifts away from decisions based solely on the significance of effects and focuses instead on whether the adverse effects in areas of federal jurisdiction are in the public interest. For further information, see section K.2.2.

- the decommissioning and remediation of Atomic Energy Canada Limited (AECL) sites (under the management of Canadian Nuclear Laboratories (CNL))

  With the implementation of the government-owned contractor-operated (GoCo) model at AECL sites, CNL continues to significantly accelerate decommissioning and remediation activities. Notable progress has occurred at all sites since the Sixth Review Meeting. This includes:

  - the decommissioning and demolition of 77 structures in the supervised and controlled areas at Chalk River Laboratories (CRL), bringing the total number of removed redundant structures to 92 of the more than 120 committed from 2015 through 2026

  - progress made to place the National Research Universal (NRU) reactor in a storage-with-surveillance state (following end of operation in March 2018)

  - the decommissioning licence for Whiteshell Laboratories (WL) site renewed for a period of five years (commencing December 2019)

  - the decommissioning of a further 20 redundant structures at the WL site, and overall decommissioning of WL on track for completion by 2027

  - the environmental assessment and licensing of regulatory processes launched in 2017 for:

    - a near surface disposal facility (NSDF) for the disposal of up to 1,000,000 m^3 of low-level radioactive waste (LLW) at CRL. Pending regulatory approval, the proposed disposal facility will be constructed, and the forecasted date of operations is 2024

    - the *in situ* decommissioning of the Nuclear Power Demonstration (NPD) reactor at Rolphton, near CRL. Pending regulatory approval, the site is slated to be decommissioned by 2024

    - the *in situ* decommissioning of Whiteshell Reactor-1 (WR-1) reactor at WL

    Following extensive public consultation on the draft environmental impact statements (EISs), extensive comments and questions were received from government agencies, Indigenous communities, civil society organizations and members of the public. After taking into account all of the feedback, CNL submitted revised draft EIS packages for regulatory review (NSDF in December 2019, NPD and WR-1 in March 2020). After the successful completion of the regulatory review, each one will be considered at a CNSC public Commission hearing.

  - the preparation of additional interim storage capacity for LLW at CRL while awaiting the start of operations at the NSDF

  - the evaluation of ongoing intermediate-level radioactive waste (ILW) storage requirements, including near- to medium-term capacity needs, given that current capacity is limited and the plan is to consolidate the storage of all AECL/CNL ILW at CRL, until ILW disposal becomes available

  - the expansion of CRL's capacity to store dry storage canisters for spent fuel to accommodate the consolidation of spent fuel storage at CRL while awaiting availability at the Adaptive Phased Management (APM) facility of the Nuclear Waste Management Organization (NWMO)

  - the completion of the highly enriched uranium (HEU) fuel rod repatriation program to the United States Department of Energy

  - the completed commissioning of the fuel packaging and storage facility, and the associated transfer and drying of 96 vulnerable spent fuel packages

  - major progress in the Port Hope Area Initiative (PHAI) cleanup, including:

    - completed construction of the engineered containment mound (ECM) facilities at both Port Hope and Port Granby

    - initiation of cleanup activities within the municipality of Port Hope; closing and capping the Port Hope ECM facility on track for 2026

    - nearly completed remediation at Port Granby; closing and capping the Port Granby ECM facility on track for 2021

  - the identification of means of disposal for wastes from the cleanup of contaminated sites along the Northern Transportation Route (NTR), enabling the substantial completion of remediation activities by 2026

  - continued progress retrieving and processing stored liquid wastes from several buildings at the CRL site (approximately 3 m^3 of liquid wastes removed and immobilized)

  For further information, including details of the significant progress made on the above activities since 2015, see section K.2.3.

- the long-term management of spent fuel and location of an acceptable site in a willing host community for a spent fuel repository

  The momentum for implementing the long-term management approach for spent fuel has been sustained ever since the NWMO received its 2007 mandate to implement the APM approach approved by the Government of Canada. When the site selection process was initiated in 2010, a total of 22 communities expressed interest in learning more about the project. As of March 2020, two candidate communities had been identified, one in South Bruce Municipality and one near Ignace, both in Ontario. Studies and community consultation continue in these areas. Indigenous communities are also involved, as facilitated through learning agreements. For more information, see section K.2.4

- deep geologic repository proposed by Ontario Power Generation (OPG) for its low- and intermediate-level wastes

  On August 21, 2017, the federal Minister of Environment and Climate Change asked OPG to update the analysis of the potential cumulative effects the project could have on the Saugeen Ojibway Nation's cultural heritage and to include a description of the potential effects of the project on the Saugeen Ojibway Nation's spiritual and cultural connection to the land. Further, the Minister's letter indicated that the results of the Saugeen Ojibway Nation community process had to inform the analysis. OPG engaged with the community's leadership to establish a process, which culminated in a community vote. On January 31, 2020, the Saugeen Ojibway Nation voted to not support the project. OPG respects the community's decision and has formally cancelled the project. OPG has withdrawn its application to the CNSC to construct the deep geologic repository. For further information, see section K.2.5.

- the discussion about options for an integrated strategy by Canada's radioactive waste owners under the Radioactive Waste Leadership Forum (RWLF)

  Canada's largest radioactive waste owners – AECL, OPG, Hydro-Québec (H-Q) and New Brunswick Power (NB Power) – and other selected stakeholders continue to meet under the sponsorship of the CANDU Owners' Group (COG) Radioactive Waste Leadership Forum (RWLF) to discuss opportunities for coordination and collaboration on long-term management matters, including relevant technologies and communication strategies. The RWLF launched a project to produce an integrated radioactive waste strategy for Canada. The first output of this industry-led strategy exercise is expected in the summer of 2020. For further information, see section K.2.6.

4.0 Overarching issues

During the Sixth Review Meeting, overarching issues that arose from cumulative discussions within the country groups were identified. The Contracting Parties agreed that the following issues would be covered in the National Report, along with the measures taken to address these issues:

- the implementation of national strategies for spent fuel and radioactive waste management
- the safety implications of the long-term management of spent fuel
- the linking of long-term management and disposal of disused sealed radioactive sources
- the remediation of legacy sites and facilities

For details on each item, see section K.3.

5.0 Nuclear facilities undergoing decommissioning in Canada

The following nuclear facilities are currently in the process of being decommissioned in Canada:

- CRL
- Douglas Point Waste Management Facility (WMF)
- Gentilly-1 WMF
- Gentilly-2 Nuclear Generating Station (NGS)
- Gunnar mine site
- NPD
- Saskatchewan Research Council (SRC) Safe Low-Power Critical Experiment (SLOWPOKE)-2
- WL

The status of decommissioning activities at these facilities can be found in section D.1.5 and annex 8.

6.0 Conclusion

In Canada, spent fuel and radioactive wastes are currently managed in interim storage facilities that are safe, secure and environmentally sound. Interim storage facilities are continually monitored by the licensees and the CNSC to ensure fitness for service. Canada recognizes that enhanced, long-term management approaches will be required for all its spent fuel and radioactive wastes, and it is making progress developing solutions.

Canada’s Seventh National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management describes 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

Section A – Introduction

A.1 Background

The Government of Canada has jurisdiction over nuclear energy, and Natural Resources Canada (NRCan) is the department responsible for federal 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 over 15 percent of Canada's electricity.
- The nuclear industry is a significant contributor to the Canadian economy, currently generating $17 billion in economic activity and accounting for more than 76,000 highly-skilled direct and indirect jobs.
- Canada is the world's second largest producer and exporter of uranium which ranked seventh among metal commodities in Canada for value of production in 2019.

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
- uranium refining and conversion
- nuclear fuel fabrication
- nuclear reactor operations
- nuclear research
- radioisotope manufacture and use
- radioactive waste and decommissioning

The Government of Canada makes it a high priority to ensure the safety of persons and to protect the environment from the various operations of the nuclear industry, and it 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 CNSC. In addition to NRCan and the CNSC, the major Government of Canada organizations involved in the Canadian nuclear industry include:

- Atomic Energy of Canada Limited (AECL)
- Environment and Climate Change Canada
- Global Affairs Canada
- Health Canada
- Impact Assessment Agency of Canada (IAAC)
- Transport Canada

Section E.2.7 provides information on Canada's federal structure and detailed descriptions of the federal institutions involved in nuclear energy.

The following are the centrepieces of Canada's legislative and regulatory framework for nuclear matters: the *Nuclear Safety and Control Act* (NSCA), the *Nuclear Energy Act* (NEA), the *Nuclear Fuel Waste Act* (NFWA) and the *Nuclear Liability and Compensation Act* (NLCA). 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 section E.2.1.

Provincial governments are responsible for deciding their energy mix, including the role of nuclear energy. Provincial ministries may play roles in nuclear activities and radioactive waste management; the details of those roles are determined by each province.

A.2 Regulation of nuclear substances

Under the NSCA, one objective of the CNSC is to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to protect the health and safety of persons, the environment and national security, and to comply with the measures of control and international obligations to which Canada has agreed. A nuclear substance, as defined in section 2 of the NSCA, means: deuterium, thorium, uranium or an element with an atomic number greater than 92; a derivative or compound of deuterium, thorium, uranium or an element with an atomic number greater than 92; a radioactive nuclide; a substance that is prescribed as being capable of releasing nuclear energy or as being required for the production or use of nuclear energy; a radioactive by-product of the development, production or use of nuclear energy; and a radioactive substance or radioactive thing that was used for the development or production, or in connection with the use, of nuclear energy.

Both radioactive wastes and spent fuel contain nuclear substances and therefore are regulated in the same manner as any other nuclear substance. Section B.1.2 describes the policy on managing spent fuel and radioactive waste.

A.3 Canadian philosophy and approach to safety

Canada actively promotes and regulates safety within the nuclear sector. Canada's approach is based on several factors, including:

- the review of international standards (e.g., IAEA standards and guides) and improvements to CNSC regulatory policies and standards
- consideration for the adoption of international recommendations, such as those regarding radiological dose limits to the public and workers, as outlined in the *Recommendations of the International Commission on Radiological Protection* (ICRP-103, 2007) issued by the International Commission on Radiological Protection (ICRP)
- consideration for provincial acts and regulations in place for the protection of the environment. For example, limits for controlled releases 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 Effluent Regulations*) or derived from specific licence conditions (such as the derived release limits)
- consideration for the adoption of other standards established by organizations like the Canadian Standards Association (CSA) Group

The CNSC's regulatory philosophy is based on the following:

- Licensees are directly responsible for managing regulated activities in a manner that protects health, safety, security and the environment, and that conforms with Canada’s domestic and international obligations on the peaceful use of nuclear energy.

- The CNSC is accountable to Parliament and to Canadians for assuring that these responsibilities are properly discharged.

The CNSC, therefore, ensures that the regulated parties are informed about requirements and provided with guidance on how to meet them, and then it verifies that all regulatory requirements are and continue to be met.

A.4 Continuous improvement

The CNSC is committed to the continuous improvement of both its internal operations and its regulation of the Canadian nuclear industry. Thus, the CNSC requires licensees to strive to further reduce the risks associated with their licensed activities on an ongoing basis. It assesses how licensees manage risk during both normal operations and in response to potential accident conditions, and how they apply principles like as low as reasonably achievable (ALARA) and defence in depth. In its assessments, the CNSC considers how licensees continuously evaluate, manage and further reduce uncertainties with respect to hazards and safety issues. This also includes assessing how licensees consider additional safety and mitigation options as techniques and technologies evolve.

A.5 Defence in depth

CNSC requirements necessitate the implementation of defence in depth in the design, construction and operation of nuclear facilities or undertaking of nuclear activities. With defence in depth, more than one level of defence (i.e., protective measure) is in place for a given safety objective, so that the objective will still be achieved even if one of the protective measures fails.

To achieve this, multiple independent levels of defence must be put into place to the extent practicable, taking organizational, behavioural and engineered safety and security elements into account, so that no potential human or mechanical failure relies exclusively on a single level of defence.

A.6 Protection of the environment

Environmental protection is a shared federal-provincial responsibility. The CNSC cooperates with other jurisdictions and departments, and where appropriate, enters into formal arrangements to protect the environment more effectively and to coordinate regulatory oversight.

The CNSC’s environmental protection mandate includes design objectives and best practices to minimize or eliminate the release of nuclear or hazardous substances to the environment. Environmental protection measures are commensurate with the level of risk associated with the activity. The CNSC determines whether a licensee or applicant will make adequate provision to protect the environment against unreasonable risk and verifies compliance with the associated regulatory requirements.

A.7 Protection of the health and safety of persons

The CNSC sets dose limits that are within protective health limits and establishes regulations that set requirements to prevent unreasonable risk to the health and safety of persons. These limits are described in the *Radiation Protection Regulations* (RPR) and are consistent with the recommendations of the ICRP. The Regulations also require every licensee to implement a radiation protection program that takes the principle of ALARA into consideration. In addition to radiological hazards, regulating to prevent unreasonable risk to the health and safety of persons addresses conventional health and safety hazards.

A.8 Protection of national security

To prevent risk to national security, the CNSC works closely with nuclear facility operators, law enforcement and intelligence agencies, international organizations and other governmental departments to ensure that nuclear substances and facilities are adequately protected. Nuclear security in Canada is aided by the *Nuclear Security Regulations* (NSR). These regulations set out detailed security requirements for licensed nuclear facilities and other regulated activities.

A.9 International obligations

The CNSC participates in international forums to provide global nuclear leadership and to benefit from international experience and best practices. It also participates in undertakings implemented by the IAEA, the ICRP and other international organizations, and in activities under certain treaties, such as the Joint Convention.

These international activities help inform the CNSC's decision-making processes to:

- understand and compare various ways of evaluating and mitigating risks
- share research and operational experience

A.10 Nuclear non-proliferation

The CNSC is responsible for implementing Canada's nuclear non-proliferation commitments and government policy to:

- assure Canadians and the international community that Canada's nuclear exports do not contribute to the development of nuclear weapons or other nuclear explosive devices
- promote a more effective and comprehensive international nuclear non-proliferation regime

The international *Treaty on the Non-Proliferation of Nuclear Weapons* (the non-proliferation treaty (NPT)) is the cornerstone of Canada's efforts to promote its objectives of international disarmament, non-proliferation, and the peaceful use of nuclear energy. NPT commitments to which Canada has agreed include:

- to not receive, manufacture or acquire nuclear weapons or other nuclear explosive devices
- to accept IAEA safeguards on all nuclear material for peaceful use in Canada
- to ensure that Canada's nuclear material exports are subject to IAEA oversight

The CNSC implements these commitments through the NSCA and its associated regulations, including the *Nuclear Non-proliferation Import and Export Control Regulations* (NNIECR).

A.11 Safeguards

The term "safeguards" refers to the measures taken by the IAEA, in accordance with the NPT, to verify that nuclear material is not diverted from peaceful uses to develop nuclear weapons. The safeguards agreement between the Government of Canada and the IAEA give the IAEA the right and obligation to monitor Canada's nuclear-related activities, and to verify nuclear material inventories and flows in Canada.

Through its regulatory oversight, the CNSC ensures that all applicable licensees have safeguards programs in place to allow for:

- monitoring and reporting on nuclear material and activities

- providing IAEA safeguards inspectors with access to areas where nuclear material is stored and access to certain specified nuclear-related manufacturing and research activities

- providing operational and design information for nuclear facilities to the IAEA

Where required by the safeguards agreements, the CNSC compiles licensee information and submits it to the IAEA on behalf of the Government of Canada. The CNSC has also cooperated with the IAEA to develop new safeguards approaches for Canadian facilities, and it contributes to efforts to strengthen IAEA safeguards internationally.

A.12 Main safety issue

The main safety issue that this report begins to address is the long-term management of spent fuel and radioactive wastes.

In Canada, developing and implementing the long-term management of radioactive wastes is the responsibility of the waste owner. Currently, interim storage of all waste forms 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 to develop and implement appropriate long-term solutions that inspire and uphold the public's confidence.

The long-term management of radioactive waste from past practices has been a challenge for the federal and provincial governments as they develop and implement appropriate remedial strategies and long-term waste management solutions. Several initiatives have been completed or are underway to address these sites, as described in sections H.2.1 and K.3.4.

A.13 Main themes in Canada's Seventh National Report

The main themes in this report are as follows:

- The Government of Canada's departments and agencies and the nuclear industry have roles and responsibilities – confirmed in the Government of Canada's *Radioactive Waste Policy Framework* – to ensure the safe management of spent fuel and radioactive wastes.

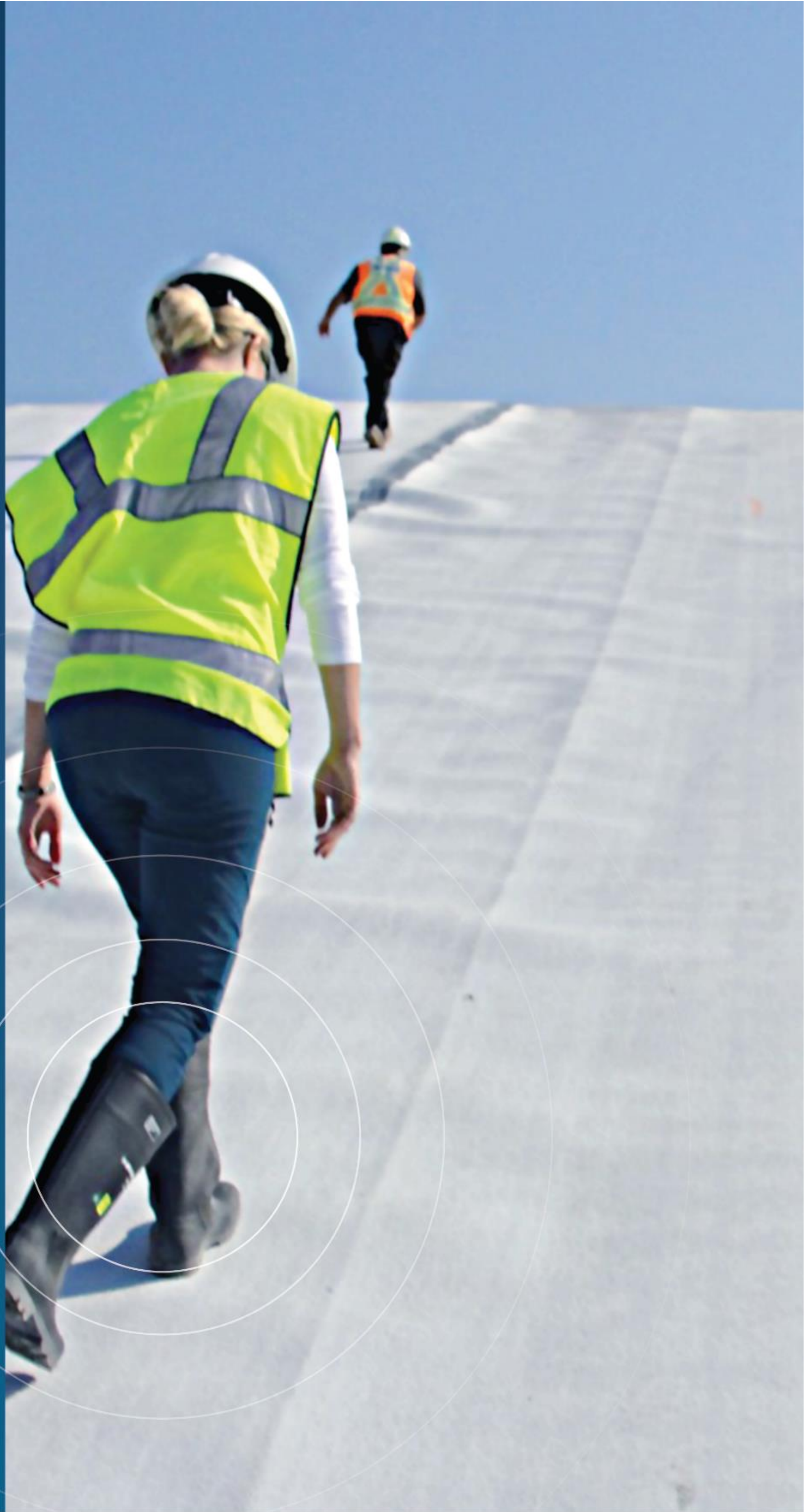
- The primary responsibility for safety rests with the licensees. All licensees take their responsibility for safety seriously and are able to raise adequate revenues to support safe operations.

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

- The 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 wastes, and for the cleanup of wastes from past practices like uranium mining and processing.

SECTION B
Policies & practices



Section B – Policies and Practices

B.1 Reporting (Article 32(1))

This section addresses the obligations under Article 32(1) of the Joint Convention.

ARTICLE 32. REPORTING

1 In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

(i) spent fuel management policy;

(ii) spent fuel management practices;

(iii) radioactive waste management policy;

(iv) radioactive waste management practices;

(v) criteria used to define and categorize radioactive waste

B.1.1 Classification of radioactive waste in Canada

Established in 1919, the Canadian Standards Association (now called the CSA Group) is a not-for-profit organization composed of representatives from the government, industry and consumer groups. Its primary product is safety and performance standards, including those for electronic and industrial equipment, boilers and pressure vessels, compressed gas handling appliances, environmental protection and construction materials. The CSA Group also provides training materials and information products.

The CSA Group, in collaboration with industry, government and the CNSC, developed a standard that includes a radioactive waste classification system (CSA N292.0, *General principles for the management of radioactive waste and irradiated fuel*), which takes into account the IAEA's general safety guide GSG-1, *Classification of Radioactive Waste,* along with the needs of the Canadian industry. The second edition was published in 2019, superseding the previous edition published in 2014. CSA N292.0-19 recognizes four main classes of radioactive waste:

- high-level radioactive waste (HLW)
- intermediate-level radioactive waste (ILW)
- low-level radioactive waste (LLW)
- uranium mine and mill tailings

Subclasses for LLW are also identified to provide better guidance on the appropriate waste management needs.

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

A definitive numerical boundary between the various categories of radioactive waste – primarily between LLW and ILW – cannot be provided, because activity limitations differ between individual radionuclides and radionuclide groups, and will be dependent on short- and long-term safety-management considerations. A contact dose rate of 2 mSv/h has been used as guidance in some cases to distinguish between LLW and ILW.

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

B.1.1.1 High-level radioactive waste

HLW is used or irradiated nuclear fuel that has been declared radioactive waste and/or waste that generates significant heat (typically more than 2 kW/m^3) via radioactive decay. HLW typically has levels of activity concentration that range from 10^4 to 10^6 TBq/m^3.

In Canada, "irradiated nuclear fuel" or "used nuclear fuel" are more accurate terms for spent fuel, because discharged fuel is considered a waste material even when it is not fully spent. Despite the name difference, in this report, the term "spent fuel" is used, and it is consistent with the terminology used in the Joint Convention.

Spent fuel is associated with penetrating radiation; thus, shielding is required. Spent fuel also contains significant quantities of long-lived radionuclides, necessitating long-term isolation. Waste forms derived from spent fuel (e.g., nuclear fuel reprocessing wastes) can also exhibit similar characteristics and are therefore considered HLW.

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

B.1.1.2 Intermediate-level radioactive waste

ILW generally requires little or no heat dissipation during its handling, transportation and long-term management. However, because of its total radioactivity level, it may be necessary to consider of the implications of ILW short-term heat generation. Because of its long-lived radionuclides, ILW generally requires a higher level of containment and isolation than can be provided in near-surface repositories.

B.1.1.3 Low-level radioactive waste

LLW contains material with radionuclide content above established clearance levels and exemption quantities, but generally has limited amounts of long-lived activity. For orientation purposes only, a limit of 400 Bq/g on average (and up to 4,000 Bq/g for individual waste packages) for long-lived alpha emitting radionuclides can be considered in the classification process. For long-lived beta and/or gamma emitting radionuclides, such as carbon-14, chlorine-36, nickel-63, zirconium-93, niobium-94, technetium-99 and iodine-129, the allowable average activity concentrations can be considerably higher (up to tens of kBq/g) and can be specific to the site and disposal facility. LLW requires isolation and containment for up to a few hundred years.

B.1.1.3.1 Very-short-lived low-level radioactive waste

Very-short-lived low-level radioactive waste (VSLLW) is waste that can be stored for a decay period of not more than a few years (a time frame of two years is commonly used) and subsequently cleared for release. VSLLW includes radioactive waste containing only short half-life radionuclides typically used for research and biomedical purposes. Examples of such radioactive waste are iridium-192 and technetium-99m sources and radioactive wastes containing similar short half-life radionuclides from industrial and medical applications.

The main criterion used to identify VSLLW is the half-life of the predominant radionuclides. In general, the management of VSLLW should only be applied to radionuclides with a half-life of 100 days or less.

B.1.1.3.2 Very-low-level radioactive waste

Very-low-level radioactive waste (VLLW) has a low hazard potential and does not meet the criteria for exemption. Long-term waste management facilities for VLLW do not need a high degree of containment and/or isolation; a near-surface repository with limited regulatory control is generally suitable. Typically, VLLW includes bulk material like low-activity soil and rubble, as well as some uranium wastes.

B.1.1.4 Uranium mine and mill tailings

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

B.1.2 Spent fuel and radioactive waste management policy

In Canada, matters that relate to nuclear activities and substances are under the jurisdiction of the Government of Canada. Natural Resources Canada (NRCan) has been charged with setting Canada's nuclear policies, including those that concern radioactive wastes. The Government of Canada's *Radioactive Waste Policy Framework* establishes the roles and responsibilities of the Government of Canada, and of the waste producers and owners. In particular:

- The federal government will ensure that radioactive waste disposal is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner.
- The federal government's responsibility is to develop policy, regulate and oversee producers and owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans.
- Based on the "polluter pays" principle, the waste producers and owners are responsible for funding, organizing, managing and operating the disposal and other facilities required for their wastes. This recognizes that arrangements may be different for nuclear fuel waste, LLW and uranium mine and mill tailings.

Under Canada's 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.

In September 2019, the IAEA undertook an IRRS mission and concluded that Canada has a comprehensive framework for nuclear and radiation safety. It also noted six good practices for other countries to consider. The review included a recommendation that the government enhance the existing policy and establish an associated strategy to give effect to the principles stated in the Government of Canada's *Radioactive Waste Policy Framework*.

As part of Canada's management response to the recommendation, the Government of Canada will review its existing policy for radioactive waste and consider ways to enhance it to give effect to the principles stated in the *Radioactive Waste Policy Framework*, including establishing an associated strategy. NRCan will undertake this review as the lead government department responsible for developing and implementing federal nuclear energy policy in Canada.

In December 2018, the CNSC issued regulatory document REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada* which gives an overview of the governance and regulatory framework for radioactive waste management and decommissioning in Canada. This overview provides the basis for the other documents in the CNSC's waste management series of regulatory documents.

REGDOC-2.11 outlines the philosophy that governs the CNSC's regulation of radioactive waste and is fully consistent with the federal *Radioactive Waste Policy Framework.* REGDOC-2.11 identifies the need for the long-term management of radioactive and hazardous wastes that arise from licensed activities.

REGDOC-2.11 includes a policy statement in which radioactive waste is defined as any form of waste material that contains a nuclear substance, as 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 about 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:

- The generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices.
- 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.
- The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time during which the maximum impact is predicted to occur.
- 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.
- 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.
- 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 principles contained in REGDOC-2.11 are consistent with those recommended by the IAEA. REGDOC-2.11 also recognizes the CNSC's commitment to optimizing regulatory effort, stating that the CNSC should 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
- achieve conformity with the measures of control and international obligations to which Canada has agreed concerning radioactive waste

B.1.3 Spent fuel management practices

B.1.3.1 Spent fuel in Canada

B.1.3.1.1 Spent fuel generated at nuclear power reactors

In Canada, spent fuel is stored in wet and dry states. 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 a dry storage facility. These dry storage facilities employ large, reinforced concrete canisters or containers. Each nuclear power plant (NPP) site in Canada has enough space to store all the spent fuel produced during the operating life of the station. A 600-megawatt CANDU nuclear reactor produces approximately 90 tonnes of heavy metal spent fuel annually.

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

- small quantities of spent fuel that are transported to research facilities for experimental or examination purposes and stored at those facilities
- the fuel from the NPD reactor, which is in dry storage at the nearby CRL site

All Canadian nuclear power reactors were constructed with on-site spent fuel storage bays or water pools. Spent CANDU fuel is initially stored in light water with continuous heat removal capability. Criticality cannot be achieved with CANDU fuel in light water, independent of temperature. Spent fuel is then stored in dry storage facilities after a specified period of decay. Secondary or auxiliary bays were constructed at the Pickering A (Units 1 to 4) Nuclear Generating Station (NGS) and the Bruce A and Bruce B NGSs for additional storage. Since 1990, dry storage technology has been chosen at all the reactor sites for additional on-site interim storage.

All CANDU fuel bundles are fabricated from natural uranium oxide pellets contained in a zirconium-alloy (zircaloy-4) tube (cladding). Variations occur in the overall length, diameter and weight of the fuel bundles between reactors; the information that follows is based on averaged data. Normally, there are 30 uranium oxide pellets per fuel bundle 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 uranium (without the oxygen component).

Each year, 4,500 to 6,000 fuel bundles per reactor are added to the wet storage bays, based on 80 to 95 percent full power reactor operation.

B.1.3.1.2 Spent fuel generated at research reactors

As of March 2020, there were four operating research reactors in Canada:

- Royal Military College of Canada (RMC) (SLOWPOKE-2, 20 KW, Kingston, Ontario)
- École Polytechnique de Montréal (SLOWPOKE-2, 20 KW, Montréal, Quebec)
- McMaster Nuclear Reactor (pool-type, 5 MW, Hamilton, Ontario)
- Zero Energy Deuterium-2 (ZED-2) (pool-type, 200 W, Chalk River, Ontario)

These reactors use low-enriched uranium (LEU) fuel.

The University of Alberta's SLOWPOKE-2 reactor in Edmonton, Alberta, was decommissioned in 2017, and the site was released for unrestricted use in 2018. The SRC's SLOWPOKE-2 reactor in Saskatoon, Saskatchewan, is undergoing decommissioning as of March 2020. These two reactors were using HEU fuel, and the fuel cores were repatriated to the U.S., the fuel's country of origin.

The ZED-2 reactor is operated occasionally and is mainly used for testing prototype fuel to determine fuel characteristics. ZED-2 uses mostly natural uranium, but it can use various fuel types, depending on the purpose. Spent fuel from ZED-2 is stored on-site at Chalk River Laboratories (CRL).

All SLOWPOKE-2 cores are pre-assembled and cannot be modified by the licensee. The cores can last 30 years (or more depending on usage) with the addition of beryllium reflector shims to compensate for reactivity decreases in fuel. When the added shims can no longer compensate for the decreased reactivity, the entire core can be replaced. Although the SLOWPOKE-2 reactors initially used HEU fuel, they were subsequently converted to LEU or decommissioned, and the spent HEU cores were returned to the U.S., the fuel's country of origin. The LEU cores, once spent, are sent to CRL for storage.

Spent fuel from the McMaster Nuclear Reactor is shipped to a licensed spent fuel management facility in the U.S. when a sufficient quantity has accumulated in the pool, approximately once a year.

In 2010, a project was undertaken to repatriate all inventories of spent HEU fuel from Canada to the U.S. As of 2019, all HEU from the SLOWPOKE research reactors had been returned to the U.S.

B.1.3.1.3 Fuel generated for medical isotope production

This type of fuel is not included in the report because, once spent, it is reprocessed to extract medical isotopes. According to Article 3(1), this activity falls outside the scope of the Joint Convention.

B.1.3.2 Wet storage technology

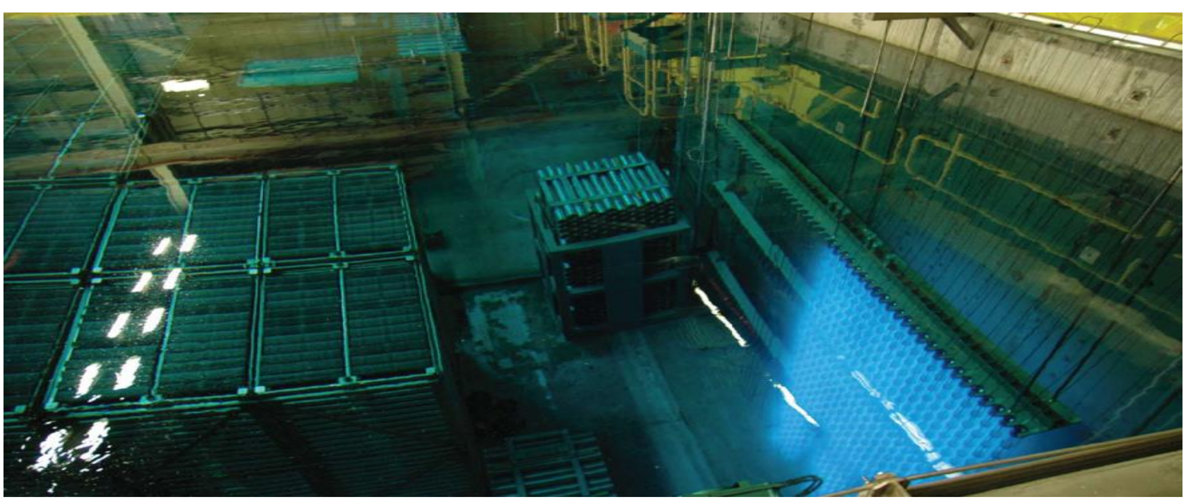
Spent fuel discharged from a nuclear reactor is stored initially in wet bays or water pools (see figure B.1). Wet bays, together with the cooling and purification systems, contain the spent fuel and associated radioactivity and provide good heat transfer to control fuel temperatures. The water also provides 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 purpose of the wet storage bays and their cooling and purification systems is to:

- provide safe temporary storage and handling of irradiated fuel, including defective bundles
- remove heat ejected by irradiated fuel bundles at a rate sufficient to keep water temperature within the design limits of the bay walls and floor
- reduce radioactivity in the bay to acceptable levels
- keep bay water in a demineralized state to minimize the corrosion of metal surfaces
- automatically control water levels

The walls and floors of CANDU reactor water pools are constructed of carbon-steel reinforced concrete approximately two metres thick. Inner walls and floors are lined with a watertight liner consisting of stainless steel or a fibreglass-reinforced epoxy compound, or a combination of the two. The bay structure is seismically qualified so the structures and bay components maintain their structural form and support function both during and following a design-basis event (such as an earthquake, for example). Other structural design considerations include load factors and load combinations (including thermal loads) for which upper and lower temperature limits have been established.

Figure B.1: Wet storage at the Bruce NGS



B.1.3.2.1 Bay liners

The bays are designed to prevent bay water from 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 any leakage that does occur is captured and directed to a controlled drainage system. The design has provisions for leak detection and tracking.

B.1.3.2.2 Storage in wet bays

A number of designs are used to hold spent fuel for storage in wet bays, all of which meet IAEA safeguards requirements. Storage in the wet bays is seismically qualified and all handlings are monitored by the IAEA.

At Ontario Power Generation (OPG) and Bruce Power (BP) facilities, baskets, trays and modules are stacked vertically in the bays within seismically qualified stacking frames. OPG and BP use a standardized site-specific, storage-transportation module that stores the fuel compactly. Fuel stored in baskets and trays is transferred to modules prior to being loaded into dry fuel storage containers. To reduce handling, the storage-transportation module is also suitable for holding the fuel during transportation. The modules are loaded directly into dry fuel storage containers and stacked, as shown in figure B.4.

Hydro-Québec (H-Q) stores the spent fuel horizontally on racks, in its wet bays. Before it is transferred to dry storage, the spent fuel is transferred in fuel baskets using pneumatic tools.

NB Power transfers the spent fuel from the reactor to the spent fuel reception bay where the fuel is stored in trays. From the reception bay it is transferred to the spent fuel storage bay and remains in the trays for its seven-year storage. From this location, the spent fuel is loaded into baskets and transferred to dry storage.

B.1.3.2.3 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 and when resin traps must be cleaned out. Water-pool chemical control aims to:

- 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

Demineralized water is used to ensure purity.

B.1.3.3 Experiences with wet storage

Early operating experiences at the CRL 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 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, contributed to establishing current safe-storage techniques. At CRL, the only wet storage still in operation are the NRU reactor rod bays.

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" (i.e., stored in a sealed cylinder). With more operating experience, canning has been found to be generally unnecessary due to the 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, some radiation-induced deterioration of the liner has been detected at the Pickering NGS (where the first epoxy liner was used). Potential leaks in the Unit 1–4 primary bay were located and repaired before Pickering Units 1 and 4 were 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 2002–03 at various locations in the Pickering 1–4 primary bay. Similar repairs were conducted for the Pickering Unit 5–8 primary bay in 2016–17.

The Bruce A NGS also utilizes an epoxy polymer liner, which has experienced minor deterioration over time. A comprehensive inspection was completed in 2018 to assess the health of the liner. There had been no leaks present and continued inspections are conducted frequently to ensure deterioration does not increase.

B.1.3.4 Dry storage technology

After a cooling period of six to 10 years in a wet bay (the exact cooling period is site-specific), spent fuel is then transferred to an interim dry storage facility.

Currently, three basic designs are used for the dry storage of spent fuel in Canada:

- AECL concrete canister
- AECL modular air-cooled storage (MACSTOR) system
- OPG dry storage container (DSC)

All transfers of spent fuel to dry storage are subject to IAEA surveillance. All loaded OPG DSCs in interim storage are also under the surveillance of the IAEA through the application of a dual sealing system.

B.1.3.4.1 AECL concrete canister

The AECL concrete canister fuel storage program was developed at WL in the early 1970s to demonstrate that dry storage for spent reactor fuel was a feasible alternative to water pool storage. Owing to the success of the demonstration program, concrete canisters were used to store WR-1 spent fuel. Further, the AECL concrete canister design is used at CRL for the dry storage of fuel bundles from the NPD reactor, the Point Lepreau NGS and the partially decommissioned Douglas Point (see figure B.2) and Gentilly-1 reactors.

The canister system comprises the following main components:

- fuel basket
- shielded workstation
- transfer flask
- concrete canister

The fuel basket is constructed of stainless steel and comes in three designs:

- a design to hold 54 bundles (used for fuel from Douglas Point and NPD)

- a design to hold 38 bundles, each of which is placed over a basket pin (used for fuel from Gentilly-1)
- a design to hold 60 bundles (used for fuel from Point Lepreau)

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 sub-assemblies 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 the workers.

The fuel basket transfer flask is used to shield the basket when it is moved from the shielded workstation at the NPP to the dry storage canister at the waste management facility (WMF).

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. A provision is made for IAEA safeguard seals to be placed on top of the canister plug so the plugs cannot be removed without breaking the seals.

Two small-diameter pipes allow the air between the liner and the fuel baskets to be monitored 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 spent fuel.

Three barriers (defence in depth) ensure the containment of the radioactive products:

- fuel sheath
- fuel basket
- internal liner

Figure B.2: AECL concrete canisters at Douglas Point

B.1.3.4.2 AECL MACSTOR system

The MACSTOR system is a variant of the concrete canister storage technique. MACSTOR modules are currently installed and being operated at the Gentilly-2 NGS site in Quebec, the Cernavoda site in Romania and the Qinshan site in China.

The original MACSTOR design (MACSTOR-200) is a secure, reinforced concrete structure that houses 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 that extend to the outside of the MACSTOR module are provided at its base. These pipes allow for confirmation of the integrity of confinement. The MACSTOR-200 is used at the Gentilly-2 site (see figure B.3) and the Cernavoda site.

The newer design, MACSTOR-400, can store twice as much fuel with a marginal increase in construction costs when compared to the MACSTOR-200. The MACSTOR-400 houses 40 vertical steel cylinders, each of which can 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 and will be used at the Cernavoda site.

The heat of the spent fuel is dissipated primarily by natural convection through ventilation ports that extend through the concrete walls. 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 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 for the concrete canister. Both use the fuel basket, shielded workstation and transfer flask. The only essential difference between the two is the storage structure itself.

Figure B.3: MACSTOR-200 at Gentilly-2

B.1.3.4.3 OPG dry storage container

OPG currently operates three spent fuel dry storage facilities, located at the Darlington, Pickering and Western WMFs. OPG dry storage facilities employ DSCs (see figures B.4 and B.5). These are large, transportable containers with an inner cavity for fuel containment. Each one is designed to hold 384 fuel bundles stacked in modules and weighs approximately 60 tonnes when empty, 70 tonnes when loaded.

The containers are rectangular with walls of reinforced, high-density concrete sandwiched between interior and exterior shells made of carbon steel. The inner liner is an integral part of the containment boundary, while the outer liner is intended to enhance structural integrity and facilitate the decontamination of the surface of the DSCs. Helium is used as the inert cover gas in the DSCs cavity to protect the fuel bundles from potential oxidation reactions and to facilitate leak testing of the containment boundary. OPG dry storage facilities are located indoors. There are no anticipated radiological releases under normal operating conditions.

Figure B.4: OPG dry storage container

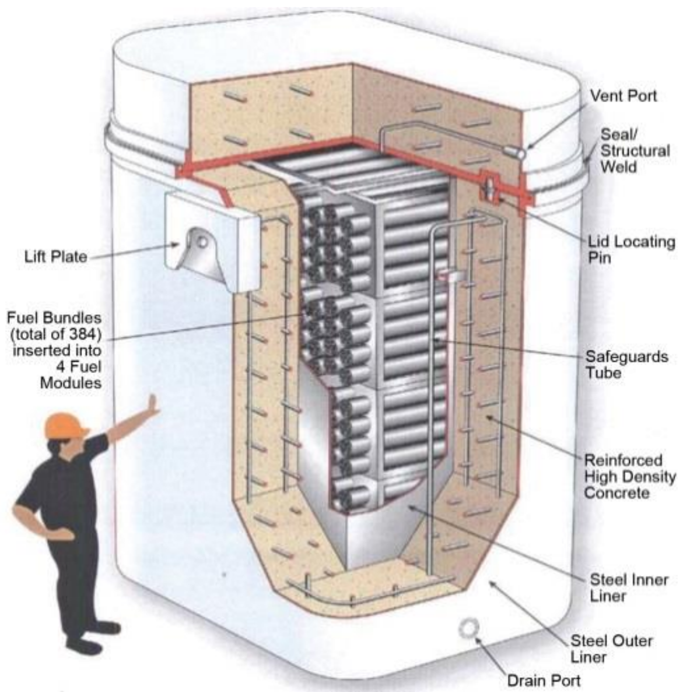


Figure B.5: Dry storage containers at an OPG WMF

B.1.3.5 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 have concluded that CANDU fuel bundles, whether intact or with defects, can be stored in DSCs for up to 100 years or more without losing integrity. Additional research is ongoing.

The experience gained at licensed dry storage facilities 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. DSCs have been used successfully and safely at the Pickering WMF since 1996. The safety performance of the facility has been excellent for the entire period. Both the dose rates and emissions from the processing area have remained below regulatory limits.

The thermal and shielding analyses carried out for design and safety assessment purposes have been found to be conservative. Analyses and measurements carried out at the Pickering WMF 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, as expected, that 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 DSCs.

To verify the results of the thermal analysis, an experimental thermal performance verification program was carried out in the summer of 1998. A DSC 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 DSCs containing 10-year cooled fuel. Temperatures were also measured at the interspaces between the DSCs, as were indoor and outdoor ambient temperatures. The results demonstrated the conservatism of the temperatures predicted analytically.

Similar assessments and measurements were performed on AECL MACSTORs and AECL concrete canisters to confirm and demonstrate the safe storage of spent fuel in these structures.

B.1.3.6 Spent fuel storage facilities

For a description of the spent fuel storage facilities in Canada, see annex 4.

B.1.3.7 Long-term management of spent fuel

Canada does not yet have a long-term WMF for spent fuel. All spent fuel is currently held in interim wet or dry storage at the NPP where it was produced, with the exception of the spent fuel produced at the now-closed NPD facility, which is stored at CRL.

To address the long-term management of spent fuel, the three major waste owners – OPG, H-Q and NB Power – established the Nuclear Waste Management Organization (NWMO) in 2002 under the NFWA.

NWMO is responsible for implementing the Adaptive Phased Management (APM) approach that was selected by the Government of Canada for the long-term management of spent fuel (see sections G.7 and K.2.4). OPG, NB Power, H-Q and AECL are responsible for the management of the spent fuel generated at their respective sites until the NWMO is ready to accept the spent fuel for management in a facility constructed using the APM approach. OPG is also responsible for the interim storage of the spent fuel generated at the Bruce NGSs.

B.1.4 Radioactive waste management practices

The radioactive content of wastes varies with the source; therefore, management techniques depend on the characteristics and volume of the waste.

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

Radioactive waste from hospitals and universities is generally shipped to Chalk River Laboratories (CRL) for management. The storage facilities CRL include shielded above-ground storage buildings, concrete bunkers and concrete tile holes. In some cases, radioactive waste is shipped to waste treatment facilities in the U.S. with the volume-reduced residues returned for storage by the waste owner in Canada.

Canadian methods for the management of radioactive waste are similar to those of other countries. As disposal facilities are not yet available in Canada for radioactive wastes, emphasis is placed primarily on minimization, volume reduction, conditioning and interim or long-term storage of the wastes. Some of the waste may be reduced in volume (for example, 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 waste after sufficient radioactive decay or reclaiming existing storage space through further compaction (super compaction), segregation, or both. As is the case with 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 across the industry, from mines to reactors, is the same: to control and limit the release of potentially harmful substances into the environment.

In keeping with the Government of Canada's *Radioactive Waste Policy Framework,* Canada has taken different approaches for managing HLW, ILW, LLW 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 wastes. Long-term strategies and solutions for historic LLW are being developed and implemented for the various regions of the country.

For a description of the radioactive WMFs in Canada, see annex 5.

B.1.4.1 Non-fuel high-level radioactive waste

The irradiated fuel bays at the Bruce B NGS store cobalt-60 produced from the harvesting of cobalt adjuster rods at the Bruce B NGS. The cobalt-60 initially produced is sold to Nordion Inc. under an agreement between the two parties, where it is processed and converted into high-strength industrial and medical radiation sources. That agreement provides Nordion with an allowance to send back to the Bruce B NGS as much cobalt-60 as was originally supplied (with certain conditions). A separate agreement between OPG and BP obligates OPG to take title of the spent cobalt that has been received into the Bruce B NGS irradiated fuel bay from Nordion.

B.1.4.2 Low- and intermediate-level radioactive waste

As the waste owners, AECL and OPG (which own 20 of Canada's 22 CANDU reactors) are responsible for approximately 90 percent and 99 percent, respectively, of the annual accumulated volume of low- and intermediate-level radioactive wastes (L&ILW) as of 2019. These accumulation rates represent the waste generated from research and development activities at CRL (including from decommissioning and environmental remediation) and nuclear power production in Ontario respectively. Included in AECL's accumulation rate is L&ILW for long-term management from a number of small producers and users of radioactive materials (e.g., hospitals and universities). The other two CANDU reactors (owned by NB Power and H-Q) and Cameco's uranium processing and conversion facilities in Ontario generate the majority of the remaining waste. In general, the owners of L&ILW are licensed by the CNSC to manage and operate interim storage facilities for their radioactive wastes.

The majority of L&ILW from OPG owned CANDU reactors (including Bruce A and B) is safely stored in a central location at the Western WMF at the Bruce nuclear site in Kincardine, Ontario. Some ILW from unit refurbishments is stored at the Darlington and Pickering reactor sites within their respective WMFs. NB Power and H-Q have their own facilities for the interim storage of L&ILW at their reactor sites.

As described in section K.3.4, activities dealing with legacy radioactive waste and decommissioning liabilities at AECL sites are being advanced by CNL under a government-owned contractor-operated (GoCo) arrangement. For waste from research and development, AECL/CNL have waste storage facilities at two sites – CRL and WL – as well as at its three prototype reactor sites. As decommissioning progresses, L&ILW are to be consolidated at CRL for storage. Operational storage facilities include a bulk materials landfill for de-watered sewage sludge, shielded modular above-ground storage structures, concrete bunkers and tile holes. Additional capacity for LLW storage has been created at CRL while waiting for the NSDF to become operational for the disposal of LLW. This additional capacity is in the form of hard-standing to accept LLW packaged in approved sea containers. On behalf of AECL, CNL also accepts L&ILW from small generators, like those in hospitals, universities and small industries, on a fee-for-service basis.

In addition to existing interim storage facilities at CRL, a key enabling component is the proposed construction of the near surface disposal facility (NSDF) with a total planned disposal capacity of 1 million m^3, scheduled to be available by 2024 for the disposal of LLW. Progress and achievements over the last three years are summarized in section K.2.3.2.

Radioactive waste from hospital nuclear medicine departments and from 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 like 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 from past practices (referred to as historic waste) that was once managed in a manner no longer considered acceptable, but for which the current owner cannot be reasonably held responsible. Canada's historic waste inventory consists largely of refinery process residues in the area of Port Hope, Ontario, and radium- and uranium-contaminated soils in the form of spilled ores on the Northern Transportation Route (NTR) from the former Port Radium mine site in the Northwest Territories. The Government of Canada has accepted responsibility for the long-term management of these wastes.

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 m^3 and relate to the historic operations of a radium and uranium refinery in Port Hope dating back to the 1930s. In March 2001, the Government of Canada and the local municipalities agreed on community-developed proposals as potential solutions for the cleanup and long-term management of historic LLW in the Port Hope area, and launched the Port Hope Area Initiative (PHAI). The PHAI and other initiatives that address historic waste are described in section K.3.4 and annex 7.2. These initiatives come under the responsibility of AECL, and the work is delivered by CNL, based on a GoCo model.

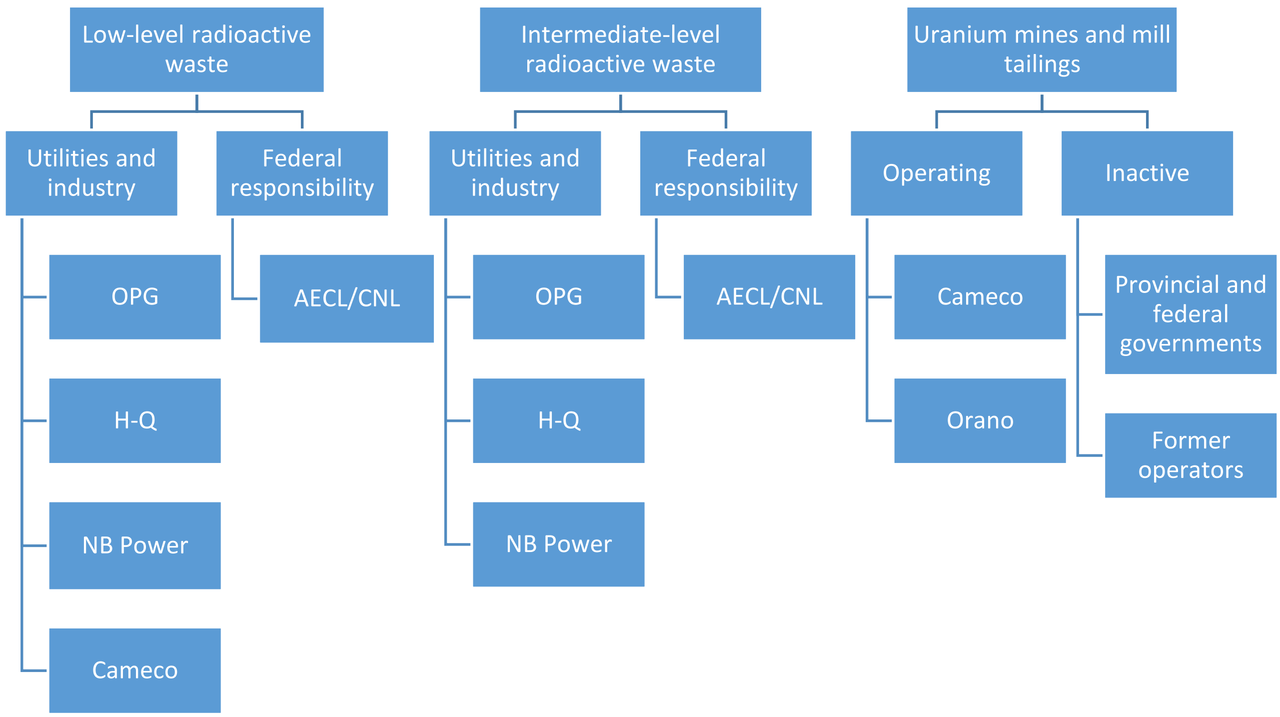
Activities continue to be carried out to quantify the extent of historic LLW liabilities across Canada (non-Port Hope sites) and develop plans for their discharge. As part of one key objective, CNL will significantly reduce or eliminate liabilities by 2026 by safely executing remediation projects. This will facilitate the cost-effective long-term management of historic LLW, in keeping with the policy direction provided by AECL.

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. These wastes include existing radioactive wastes and wastes resulting from decommissioning disused buildings and infrastructure, and from environmental remediation.

B.1.4.2.1 Long-term management of low- and intermediate-level radioactive waste

Although 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 its long-term management. Figure B.6 shows the organizations that are responsible for the long-term management of radioactive waste in Canada.

Figure B.6: Organizations responsible for the long-term management of radioactive waste in Canada



OPG, NB Power and H-Q are responsible for the long-term management of L&ILW generated by nuclear reactor operations. For OPG, this includes L&ILW generated at the Bruce NGSs. In 2020, OPG cancelled its proposed deep geologic repository project at the Bruce site. OPG is moving forward with developing alternate solutions for the permanent disposal of L&ILW.

AECL is responsible for the long-term management of L&ILW at its sites – CRL, WL and three partially decommissioned prototype reactors (Gentilly-1, Douglas Point and the NPD) – as well as for the L&ILW it accepts from other Canadian licensees (mostly originating from hospitals and universities) on a fee-for-service basis. Under a GoCo model, CNL delivers this work on behalf of AECL. For information on the AECL/CNL long-term waste management strategy for L&ILW, see section K.2.3.

AECL is also responsible for the cleanup and safe management of historic LLW at sites across Canada for which the Government of Canada has accepted responsibility. This includes the PHAI and activities associated with the Low-Level Radioactive Waste Management Office. Again, this work is delivered by CNL on behalf of AECL. For additional information see section K.3.4.

Cameco is responsible for the long-term management of LLW at the Blind River Refinery, Port Hope Conversion Facility and Cameco Fuel Manufacturing Facility. Historic LLW located at the Port Hope Conversion Facility is eligible for disposal in the PHAI's long-term WMF. Other LLW is stored at the site pending decontamination for unconditional release or disposal at an appropriately licensed facility. For additional information, see annex 5.5.

B.1.4.3 Uranium mine and mill tailings

Uranium mining and milling wastes comprise 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 ore slurry or run-of-mine ore (which is first crushed) is received by the mill and treated with chemicals; the uranium content in the ore is then extracted, leaving a waste product known as mill tailings. 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.

The method used to manage tailings from uranium mine operations also 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 and the size of the deposit. Canada's operating mines (all of which are located in northern Saskatchewan) have high-grade ore deposits, compared to past mines operated in Canada; therefore, smaller volumes of tailings are being produced.

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 extent that the long-term care and control of these non-radioactive contaminants are what drive the level of care needed to manage it, not the radioactivity of the waste rock.

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

More than 200 million tonnes of uranium mill tailings have been generated in Canada since the mid-1950s. There are 25 tailings sites in Ontario, Saskatchewan and the Northwest Territories, 22 of which no longer receive waste material. The three remaining operational tailings management facilities (TMFs) are located in Saskatchewan. The ore mined at McArthur River is transported to Key Lake for milling, resulting in no tailings management areas (TMAs) at the McArthur mine site. Similarly, the ore from Cigar Lake is transported to McClean Lake for milling; tailings reside at the McClean Lake TMF. Both milling and mining have been conducted at Rabbit Lake, and as a result, tailings are managed at that site. All operational and inactive uranium tailings sites are the joint regulatory responsibility of the CNSC and the provinces and territories in which the sites are located.

TMFs have evolved over the decades, from the simple deposition of tailings into natural landforms, lakes or abandoned underground mines, 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) during operations to enhance radiation protection and to avoid the oxidization and winter freezing of the tailings.

Contaminated industrial wastes are typically recycled, deposited in underground workings, landfilled at the site-specific TMFs or designated locations (such as mined-out pits designated for contaminated waste). 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 contained in this volume is negligible and is effectively accounted for.

In addition to the tailings produced from milling uranium ore, millions of cubic metres of waste rock are excavated to gain access to ore. In the northern Saskatchewan open-pit sites located within the Athabasca Basin, most of this waste rock is sandstone which is environmentally benign and suitable for surface disposal. Some of the waste rock, however, 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), keeping it in an environment similar to that from which it was mined and preventing oxidation reactions. In underground mines, waste rock can be used in the mine as backfill material. Waste rock materials used for purposes underground are not classified as waste materials in the waste inventory. At sites with a waste segregation program, clean waste rock can be used for construction material.

The inventory of nuclear substances in some inactive uranium TMAs can cause some areas to be licensed as Class I nuclear facilities under the NSCA's *Class I Nuclear Facilities Regulations* (CINFR), which has implications for the licensing requirements and long-term management of such facilities. Those responsible for inactive TMAs with smaller inventories can be licensed for the possession of nuclear substances. These inactive tailings disposal areas and facilities remain under CNSC licence control in the absence of a suitable alternative (such as provincial institutional controls). However, the Government of Saskatchewan has developed such an alternative for the institutional control of decommissioned mining sites (not limited to uranium) on Crown land.

Current management practices for CNSC-licensed facilities use a lifecycle planning process. A preliminary decommissioning plan (PDP) and financial guarantees for decommissioning are integral to the licence approval process and are required in the first stages of CNSC licensing (site preparation and construction). The CNSC assesses the environmental and health effects of nuclear facilities and activities at every phase of their lifecycle or duration.

B.1.4.3.1 Province of Saskatchewan

Saskatchewan is the only province in Canada with operating uranium mines. In the past, mine and mill operators have requested harmonized action in areas like inspections and reporting requirements that involve the Saskatchewan Ministry of Environment, the Saskatchewan Ministry of Labour Relations and Workplace Safety, and the CNSC. The province and the CNSC continue to coordinate the regulation of the uranium mining and milling operations to encourage greater administrative efficiency in regulating the uranium industry. This lays the groundwork for the two groups to coordinate and harmonize their respective regulatory regimes.

B.1.4.3.2 Operational tailings and waste rock management strategy

B.1.4.3.2.1 Overview

A significant portion of the world's primary uranium production comes from uranium deposits in the Athabasca Basin in northern Saskatchewan. These deposits are found at:

- the current production sites of Cigar Lake, which suspended production in March 2020, and McClean Lake
- the McArthur River mine and Key Lake mill, which have suspended production indeterminately due to prolonged market weakness, and which have been in a state of care and maintenance since 2018
- the Rabbit Lake mine and mill, which suspended operations indefinitely in 2016 and is currently in a state of safe care and maintenance

McArthur River and Cigar Lake are two of the highest-grade uranium ore bodies in the world. Some of the ore bodies in the Athabasca Basin contain other elements, such as nickel and arsenic, which brings additional considerations to the management of tailings and waste rock that result 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

B.1.4.3.2.2 Tailings management strategy

Mills with 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, the ore from Cigar Lake is transported to McClean Lake for processing.

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 details, two basic principles underlie the containment of the tailings:

- **hydraulic containment during the operational phase** – The water level in the pit at the start of tailings placement is well below the natural groundwater level in the area as a result of dewatering during mining. Dewatering creates a cone of depression in the groundwater system, in which causes the natural flow to be directed toward the pit from every direction. This hydraulic containment feature is maintained throughout the operational life of the tailings facility by keeping the pit in a partially dewatered state. Since water has to be pumped continuously from the pit, the 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 by controlling 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 (e.g., 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 very low hydraulic conductivity. When surrounded by a material with much higher hydraulic conductivity, the natural groundwater path travels 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, consequently, a 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 the 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 and 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 that govern the system. This performance is confirmed during the life of the operation and through the post-decommissioning monitoring, which continues until stable conditions are achieved and for as long as is necessary thereafter.

Annex 6 provides site-specific details for the Athabasca Basin tailings facilities. The development of these facilities began over 30 years ago; their favourable operational experience and the design evolutions based on that experience inspire confidence in their performance, now and in the future.

B.1.4.3.2.3 Waste rock management strategy

In addition to tailings from the milling process, uranium production yields large volumes of waste rock that are removed before ore can be accessed. The segregation of these materials according to their future management requirements is a core management strategy. Material excavated from open pits is divided into three main categories: clean waste (both overburden and waste rock), special waste (containing sub-economic mineralization) and ore.

B.1.4.3.2.3.1 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 m) 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 its perimeter but increases to as much as 1,200 m toward the centre of the Basin. Depths up to about 200 m are practical for open-pit mining. The sites at and near the Basin's 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. The stockpiles, minus whatever amount has been used for construction purposes, are subsequently reclaimed and vegetated.

B.1.4.3.2.3.2 Waste segregation

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 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 acid rock drainage phenomenon is common to many types of mining. Sophisticated methods are now available for segregating those amounts of waste rock that represent a potential environmental risk if left on the surface for the long term, due to either acid rock drainage or dissolved contaminants in leachate.

This material, referred to as special waste, is managed differently than the environmentally benign waste rock. Segregation methods include borehole logging, collecting and analyzing borehole samples prior to mining, and analyzing 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, based on uranium content, as ore, special waste or clean waste rock and direct it to the appropriate stockpile.

Because uranium ore deposits are in secular equilibrium with their progeny, good correlations can be made between the 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 been tested at McClean Lake and has since been incorporated into the mine site's overall waste rock management strategy.

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. Surplus amounts can be stockpiled, and the stockpiles reclaimed and vegetated. Special waste is either used as aggregate and underground backfill, returned underground to other mined areas, or transferred to sites with mills or mined-out open pits.

B.1.4.3.2.3.3 Special waste

As noted above, waste rock near ore bodies is potentially problematic. Because it has some halo mineralization around the ore deposit, the waste rock can potentially generate acid in some instances or become a source of contaminated leachates when exposed to an atmosphere containing oxygen. Disposal of this special waste in mined-out pits that are flooded to cut off oxygen 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 it is 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 to collect and treat runoff water. After mining activities have ended, the special waste is backhauled into the mined-out pit. 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, waste material with uranium content greater than approximately 300 parts per million triuranium octoxide or 0.025 percent (250 parts per million) uranium is classed as special waste.

Like with tailings facilities, the 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 is continued until stable conditions are achieved and for as long as is necessary thereafter.

B.1.4.3.2.3.4 Ore

The cut-off grade that defines the threshold between ore to be processed through the mill and mineralized waste will vary, depending on market conditions for uranium. Typically, cut-off grades are in the order of 0.1 percent for the Saskatchewan mines.

B.1.4.3.2.4 Waste water treatment and effluent discharge

Mine and mill facilities have water treatment systems to manage the contaminated water collected from their tailings disposal facilities, the water inflows collected during open-pit or underground mining, and seepages from waste rock piles. The treatment processes vary from flow-through to batch discharge systems and rely largely 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 treated-water discharge points. Uranium mines and mills also treat for radionuclides. Specifically, focus is placed on the 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 and by effluent quality regulation.

In northern Saskatchewan, effluent quality regulation ensures that the Saskatchewan Environmental Quality Guidelines 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. During this reporting period (April 1, 2017, to March 31, 2020), the total volume of treated waste water that met regulatory requirements and was subsequently discharged to the receiving environment was 17.6 million m^3 from five active uranium mining and/or milling sites in northern Saskatchewan (see table B.1).

Table B.1: Active uranium mining/milling site waste water volumes

Active uranium mining and/or milling site in northern Saskatchewan	Total volume of waste water that met discharge requirements
Orano – McClean Lake	5,695,516 m^3
Cameco – Rabbit Lake	3,923,355 m^3
Cameco – Cigar Lake	335,800 m^3
Cameco – McArthur River	2,370,659 m^3
Cameco – Key Lake (Horsefly Lake)	4,035,425 m^3
Cameco – Key Lake (Wolf Lake)	1,223,837 m^3
Total	**17,584,592 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 the 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 and chemical precipitation technologies.

B.1.4.3.3 Long-term management of uranium mine and mill waste

Cameco Corporation and Orano Canada Inc. (formerly known as AREVA Resources Canada Inc.) manage the only operating uranium mines and mills in Canada (see annex 6). Inactive uranium mine and mill sites are located in Ontario, the Northwest Territories and Saskatchewan, as described in annex 7.

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

- tailings sites that are currently being decommissioned
- tailings sites at operating mill sites where closure activities have been partially completed or are in progress (e.g., Rabbit Lake and Key Lake)
- tailings sites at former milling locations, including recently decommissioned sites with engineered tailings containment systems, 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)

These inactive sites are licensed by the CNSC. The site owners are responsible for monitoring and for any future maintenance or remedial work that may be required to protect human health and safety or the environment. Three former uranium mine tailings sites are located in Saskatchewan: Cluff Lake and the Gunnar and Lorado sites. The Lorado and Cluff Lake sites have been decommissioned, and the Gunnar site is in the process of being decommissioned, as described in annexes 7.1.1.3, 7.1.1.4 and 7.1.1.2, respectively. The Cluff Lake project is in the process of transitioning to Saskatchewan's Institutional Control Program (which is discussed in section H.7).

B.1.4.4 Radioactive waste from uranium fuel fabrication and processing

In the past, wastes from uranium 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 WMF. Subsequent to 1988, the volume of LLW produced from these operations has been greatly reduced through incineration and the recovery and reuse of uranium-bearing materials. The residual volume of LLW is segregated, managed and stored at licensed WMFs in Canada. In some cases, radioactive waste is shipped to waste treatment facilities in the U.S., and the volume-reduced residues are returned for storage by the waste owner in Canada.

Uranium fuel fabrication and processing waste consists of a variety of potentially uranium-contaminated wastes, including:

- contaminated zirconium
- contaminated combustible materials (e.g., wood, paper, gloves, coveralls)
- rubber and plastic
- oils and solvents
- metal
- sludges (sewage, process equipment and wash water)
- recoverable materials (ammonium nitrate, fluoride, calcined product and regeneration products)

B.1.4.5 Radioactive waste from nuclear power reactors

Radioactive wastes resulting from nuclear reactor operations are stored in a variety of structures located in radioactive WMFs, locations or sites across Canada. Prior to storage, the volume of the radioactive waste may be reduced by incineration, compaction, shredding or metal melt. In addition, the NPP contains facilities for decontaminating parts and tools, laundering protective clothing, and refurbishing and rehabilitating equipment. Radioactive waste from NPPs consists of varying types of L&ILW, such as:

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

B.1.4.6 Radioactive waste from research reactors

At all research reactors, radioactive waste is segregated into short-lived and long-lived radioactive waste. Short-lived radioactive waste is stored on-site to allow for decay until it can be disposed of in a conventional manner. Long-lived radioactive waste is kept on-site temporarily until a sufficient quantity is accumulated for transportation to CRL for storage.

Typically, the research reactors operating in Canada do not produce liquid waste. The water is purified through filtration and ion exchange systems, then recycled back to the reactor. The spent ion exchange resins are stored with the long-lived radioactive waste and eventually sent to CRL.

B.1.4.7 Radioactive waste from radioisotope production and use

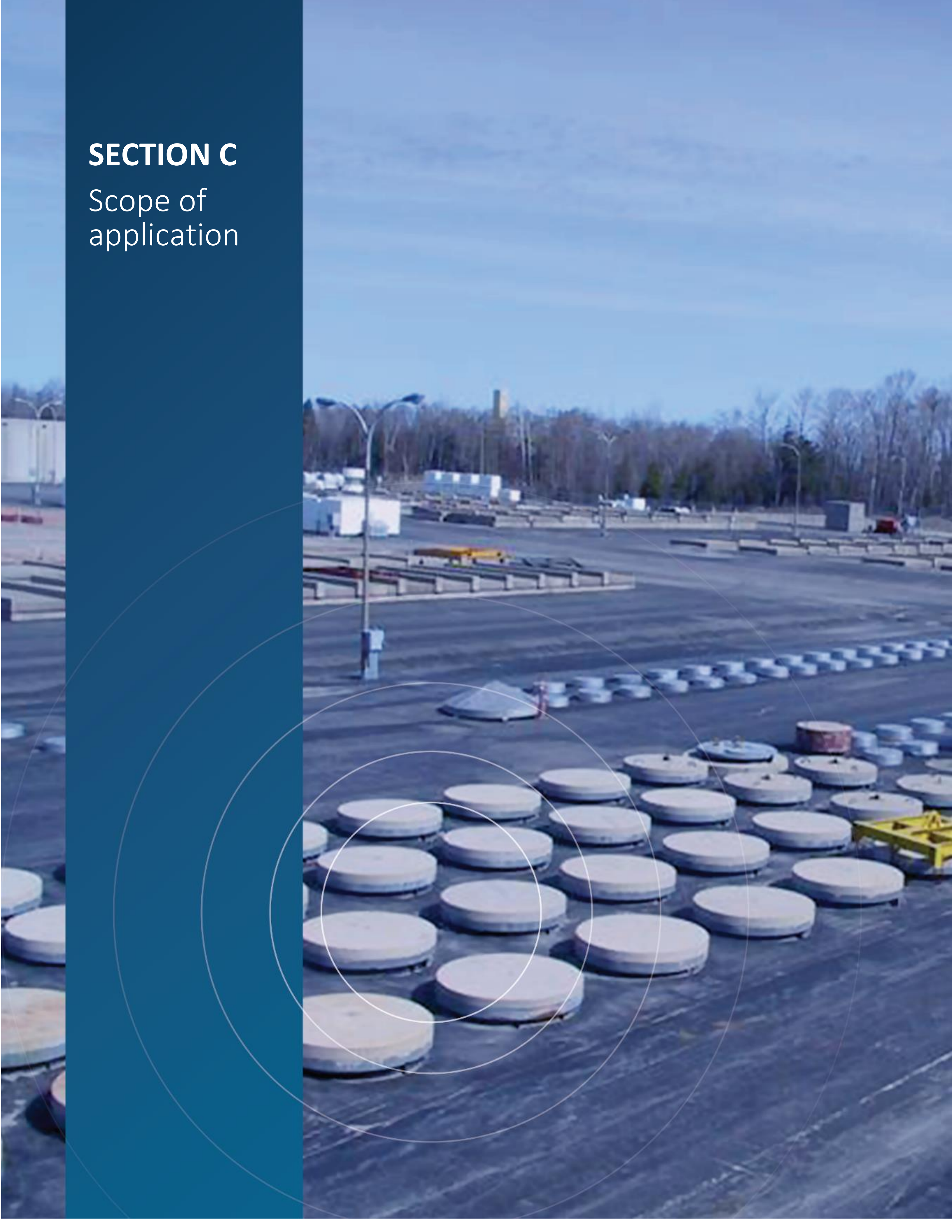
Radioisotope production and use generate a variety of radionuclides for commercial use, such as cobalt-60 for sterilization and cancer therapy units, and molybdenum-99 or other isotopes for use as tracers for medical research, diagnoses and therapy. A number of WMFs process and manage the wastes that result from the production and 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, then discharged into the municipal sewer or garbage system.

B.1.4.8 Historic radioactive 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 long-term responsibility. AECL is responsible for the cleanup and safe management of historic LLW at sites across Canada for which the Government of Canada has accepted responsibility. This includes the PHAI and activities associated with the Low-Level Radioactive Waste Management Office. This work is delivered by CNL on behalf of AECL, based on a GoCo model.

Historic LLW cleanups have been completed across Canada and several sites with historic radium or uranium contamination continue to be monitored. At some sites, materials have been placed in interim storage pending the development of a long-term management approach. Ongoing monitoring, inspection and maintenance are conducted at these sites. Under the current plan, the majority of these liabilities will be addressed by 2026.

SECTION C
Scope of application



Section C – Scope of Application

C.1 Scope of application (Article 3)

This section addresses the obligations under Article 3 of the Joint Convention.

ARTICLE 3. SCOPE OF APPLICATION

1. This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.
2. This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.
3. This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.
4. This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

C.1.1 Introduction

REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada*, defines radioactive waste as any material (liquid, gaseous or solid) that contains a radioactive nuclear substance, as defined in section 2 of the NSCA, and which the owner has declared to be waste. In addition to containing nuclear substances, radioactive waste may also contain non-radioactive hazardous substances, as defined in section 1 of the *General Nuclear Safety and Control Regulations* (GNSCR).

Radioactive waste is 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 (NORM)
- radioactive waste generated by military and defence programs

C.1.2 Reprocessed spent fuel

Given Canada's large natural source 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; as such, they are not included in this report.

Note, however, that AECL conducted early reprocessing experiments at CRL from the 1940s to the 1960s. CNL stores liquid waste which resulted from the reprocessing experiments in three tanks. The last transfer of radioactive liquid solutions to any of these storage tanks occurred in 1968, and no liquids have been added since then. Between 1958 and 1960, AECL conducted some experiments to convert high-level radioactive liquid solutions into a solid (glass). The program generated 50 glass blocks, each weighing about 2 kg, which are now safely stored on-site. Further information regarding the wastes from these experiments can be found in annex 5.1.1.

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

C.1.3 Naturally occurring radioactive material

Naturally occurring radioactive material (NORM) is material found in the environment that contains radioactive elements of natural origin. NORM primarily contains uranium and thorium (elements that also release radium and radon gas once they begin to decay) and potassium. These elements are naturally decaying and are considered a primary contributor to an individual's yearly background radiation dose.

In Canada, NORM is regulated by the provincial and territorial governments, each having its own specific regulations on the handling and disposal of the material. The Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials were developed by the Federal Provincial Territorial Radiation Protection Committee to harmonize standards throughout the country and ensure appropriate control of NORM; however, provincial regulations should also be consulted.

NORM is exempt from the NSCA and its associated regulations, except in the following circumstances:

- when NORM is associated with the development, production or use of nuclear energy, as set out in the GNSCR
- when NORM is imported into Canada or exported from Canada, as set out in the NNIECR
- the transport of NORM when the specific activity is greater than 70 Bq/g (70 kBq/kg), as set out in the *Packaging and Transport of Nuclear Substances Regulations, 2015* (PTNSR, 2015) and the *Transport of Dangerous Goods Regulations* (TDGR)

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

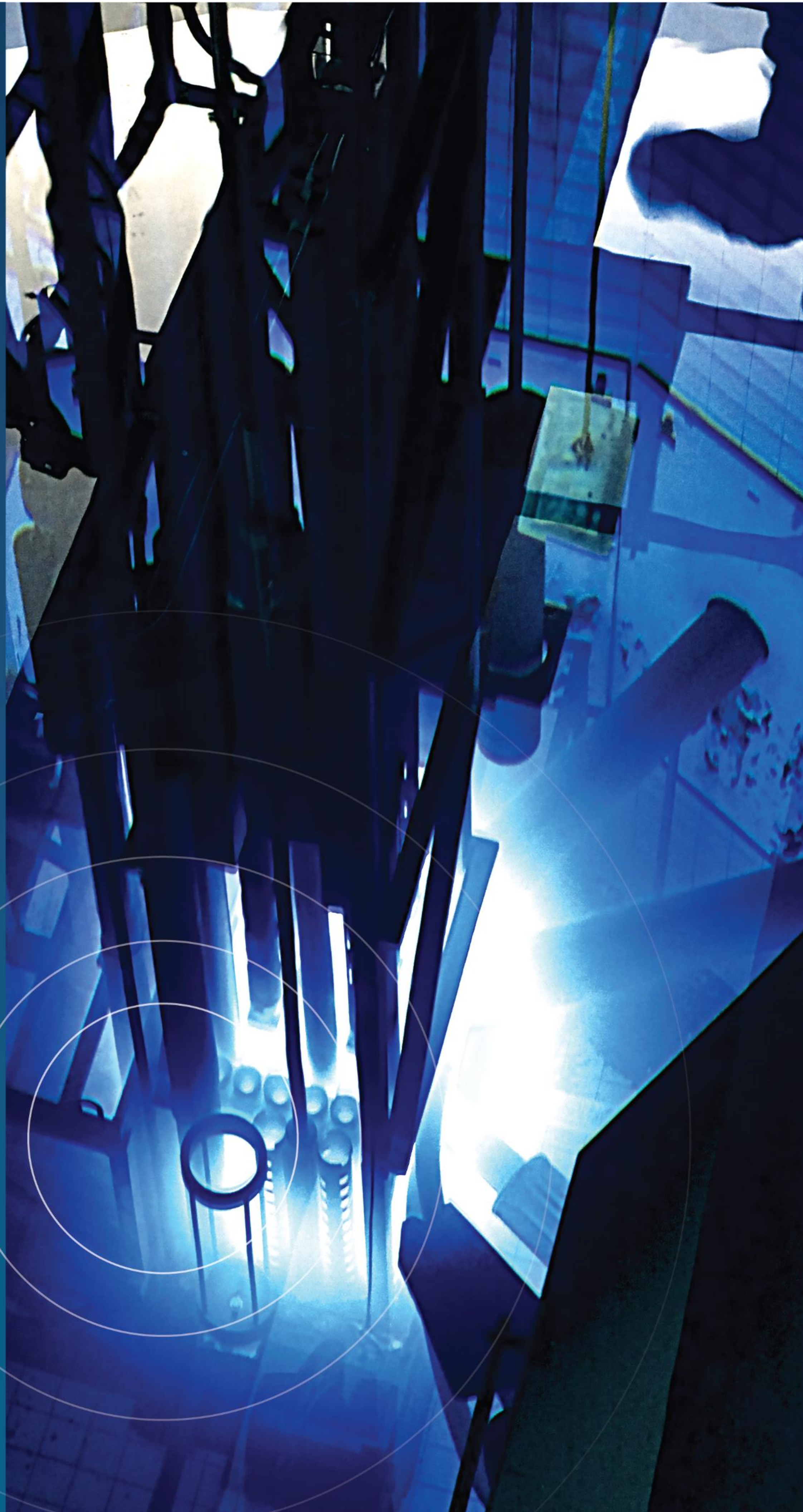
C.1.4 Spent fuel and radioactive waste within military or defence programs

Under section 5 of the NSCA, the programs of the Department of National Defence are not subject to the NSCA or its associated regulations; however, the RMC SLOWPOKE-2 reactor is subject to the NSCA, because it is operated as a research reactor. Therefore, under Article 3(3) of the Joint Convention, the RMC SLOWPOKE-2 reactor is the only military or defence program addressed in this report.

C.1.5 Discharges

In Canada, each radioactive WMF with releases to the environment must have in place an approved effluent monitoring program. Some of these facilities also have performance indicators, such as administrative levels and action levels, to evaluate the effectiveness of the pollution prevention controls. For more information on effluent monitoring programs, see section F.4.6. Radiological effluent discharge levels for radioactive WMFs are listed in annexes 4, 5, 6 and 7.

SECTION D
Inventories and lists



Section D – Inventories and Lists

D.1 Reporting (Article 32(2))

This section addresses the obligations under Article 32(2) of the Joint Convention.

ARTICLE 32. REPORTING

1. This report shall also include:

(i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

(ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

(iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

(iv) an inventory of radioactive waste that is subject to this Convention that:

(a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

(b) has been disposed of; or

(c) has resulted from past practices.

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

(v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

D.1.1 Spent fuel management facilities in Canada

Table D.1 below lists the facilities in Canada that manage spent fuel.

Table D.1: Facilities in Canada that manage spent fuel

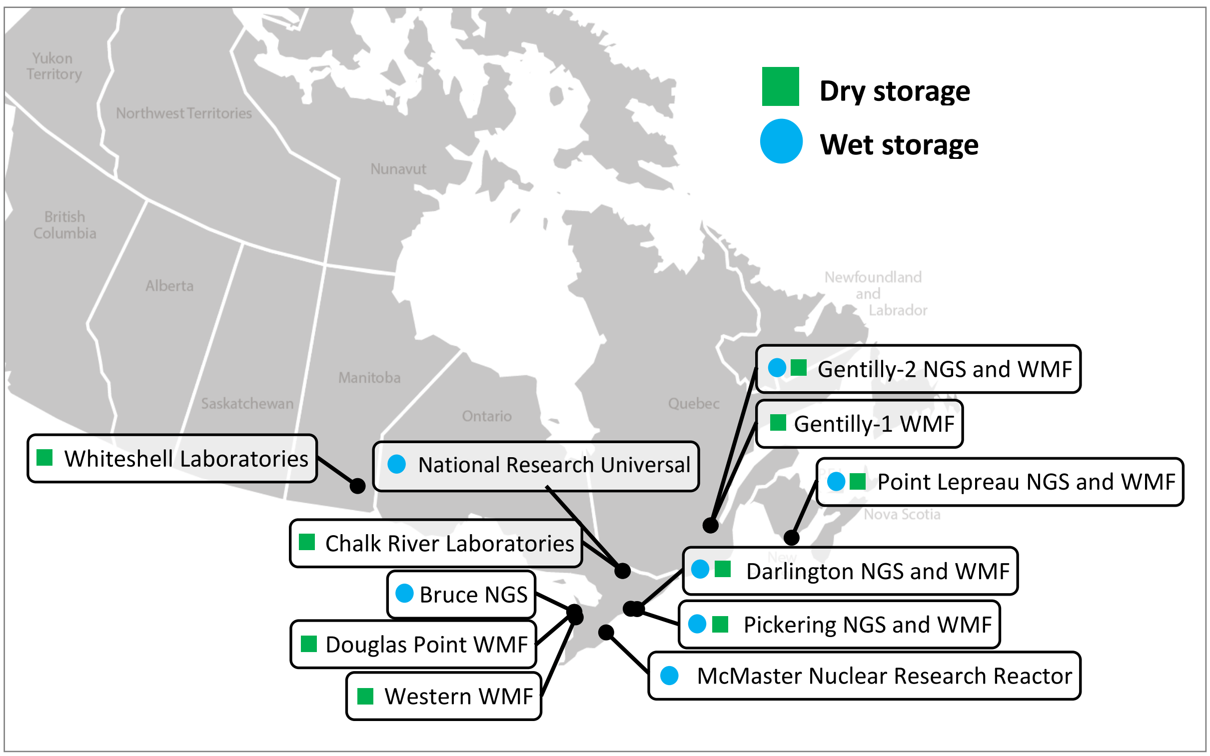
Facility	Owner	Location	Purpose/feature
Bruce Nuclear Generating Station	OPG	Tiverton, Ontario	Wet storage
Chalk River Laboratories	AECL	Chalk River, Ontario	Dry storage
Darlington Nuclear Generating Station	OPG	Clarington, Ontario	Wet storage
Darlington Waste Management Facility	OPG	Clarington, Ontario	Dry storage
Douglas Point Waste Management Facility	AECL	Tiverton, Ontario	Dry storage
Gentilly-1 Waste Management Facility	AECL	Gentilly, Quebec	Dry storage
Gentilly-2 Nuclear Generating Station	H-Q	Gentilly, Quebec	Wet storage
Gentilly-2 Waste Management Facility	H-Q	Gentilly, Quebec	Dry storage
McMaster Nuclear Research Reactor	McMaster University	Hamilton, Ontario	Wet storage
National Research Universal	AECL	Chalk River, Ontario	Wet storage

Facility	Owner	Location	Purpose/feature
Pickering Nuclear Generating Station	OPG	Pickering, Ontario	Wet storage
Pickering Waste Management Facility	OPG	Pickering, Ontario	Dry storage
Point Lepreau Nuclear Generating Station	NB Power	Maces Bay, New Brunswick	Wet storage
Point Lepreau Waste Management Facility	NB Power	Maces Bay, New Brunswick	Dry storage
Western Waste Management Facility	OPG	Tiverton, Ontario	Dry storage
Whiteshell Laboratories	AECL	Pinawa, Manitoba	Dry storage

For detailed descriptions of the facilities listed in table D.1, see annex 4.

Figure D.1 below shows the locations of facilities in Canada that manage spent fuel, as listed in table D.1.

Figure D.1: Facilities in Canada that manage spent fuel



D.1.2 Inventory of spent fuel in Canada

Table D.2 below shows the total volume of HLW in Canada and its respective volume, expressed as a percentage of the total volume of all radioactive waste in Canada.

Table D.2: Total volume of HLW in Canada

Waste category	Volume (as of December 31, 2019)	Percentage of total
High-level radioactive waste	12,718 m^3	0.6%

Table D.3 below inventories spent fuel in wet storage in Canada.

Table D.3: Inventory of spent fuel in wet storage in Canada as of December 31, 2019

Facility	Number of spent fuel bundles in wet storage	Kilograms of uranium [1]
Bruce Power Nuclear Generating Station	736,290	13,942,460
Darlington Nuclear Generating Station	340,392	6,518,918
Gentilly-2 Nuclear Generating Station	5,725	109,264
McMaster Nuclear Research Reactor	13	13
National Research Universal [2]	804	2,646
Pickering Nuclear Generating Stations	428,809	8,458,694
Point Lepreau Nuclear Generating Station	33,460	636,805

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

Figure D.2 below shows the number of spent fuel bundles in wet storage in Canada as of December 31, 2019, as inventoried in table D.3.

Figure D.2: Number of spent fuel bundles in wet storage in Canada as of December 31, 2019

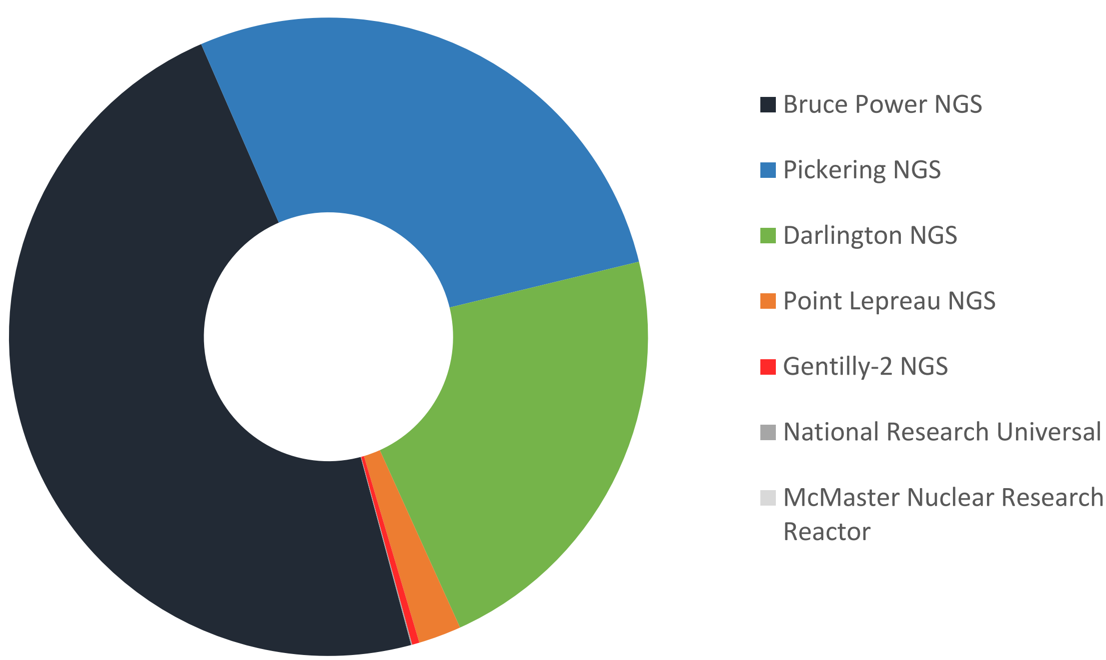


Table D.4 below inventories spent fuel in dry storage in Canada.

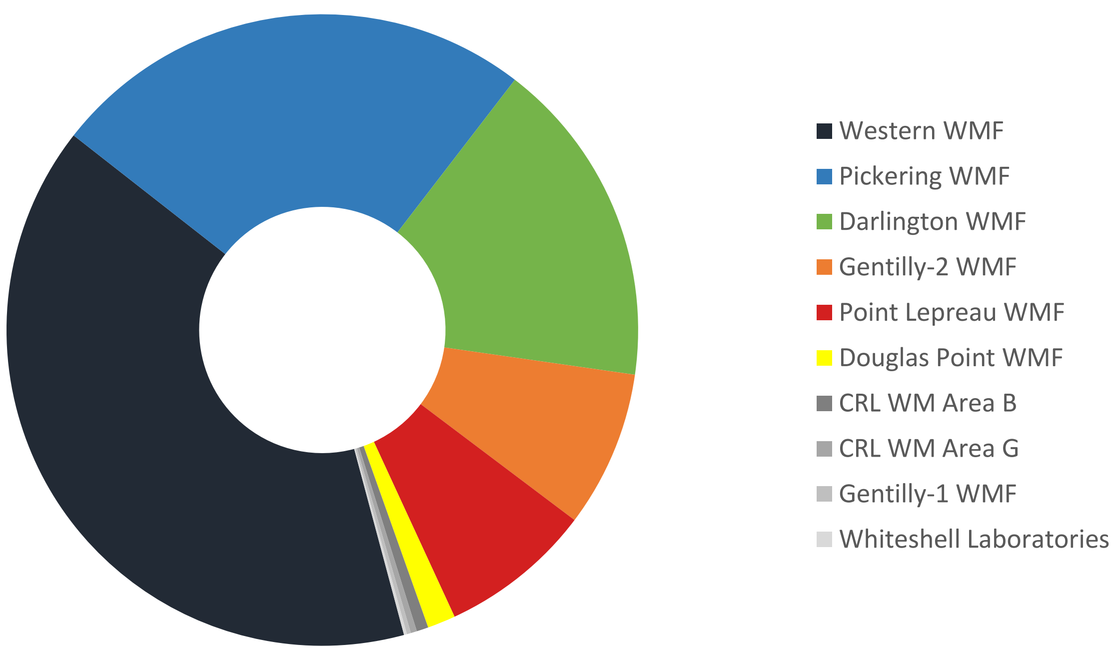
Table D.4: Inventory of spent fuel in dry storage in Canada as of December 31, 2019

Facility	Number of spent fuel bundles in dry storage	Kilograms of uranium [1]
CRL Waste Management Area B (spent research reactor fuel) [2]	9,334 [3]	22,646[3]
CRL Waste Management Area G	4,886	65,385
Darlington Waste Management Facility	260,649	4,974,978
Douglas Point Waste Management Facility	22,256	299,827
Gentilly-1 Waste Management Facility	3,213	67,596
Gentilly-2 Waste Management Facility	124,200	2,359,940
Pickering Waste Management Facility	385,230	7,652,154
Point Lepreau Waste Management Facility	121,498	2,305,827
Western Waste Management Facility	615,542	11,710,238
Whiteshell Laboratories	2,290	23,834

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

Figure D.3 below shows the number of spent fuel bundles in dry storage in Canada as of December 31, 2019, as inventoried in table D.4.

Figure D.3: Number of spent fuel bundles in dry storage in Canada as of December 31, 2019



D.1.3 Radioactive waste management facilities in Canada

Table D.5 below lists the facilities in Canada that manage non-spent fuel radioactive waste.

Table D.5: Facilities in Canada that manage non-spent fuel radioactive waste

Facility	Owner	Location	Purpose/feature
Non-fuel HLW			
Bruce Nuclear Generating Station	OPG	Tiverton, Ontario	Storage of non-spent fuel HLW
LLW and ILW			
Best Theratronics Manufacturing Facility, Kanata	Best Theratronics	Kanata, Ontario	Storage of disused sealed sources and depleted uranium shielding (LLW and ILW)
Blind River Refinery	Cameco	Blind River, Ontario	Storage of LLW
BWX Technologies (BWXT) Fuel Manufacturing, Peterborough	BWXT Nuclear Energy Canada (NEC)	Peterborough, Ontario	Storage of LLW
BWXT Fuel Manufacturing, Toronto	BWXT NEC	Toronto, Ontario	Storage of LLW
Cameco Fuel Manufacturing Facility	Cameco	Port Hope, Ontario	Storage of LLW
Chalk River Laboratories	AECL	Chalk River, Ontario	Storage of LLW and ILW
Darlington Waste Management Facility	OPG	Clarington, Ontario	Storage of ILW
Douglas Point Waste Management Facility	AECL	Tiverton, Ontario	Storage of decommissioning reactor waste (LLW and ILW)
Gentilly-1 Waste Management Facility	AECL	Gentilly, Quebec	Storage of decommissioning reactor waste (LLW)
Gentilly-2 Waste Management Facility	H-Q	Gentilly, Quebec	Storage of LLW and ILW
Nordion Manufacturing Facility, Kanata	Nordion	Kanata, Ontario	Storage of disused sealed sources (ILW)
Nuclear Power Demonstration	AECL	Renfrew County, Ontario	Storage of decommissioning reactor waste (LLW and ILW)
Pickering Waste Management Facility	OPG	Pickering, Ontario	Storage of ILW
Point Lepreau Waste Management Facility	NB Power	Maces Bay, New Brunswick	Storage of LLW and ILW
Port Hope Conversion Facility	Cameco	Port Hope, Ontario	Storage of LLW
Radioactive Waste Operations Site 1	OPG	Tiverton, Ontario	Storage of LLW and ILW
Western Waste Management Facility	OPG	Tiverton, Ontario	Storage of LLW and ILW
Whiteshell Laboratories	AECL	Pinawa, Manitoba	Storage of LLW and ILW

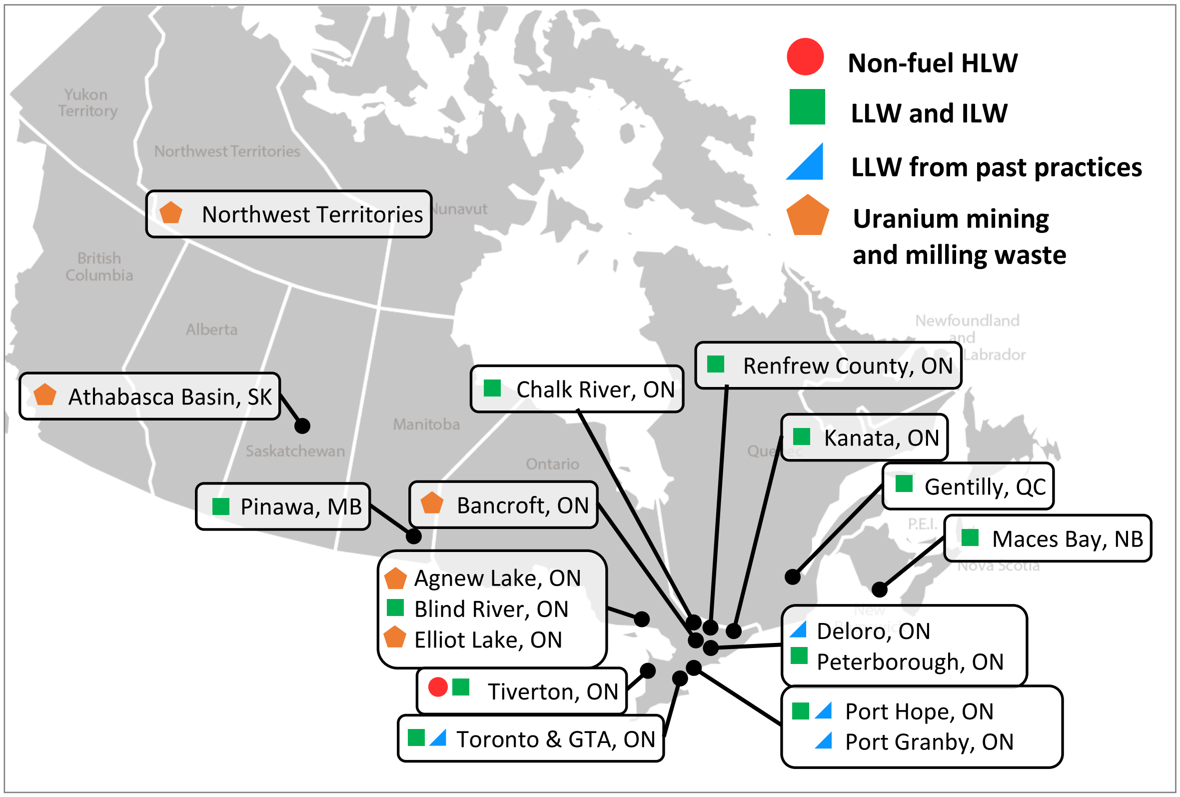
Facility	Owner	Location	Purpose/feature
LLW from past practices			
Deloro Mine Site	Ministry of the Environment, Parks and Conservation of Ontario	Deloro, Ontario	Management of LLW from past practices
Greater Toronto Area	AECL/Regional Municipality of Peel, Ontario	Greater Toronto Area, Ontario	Management of LLW from past practices
Port Granby	AECL	Port Granby, Ontario	Management of LLW from past practices
Port Hope	AECL	Port Hope, Ontario	Management of LLW from past practices
Welcome Waste Management Facility	AECL	Port Hope, Ontario	Management of LLW from past practices
Uranium mining and milling waste			
Agnew Lake	Ontario Ministry of Northern Development and Mines	Agnew Lake, Ontario	Management of uranium tailings and waste rock
Beaverlodge	Cameco	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Bicroft	Barrick Gold Corporation	Bancroft, Ontario	Management of uranium tailings and waste rock
Cigar Lake	Cameco	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Cluff Lake	Orano	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Denison	Denison Mines Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Dyno	EnCana West Limited (EWL) Management Ltd.	Bancroft, Ontario	Management of uranium tailings and waste rock
Gunnar	Saskatchewan Research Council	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Key Lake	Cameco	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Lacnor	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Lorado	Saskatchewan Research Council	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Madawaska	EWL Management Ltd.	Bancroft, Ontario	Management of uranium tailings and waste rock
McClean Lake	Orano	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock

Facility	Owner	Location	Purpose/feature
McArthur River	Cameco	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Milliken	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Nordic	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Panel	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Port Radium	Indigenous and Northern Affairs Canada	Northwest Territories	Management of uranium tailings and waste rock
Pronto	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Quirke 1 and 2	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Rabbit Lake	Cameco	Athabasca Basin, Saskatchewan	Management of uranium tailings and waste rock
Rayrock	Indigenous and Northern Affairs Canada	Northwest Territories	Management of uranium tailings and waste rock
Spanish American	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Stanleigh	Rio Algom Ltd.	Elliot Lake, Ontario	Management of uranium tailings and waste rock
Stanrock/Can-Met	Denison Mines Inc.	Elliot Lake, Ontario	Management of uranium tailings and waste rock

For detailed descriptions of the facilities listed in table D.5, see annexes 5, 6 and 7.

Figure D.4 below shows the locations of facilities in Canada that manage non-spent fuel radioactive waste, as listed in table D.5.

Figure D.4: Facilities in Canada that manage non-spent fuel radioactive waste



D.1.4 Inventory of radioactive waste in Canada

Table D.6 below shows the total volume of L&ILW and uranium mine and mill tailings in Canada and their respective volumes, expressed as a percentage of the total volume of all radioactive waste in Canada.

Table D.6: Total volume of L&ILW in Canada

Waste category	Volume (as of December 31, 2019)	Percentage of total
Low-level radioactive waste	2,075,022 m^3	98.7%
Intermediate-level radioactive waste	15,681 m^3	0.7%
Uranium mine and mill tailings	218 million tonnes	

D.1.4.1 Non-fuel high-level radioactive waste

Table D.7 below inventories non-spent fuel HLW in storage in Canada.

Table D.7: Inventory of non-spent fuel HLW in storage in Canada as of December 31, 2019

Facility	Description of stored waste	Storage method	On-site waste inventory as of December 31, 2019	
			Volume (m^3)	Activity (TBq)
Bruce Power	Disused cobalt-60 sealed sources	Pool storage	3	N/A

Note: N/A means "not available".

D.1.4.2 Low- and intermediate-level radioactive waste

Table D.8 below inventories L&ILW in storage in Canada.

Table D.8: Inventory of L&ILW in storage in Canada as of December 31, 2019

Facility	Description of stored waste	Storage method	On-site waste inventory as of December 31, 2019			
			ILW		LLW	
			Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Best Theratronics Manufacturing Facility, Kanata	Disused cobalt-60 sealed sources, disused cesium-137 sealed sources, depleted uranium shielding components	Pool storage or dry containers	<1	71	<1	N/A
Blind River Refinery	Non-combustible process waste	LLW: 205 L-drums	nil	nil	4,400	N/A
BWXT Fuel Manufacturing, Peterborough	Solid waste from processing	LLW: 205 L-drums, waste boxes	nil	nil	2	<1
BWXT Fuel Manufacturing, Toronto	Solid waste from processing	LLW: 205 L-drums, skids	nil	nil	33	<1
Cameco Fuel Manufacturing Facility	Non-combustible process waste	LLW: 205 L-drums	nil	nil	4,000	N/A
Chalk River Laboratories	Research reactor and isotope production waste, external waste, decommissioning waste	ILW: tile holes, bunkers and legacy tanks ILW/LLW: shielded modular above-ground storage (SMAGS) LLW: sand trenches, low-level storage buildings, above-ground stockpiles, modular above-ground storage (MAGS) and bulk materials landfill	1,050 [1]	N/A	136,582 [2]	N/A

Facility	Description of stored waste	Storage method	On-site waste inventory as of December 31, 2019			
			ILW		LLW	
			Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
	Contaminated soils	Luggers, 205 L-steel drums, B-25 containers in SMAGS, sand trenches and above-ground stockpiles	nil	nil	156,276	N/A
	Decommissioning waste (January 1, 2005, to December 31, 2016)	ILW: tile holes and bunkers LLW: MAGS, SMAGS	332	N/A	16,894	N/A
Darlington Waste Management Facility	Interim storage of intermediate-level reactor refurbishment waste from Darlington	ILW: retube waste containers stored inside Darlington storage overpacks	628	77,900 [3]	nil	nil
Douglas Point Waste Management Facility	Decommissioned reactor waste	Reactor building	6	N/A	92	N/A
Gentilly-1 Waste Management Facility	Decommissioned reactor waste (IX resin)	Reactor building	nil	nil	161	N/A
Gentilly-2 Waste Management Facility	Operational reactor waste	ILW: radioactive waste storage area (ASDR) and solid radioactive waste management facility (concrete cells) LLW: ASDR and solid radioactive waste management facility (concrete cells)	358	53	1,339	5

Facility	Description of stored waste	Storage method	On-site waste inventory as of December 31, 2019			
			ILW		LLW	
			Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Nordion Manufacturing Facility, Kanata	Disused cobalt-60 sealed sources; disused cesium-137 sealed sources	Pool storage or dry containers	5	4,126	nil	nil
Nuclear Power Demonstration	Decommissioned reactor waste	Reactor building	389	N/A	2,289	N/A
Pickering Waste Management Facility	Interim storage of intermediate-level reactor refurbishment waste from Pickering A (Units 1 to 4)	ILW: dry storage modules	1,012	2,374 [4]	nil	nil
Point Lepreau Waste Management Facility	Operational waste: drums, filters and compactible/non-compactible boxed waste	LLW: concrete vault structures ILW: concrete vault structures, filter storage structures and refurbishment canisters	362	794	1,787	178
Port Hope Conversion Facility	Non-combustible process waste	LLW: 205 L-drums	nil	nil	4,000	N/A
	Decommissioning waste	Drums or other appropriate industrial packaging	nil	nil	1700	N/A
Radioactive Waste Operations Site-1	Interim storage of low- and intermediate-level reactor waste generated by Douglas Point and Pickering A (Units 1 to 4)	ILW: in-ground storage structures (trenches, tile holes) LLW: in-ground storage structures (trenches)	5	12 [5]	325	<1

Facility	Description of stored waste	Storage method	On-site waste inventory as of December 31, 2019			
			ILW		LLW	
			Volume (m^3)	Activity (TBq)	Volume (m^3)	Activity (TBq)
Western Waste Management Facility	Interim storage of low- and intermediate-level reactor waste generated by Bruce Power, Darlington, and 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)	11,293 [6]	56,702 [5]	104,906 [7]	86
Whiteshell Laboratories	Decommissioning waste (January 1, 2005, to December 31, 2016)	ILW: in-ground concrete bunkers and storage tanks LLW: above-ground concrete bunkers	240	N/A	16,861	N/A

Note: N/A means "not available".

[1] Prior estimates were based on a conservative assumption that all waste stored within a structure that could contain ILW would be categorized as ILW until better characterization data became available. Between 2016 and 2019, retrieval and processing operations were conducted on selected legacy wastes in storage, and records were verified to extrapolate the current volumes.

[2] Volume reduced since 2016, as some material was categorized as packaged waste and included waste that was to be generated in the future.

[3] Approximate activity after three years of decay.

[4] Approximate activity after 30 years of decay.

[5] Approximate activity based on 2013 inventory.

[6] Includes station in-tank spent resin volumes assumed to be eventually transferred to the Western WMF and stored long-term.

[7] Includes LLW volumes currently stored off-site at EnergySolutions Canada but which are assumed to eventually return to and be stored long term at the Western WMF.

Figure D.5 below shows the volume of LLW in storage in Canada as of December 31, 2019, as inventoried in table D.8.

Figure D.5: Volume of LLW in storage in Canada as of December 31, 2019

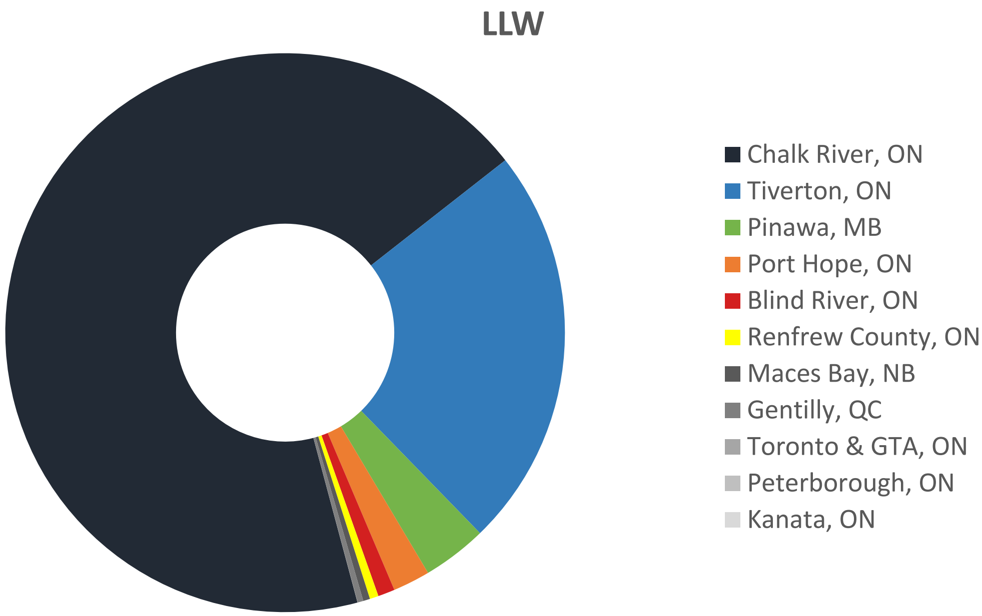
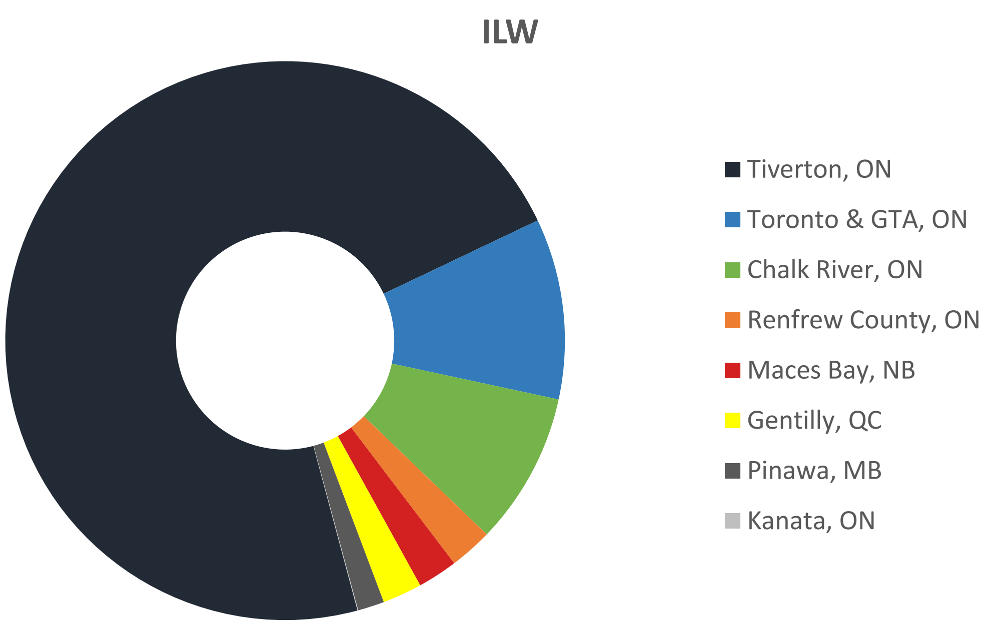


Figure D.6 below shows the volume of ILW in storage in Canada as of December 31, 2019, as inventoried in table D.8.

Figure D.6: Volume of ILW in storage in Canada as of December 31, 2019



D.1.4.3 Low-level radioactive waste that has resulted from past practices

Table D.9 below inventories LLW that has resulted from past storage practices in Canada.

Table D.9: Inventory of LLW that has resulted from past storage practices in Canada

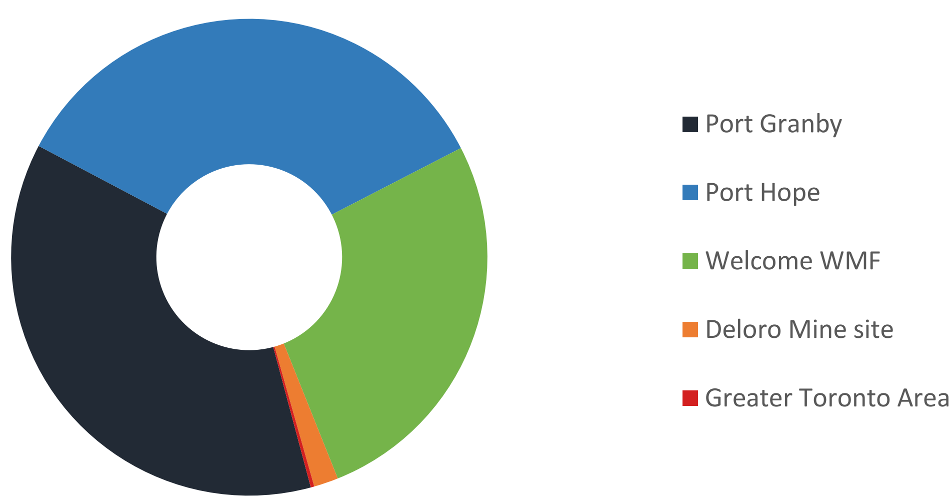
Site name or location	Description of stored waste	Storage method	LLW	
			Volume (m^3)	Activity (TBq)
Deloro Mine site [1]	Contaminated soils and historical tailings	*In situ* (fenced-in area)	34,500	2
Greater Toronto Area	Radium-contaminated soils, radium contamination fixed to structural elements in buildings	*In situ* and consolidated storage Above-ground consolidated mound	4,900	N/A
Port Granby	Waste and contaminated soils	Trench burial	765,622	N/A
Port Hope	Contaminated soils	*In situ* and consolidated storage	720,000	N/A
Welcome Waste Management Facility	Contaminated soils	Above-ground mound	550,000	N/A

Note: N/A means "not available".

[1] Site no longer under licence by the CNSC.

Figure D.7 below shows the volume of LLW that has resulted from past storage practices in Canada as of December 31, 2019, as inventoried in table D.9.

Figure D.7: Volume of LLW that has resulted from past storage practices in Canada as of December 31, 2019



D.1.4.4 Uranium mining and milling waste

D.1.4.4.1 Operational mine and mill sites

Table D.10 below inventories uranium tailings and waste rock in storage at operational mine and mill sites in Canada.

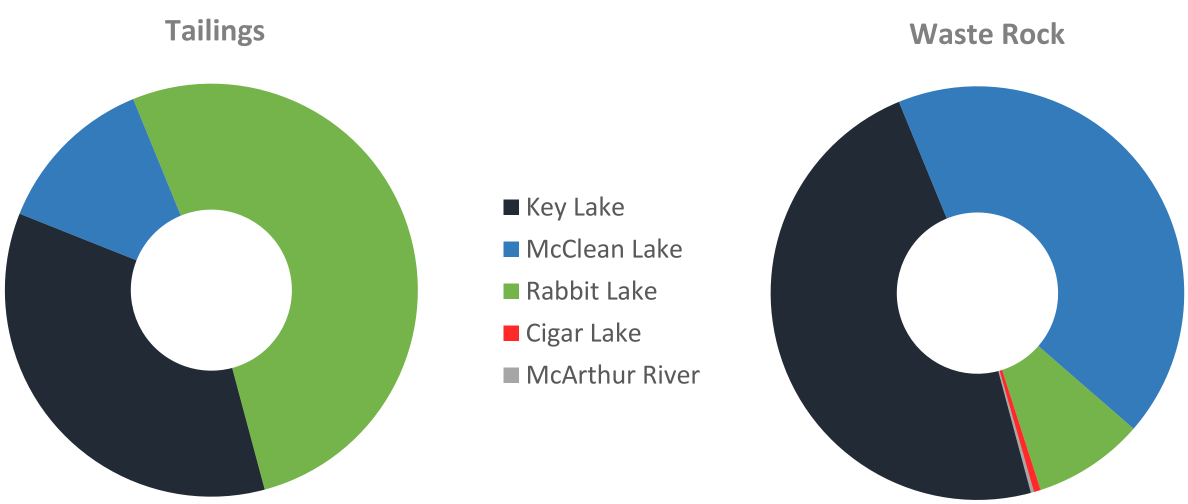
Table D.10: Inventory of uranium tailings and waste rock in storage at operational mine and mill sites in Canada as of December 31, 2019

Operating mine and mill site	Storage method	On-site waste inventory as of December 31, 2019		
		Tailings	Waste rock	
		Mass (tonnes)	Mineralized (tonnes)	Non-mineralized (tonnes)
Cigar Lake	No tailings on-site; ore is transported to McClean Lake for milling	nil	685,647	84,172
Key Lake	Deilmann TMF	6,177,572[1]	1,123,058	68,028,327
McArthur River	No tailings on-site; ore is transported to Key Lake for milling	nil	116,501	226,811
McClean Lake	In-pit TMF	2,243,859 [2]	10,200,000	51,200,000
Rabbit Lake	Rabbit Lake in-pit TMF	9,126,693	1,348,389	11,157,174

[1] Includes tailings accumulated from the processing of ores from McArthur River.
[2] Includes tailings accumulated from the processing of ores from Cigar Lake.

Figure D.8 below shows the mass of uranium tailings and waste rock in storage at operational mine and mill sites in Canada as of December 31, 2019, as inventoried in table D.10.

Figure D.8: Mass of uranium tailings and waste rock in storage at operational mine and mill sites in Canada as of December 31, 2019



D.1.4.4.2 Decommissioned and inactive tailings sites

Table D.11 below inventories uranium tailings and waste rock in storage at decommissioned and inactive tailings sites in Canada.

Operations at the sites in table D.11 pre-dated current waste segregation practices. As a result, the breakdown between mineralized and non-mineralized waste rock is not available.

Table D.11: Inventory of uranium tailings and waste rock in storage at decommissioned and inactive tailings sites in Canada as of December 31, 2019

Site name or location	Storage method	On-site waste inventory as of December 31, 2019	
		Tailings Mass (tonnes)	Waste rock Mass (tonnes)
Decommissioned tailings sites			
Cluff Lake	Tailings management area – surface	3,230,000	18,400,000
Inactive tailings sites			
Agnew Lake	Lake-vegetated, above-ground tailings	510,000	N/A
Beaverlodge	Above-ground tailings and mine backfill	5,700,000 [1]	4,800,000
Bicroft	Above-ground tailings in two areas	2,000,000	N/A
Denison	Flooded, above-ground tailings in two areas	63,800,000	N/A
Dyno	Above-ground tailings	600,000	N/A
Gunnar	Above-ground tailings	4,400,000	N/A
Key Lake	Above-ground TMF	3,579,781 [2]	reported in table D.10
Lacnor	Above-ground tailings	2,700,000	N/A
Lorado	Above-ground tailings	360,000	N/A
Madawaska	Above-ground tailings in two areas	4,000,000	N/A
Milliken	Tailings management area	150,000	N/A
Nordic	Above-ground tailings	12,000,000	N/A
Panel	Flooded, above-ground tailings	16,000,000	N/A
Port Radium	Above-ground tailings in four areas	907,000	N/A
Pronto	Above-ground tailings	2,100,000	N/A
Quirke 1 and 2	Flooded, above-ground tailings	46,000,000	N/A
Rabbit Lake	Above-ground TMF	6,500,000	reported in table D.10

Site name or location	Storage method	On-site waste inventory as of December 31, 2019	
		Tailings Mass (tonnes)	Waste rock Mass (tonnes)
Rayrock	Above-ground tailings in north and south tailings piles	71,000	N/A
Spanish American	Flooded, above-ground tailings	450,000	N/A
Stanleigh	Flooded, above-ground tailings	19,953,000	N/A
Stanrock/Can-Met	Above-ground tailings	5,750,000	N/A

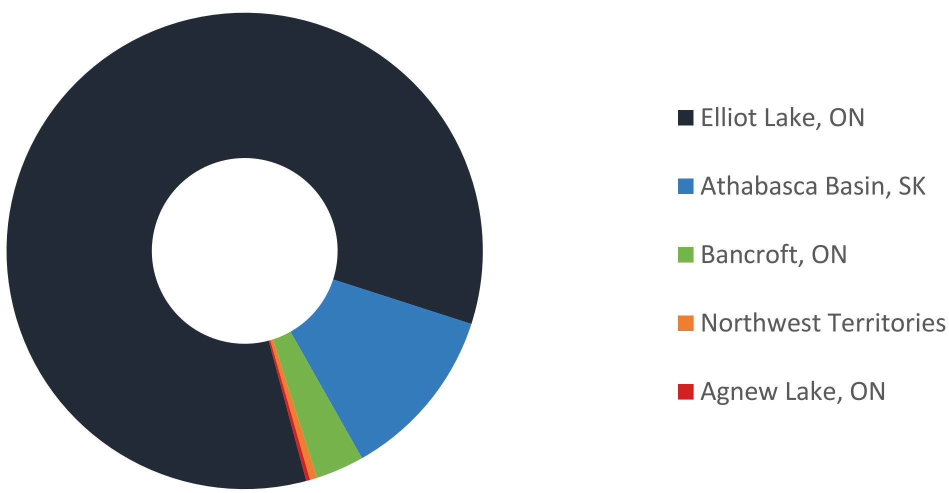
Note: N/A means "not available".

[1] Tailings volume does not include 4,300,000 tonnes that have been used as backfill.

[2] Based on monthly production reports between 1983 and 1996. In 1996, tailings placement switched to the Deilmann TMF.

Figure D.9 below shows the mass of uranium tailings and waste rock in storage at decommissioned and inactive tailings sites in Canada as of December 31, 2019, as inventoried in table D.11.

Figure D.9: Mass of uranium tailings and waste rock in storage at decommissioned and inactive tailings sites in Canada as of December 31, 2019



D.1.5 Nuclear facilities undergoing decommissioning in Canada

Table D.12 below lists the nuclear facilities currently in the process of being decommissioned in Canada and includes the status of the decommissioning activities at those facilities.

Table D.12: Nuclear facilities undergoing decommissioning in Canada

Facility	Decommissioning status
Chalk River Laboratories	A number of CRL nuclear facilities are at different stages of decommissioning. The dedicated isotopes facilities (Multipurpose Applied Physics Lattice Experiment (MAPLE) and new processing facility) remain in an extended shutdown state. The NRU reactor was permanently shut down in March 2018, then de-fuelled and de-watered, and it continues to move through the shutdown state to achieve storage-with-surveillance conditions. The National Research Experimental (NRX) and the active waste disposal system remain in storage-with-surveillance. A few other facilities have been newly turned over to facilitate decommissioning, such as the nuclear fuel fabrication facility and the tritium facility. The NRX ancillary buildings, fuel storage bays, plutonium recovery laboratory, plutonium tower, wastewater evaporator and filter water storage reservoir are at different stages of active decommissioning.
Douglas Point Waste Management Facility	The Douglas Point reactor is in storage-with-surveillance. In this state, facilities are monitored and maintained in order to allow for radioactive decay.
Gentilly-1 Waste Management Facility	The Gentilly-1 reactor is in storage-with-surveillance.
Gentilly-2 Nuclear Generating Station	The Gentilly-2 NGS was shut down since December 2012. Since then, many activities have taken place to prepare for the storage-with-surveillance phase, including the complete defueling of the reactor core, draining of the light water circuits, draining of the heavy water circuits, transfer of oils from some internal systems, and transfer of used resins from internal systems. The initial plan was to be in dry storage state (all spent fuel out of the spent fuel bay) on December 31, 2020; however, these plans may be delayed due to COVID-19.
Gunnar mine site	Since the issuance of their licence, SRC began remediation work at the Gunnar mine site which has included developing borrow areas and haul roads, consolidating, re-grading and covering tailings at both Gunnar main and central tailings areas. For 2020, SRC plans on commencing work on the other cleanup aspects, which includes the construction of landfills and the consolidation of waste (both radioactive and hazardous wastes). In addition, work to remediate the tailings located in Langley Bay is also scheduled to commence in 2020.
Nuclear Power Demonstration	NPD is in storage-with-surveillance. In this state, facilities are monitored and maintained in order to allow for radioactive decay.
Saskatchewan Research Council SLOWPOKE-2	The SRC SLOWPOKE-2 facility is being decommissioned after 38 years of operation. The end-state objective for decommissioning of the reactor will allow for the unrestricted use of the building. The decommissioning project is nearly completed and the licensee is expected to request a licence to abandon the site during 2020.

Facility	Decommissioning status
Whiteshell Laboratories	WL consists of many individual facilities. A number of these facilities are in the process of active decommissioning, while others remain in storage-with-surveillance. For example, all systems and components of the SLOWPOKE Demonstration Reactor have been removed, with the exception of the pool liner and cover. The main research building (building 300) is undergoing decommissioning and demolition in a phased manner. The WR-1 is currently in storage-with-surveillance.

For further information on the decommissioning status of the facilities listed in table D.12, see annex 8.

SECTION E

Legislative & regulatory systems

Section E – Legislative and Regulatory Systems

E.1 Implementing measures (Article 18)

This section addresses the obligations under Article 18 of the Joint Convention.

Section 9 of the NSCA sets out the objects of the CNSC as follows:

(a) to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to

  (i) prevent unreasonable risk, to the environment and to the health and safety of persons, associated with that development, production, possession or use,

  (ii) prevent unreasonable risk to national security associated with that development, production, possession or use, and

  (iii) achieve conformity with measures of control and international obligations to which Canada has agreed; and

(b) to disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use referred to in paragraph (a).

E.2 Legislative and regulatory framework (Article 19)

This section addresses the obligations under Article 19 of the Joint Convention.

ARTICLE 19. LEGISLATIVE AND REGULATORY FRAMEWORK

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.
2. This legislative and regulatory framework shall provide for:
   (i) the establishment of applicable national safety requirements and regulations for radiation safety;
   (ii) a system of licensing of spent fuel and radioactive waste management activities;
   (iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;
   (iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;
   (v) the enforcement of applicable regulations and of the terms of the licences;
   (vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and radioactive waste management.
3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

E.2.1 Establishment of the Canadian legislative and regulatory framework

The following are the statutes used to regulate and oversee the nuclear industry in Canada, which includes the management of radioactive waste and spent fuel: the *Nuclear Safety and Control Act* (NSCA), *Nuclear Energy Act* (NEA), *Nuclear Fuel Waste Act* (NFWA) and *Nuclear Liability and Compensation Act* (NLCA). The nuclear industry is also subject to the *Impact Assessment Act* (IAA), *Canadian Environmental Protection Act* (CEPA) and *Fisheries Act*. The NSCA is the main legislation that deals with safety considerations. In Canada, an act is a means by which a law is made by Parliament.

A number of Government of Canada departments are involved in administering this federal legislation. 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 legislation and regulations in force in the individual provinces and territories where nuclear-related activities are carried out. Where an overlap occurs in jurisdictions and responsibilities, the CNSC takes the lead in efforts to harmonize regulatory activities, including joint regulatory groups which involve provincial and territorial regulators.

E.2.1.1 *Nuclear Safety and Control Act*

The NSCA was passed by Parliament on March 20, 1997, and came into force on May 31, 2000, replacing the *Atomic Energy Control Act*. This was the first major overhaul of Canada’s nuclear regulatory regime since the creation of the Atomic Energy Control Board in 1946. The NSCA provides legislative authority for all nuclear industry developments, including health and safety standards for nuclear energy workers, environmental protection measures, security of nuclear facilities and public input in the licensing process. The NSCA can be viewed online at laws.justice.gc.ca.

The CNSC was established in the NSCA as an independent regulatory body responsible for regulating the use of nuclear material in Canada and the nuclear fuel cycle. The NSCA sets out the CNSC’s mandate, responsibilities and powers. It authorizes the CNSC to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in Canada. The NSCA empowers the CNSC to make regulations (see section E.2.2.2 for more details).

Under the NSCA, the CNSC’s mandate covers four major areas:

- regulation of the development, production and use of nuclear energy in Canada to protect health, safety and the environment
- regulation of the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and prescribed information
- implementation of measures respecting international control of the development, production, transport and use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons and nuclear explosive devices
- dissemination of scientific, technical and regulatory information concerning the activities of the CNSC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and use of nuclear substances

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

- radiation dose limits consistent with 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 authority to issue an order for remedial action in hazardous situations

E.2.1.2 *Nuclear Energy Act*

The NEA came into force concurrently with the NSCA in 2000. It is a revised version of the *Atomic Energy Control Act* (1946), intended to address the development and use of nuclear energy, less the regulatory aspects of the *Atomic Energy Control Act* that were moved to the NSCA. The NEA can be viewed online at laws.justice.gc.ca.

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

E.2.1.3 *Nuclear Fuel Waste Act*

Three provincial nuclear utilities –OPG, H-Q and NB Power – own 98 percent of the spent fuel in Canada. AECL owns most of the remainder. Following a decade-long environmental assessment for a deep geological repository (DGR) 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 NFWA, 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 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 on proposed approaches for the long-term management of the waste, along with a recommendation on which one of the proposed approaches should be adopted. The NFWA required this analysis to include feedback from comprehensive public consultations – which includes Indigenous peoples – and be evaluated in terms of social and ethical considerations.

Under the NFWA, the Government of Canada was 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. The NFWA can be viewed online at laws.justice.gc.ca.

After coming into force, the NFWA required the nuclear energy corporations to establish the Nuclear Waste Management Organization (NWMO) and the trust funds necessary to finance the implementation of long-term waste management activities. Following extensive studies and public consultation, (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
- the Adaptive Phased Management (APM) approach which combines the three previous options in one flexible, adaptive process for making management decisions

On June 14, 2007, the Government of Canada announced that it had selected the APM approach for the long-term management of spent fuel. This approach recognizes that the people who benefit from nuclear energy produced today must take actions to ensure that wastes are dealt with responsibly and without unduly burdening future generations. The approach is also sufficiently flexible to adjust to changing social and technological developments. The NWMO is required to implement the government's decision according to the NFWA, with funding from the nuclear energy corporations.

Over the past several years, a number of key government decisions contributed to implementing the APM approach. In April 2009, the Minister of Natural Resources approved a funding formula which ensures that sufficient money is set aside in trust to pay for the full lifecycle cost of this approach. On August 14, 2009, the Minister of Natural Resources entered into a memorandum of understanding with the NWMO regarding Indigenous engagement. The memorandum clarifies the roles and responsibilities of the Crown and the NWMO with respect to their obligation to consult with Indigenous peoples about this project and in relation to the NFWA.

Since early 2010, the NWMO has been moving forward with its siting process to identify a safe, secure and suitable site for a DGR to manage spent fuel in an informed and willing host community. A number of communities have inquired about the project and are exploring their interest with the NWMO. As of March 2020, Ignace in northwestern Ontario and South Bruce in southern Ontario were still considered potential host areas for the project. The NWMO expects to identify a single, preferred site by 2023 (see section K.2.4 for more details).

E.2.1.4 *Nuclear Liability and Compensation Act*

The NLCA came into force on January 1, 2017, and replaced the *Nuclear Liability Act*. The NLCA establishes the legal regime that would apply in the event of a Canadian nuclear incident that results in civil damages. The NLCA is administered by NRCan, which also has responsibility for policy direction. The NLCA can be viewed online at laws.justice.gc.ca.

The NLCA places total responsibility for civil nuclear damage on the operator of a nuclear installation. As of January 1, 2020, the operator is liable for up to $1 billion in damages. The NLCA requires the operator to carry at least half of this liability with insurance that may, subject to approval by the minister, be supplemented by alternate financial arrangements. The NLCA also provides for establishing a nuclear claims tribunal in the event of a serious nuclear incident which would deal with claims for compensation when the Government of Canada deems it to be in the public interest, having regard to the extent and estimated cost of the damage.

The NLCA also features:

- expanded categories of compensable damage to address environmental damage, economic loss and costs related to preventive measures

- a longer time period for submitting compensation claims for bodily injury (30 years versus the current 10 years)
- the process for establishing a quasi-judicial claims tribunal to replace the court system, if necessary, to accelerate claims payments and to provide an efficient and equitable forum

The NLCA also enables Canada to implement the *Convention on Supplementary Compensation for Nuclear Damage*, an international treaty under the auspices of the IAEA, which provides a liability and compensation regime to address damages, including those arising from transboundary and transportation incidents. Canada delivered the ratification documents for that Convention on June 6, 2017.

E.2.1.5 *Impact Assessment Act*

The IAA and its regulations establish the legislative basis for the federal practice of impact assessments in most regions of Canada and can be viewed online at laws.justice.gc.ca. Impact assessment is a planning and decision-making tool used to assess positive and negative environmental, economic, health and social effects of proposed projects, as well as impacts on Indigenous groups and on rights of Indigenous peoples.

The purpose of the IAA is to:

- foster sustainability, ensure respect of government commitments concerning the rights of Indigenous peoples
- include environmental, social, health and economic factors in the scope of assessments
- establish a fair, predictable and efficient impact assessment process that enhances Canada's competitiveness and promotes innovation
- consider positive and adverse effects
- include early, inclusive and meaningful public engagement
- promote nation-to-nation, Inuit–Crown, and government-to-government partnerships with Indigenous peoples
- ensure decisions are based on science, Indigenous knowledge and other sources of evidence
- assess cumulative effects within a region

The Impact Assessment Agency of Canada (IAAC) leads the conduct of impact assessments for all designated projects subject to this legislation and works in collaboration with the CNSC to review projects that are also subject to regulation under the NSCA. Nuclear projects to be assessed under the IAA are subject to an integrated impact assessment that is carried out by a review panel. An integrated impact assessment is a single assessment process meant to ensure that the requirements of the IAA and the NSCA are discharged as "one project, one assessment".

Projects with environmental assessments already initiated under *Canadian Environmental Assessment Act, 2012* (CEAA 2012) will continue under their current processes, as per the transition provision (section 182) of the IAA. This is the case for the environmental assessments of CNL's near surface disposal facility (NSDF) project, NPD Closure Project and *in situ* decommissioning of WR-1, all of which are led by the CNSC. For these projects, the CNSC is responsible for managing the environmental assessment process, including ensuring an environmental assessment report is prepared. In practice, the project proponent may be delegated to conduct technical studies for the environmental assessment or to ensure mitigation measures and/or a follow-up program are implemented; however, the CNSC Commission is the federal decision-maker when determining whether a project is likely to cause significant adverse environmental effects.

E.2.1.6 *Canadian Environmental Protection Act*

The primary purpose of the CEPA is to contribute to sustainable development by preventing pollution. It provides the legislative basis for a range of federal environmental- and health-protection programs, including:

- the assessment and management of risks from chemicals, polymers and living organisms
- programs related to air and water pollution, hazardous waste, air pollutants and greenhouse gas emissions
- ocean disposal
- environmental emergencies

E.2.1.7 *Fisheries Act*

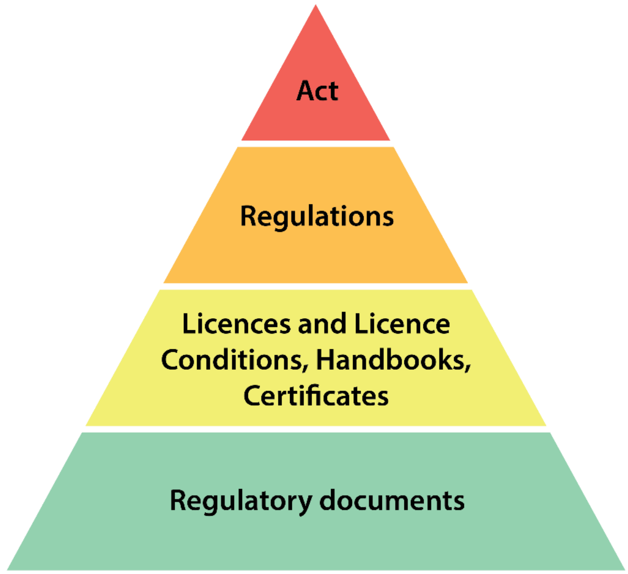
The *Fisheries Act* was one of the first laws enacted in Canada in 1868. Recognizing that healthy and productive fisheries require healthy fish habitat, legislators incorporated the habitat-protection and pollution-prevention provisions into the Act in the 1970s. In 2012, changes were made to focus on protecting fish and fish habitats that were part of or that supported commercial, recreational or Indigenous fisheries, and to streamline the regulatory process. In 2019, changes were made to the *Fisheries Act* to provide a framework for the conservation and protection of fish and fish habitats by:

- ensuring protection for fish and fish habitats, and incorporating tools to accomplish this
- providing certainty for industry, stakeholders and Indigenous groups
- promoting the long-term sustainability of aquatic resources

E.2.2 National safety requirements and regulations

To safely regulate an evolving nuclear sector, the CNSC maintains an effective and flexible regulatory framework. Figure E.1 depicts the main elements of Canada’s nuclear regulatory framework. This framework consists of laws passed by the Parliament of Canada that govern the regulation of Canada’s nuclear industry, and regulations, licences and documents that the CNSC uses to regulate the industry.

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



As shown in figure E.2, the CNSC's regulatory framework applies 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 a proliferation risk

Figure E.2: Nuclear industries regulated by the CNSC

E.2.2.1 *Nuclear Safety and Control Act*

See section E.2.1.1.

E.2.2.2 Regulations issued under the *Nuclear Safety and Control Act*

A regulation, also referred to as “delegated legislation” or “subordinate legislation,” may be viewed as the operational part of a law that commonly deals with matters, such as what is meant by certain terms used in an act, procedures and processes to be followed or standards to be met in order to comply with an act. Regulations are not made by Parliament; rather, they are made by someone to whom Parliament has delegated the authority to make them. The Commission has the authority under the NSCA to make regulations with the approval of the Governor in Council for matters related to its mandate.

Under the NSCA, the Commission has implemented regulations and by-laws with the approval of the Governor in Council. Regulations set requirements for all types of licence applications and obligations, and provide for exemptions from licensing. By-laws are in place to govern the management and conduct of the Commission’s affairs.

The following regulations and by-laws have been issued under the NSCA:

- *General Nuclear Safety and Control Regulations*

  The GNSCR provide general regulations that address licence applications and renewals, exemptions, the obligations of licensees, prescribed nuclear facilities and equipment and information, contamination, record-keeping and inspections. These regulations apply to all nuclear facilities and CNSC licensees and applicants.

  The CNSC is exploring options to amend the GNSCR to reflect best practices for safeguarding nuclear material, thereby ensuring continued effective reporting and monitoring of nuclear materials in Canada. These regulations are slated for pre-publication in the *Canada Gazette*, Part I, in 2020.

- *Administrative Monetary Penalties Regulations*

  The AMPR set out the list of violations that are subject to administrative monetary policies under the NSCA, the method and criteria by which the penalty amounts will be determined and the manner in which notices of violations must be served. These regulations apply to all persons subject to the NSCA. The AMPR were last amended on September 22, 2017.

- *Radiation Protection Regulations*

  The RPR define the ALARA principle and regulations for radiation dose limits, action limits, requirements for labelling and signage, and reports. These regulations apply to all nuclear facilities and CNSC licensees and applicants.

  CNSC staff assess licensees’ radiation protection programs to ensure that they meet the RPR requirements. Radiation protection programs are assessed at certain times in the lifecycle of a nuclear facility or regulated activity: during the initial application (construction, operation and decommissioning), and at the time of licence renewal and/or amendment. The radiation protection program forms part of the licensing basis for the nuclear facility or regulated activity.

  The current regulations, introduced in 2000, are based on guidance from the ICRP and IAEA. The CNSC is committed to ensuring its radiation protection requirements are up to date to protect workers, the Canadian public and the environment. In keeping with this commitment, the CNSC undertook reviews of the RPR to ensure continued alignment with evolving international standards, clarify requirements, update and clarify existing requirements for radiation protection during an emergency, and address gaps based on lessons learned since the RPR came into force.

The CNSC solicited feedback from stakeholders and members of the public regarding proposals to amend the RPR in 2013 through discussion paper, DIS-13-01, "Proposals to Amend the *Radiation Protection Regulations*".

To address recommendations from the CNSC Fukushima Task Force Report, the RPR were revised in September 2017 to more fully describe the requirements for addressing radiological hazards during an emergency. The CNSC is continuing to advance most of the proposed amendments to harmonize the RPR, as outlined in the What We Heard Report for DIS-13-01. The regulatory proposal was pre-published in the *Canada Gazette*, Part I on June 15, 2019. The CNSC will take all comments into account prior to finalizing the proposal for consideration by the CNSC Commission and the Governor in Council. The regulations are slated for publication in the 2020–21 fiscal year.

The RPR were last amended on September 22, 2017.

- *Class I Nuclear Facilities Regulations*

  The CINFR provide requirements for site-preparation licence applications, personnel certifications and record-keeping, and sets timelines for regulatory reviews. These regulations apply to Class IA and IB nuclear facilities, including nuclear reactors, large particle accelerators, nuclear processing plants, fuel fabrication plants and waste management facilities. The CINFR were last amended on September 22, 2017.

- *Class II Nuclear Facilities and Prescribed Equipment Regulations*

  The CIINFPER provide requirements for licence applications, prescribed equipment certification, radiation protection and record-keeping. These regulations apply to Class II nuclear facilities and Class II prescribed equipment licensees and applicants.

  These regulations are currently under review, with preliminary consultation activities planned during the 2020–21 fiscal year.

- *Uranium Mines and Mills Regulations*

  The UMMR provide requirements for site preparation, construction, operation, decommissioning and abandonment of uranium mines and mills, including licensees' obligations with respect to operating procedures, codes of practice, ventilation systems, use of respirators, protection from gamma radiation and record-keeping. They also set timelines for regulatory reviews. These regulations apply to uranium mine and mill licensees and applicants.

  The UMMR were last amended on September 22, 2017.

- *Nuclear Substances and Radiation Devices Regulations*

  The NSRDR provide requirements for the licensing and certification of nuclear substances and radiation devices, the use of radiation devices and record-keeping. These regulations apply to all nuclear substances, sealed sources, radiation devices, licensees and applicants.

  Development work to update these regulations commenced in October 2019, with consultation through *Canada Gazette*, Part I expected in the 2021–22 fiscal year.

- *Packaging and Transport of Nuclear Substances Regulations, 2015*

  The PTNSR, 2015 provide requirements for licences to transport, the transport of nuclear substances and record-keeping, as well as requirements for the design and certification of packages, special form radioactive material and other prescribed equipment. These regulations apply to all persons transporting or offering for transport nuclear substances, including nuclear facilities and CNSC licensees and applicants.

For the purpose of these regulations, the PTNSR, 2015 incorporate by reference the 2012 edition of the IAEA Regulations for the Safe Transport of Radioactive Material. The 2018 edition of the Regulation for the Safe Transport of Radioactive Material was released by the IAEA and came into effect on July 1, 2020.

- *Nuclear Security Regulations*

  Part I of the NSR defines security-related information, requirements and general obligations for application. They also include information about security requirements for high-security sites. Part II of the NSR provides security-related requirements for licensing and operating lower-risk facilities. These regulations apply to any CNSC licensee and applicant with respect to Category I, II and III nuclear material and high-security sites.

  The CNSC has commenced its review of the NSR. The last major revision was completed in 2006. Since then, operational experience and technological advancements have evolved and we need to stay updated with international recommendations, guidance and best practices. The CNSC has organized and held workshops with stakeholders, and taken their feedback into account when developing the regulatory proposal for pre-publication in the *Canada Gazette*, Part I scheduled for 2020, prior to finalizing the proposal for consideration by the CNSC Commission and the Governor in Council.

- *Nuclear Non-proliferation Import and Export Control Regulations*

  The NNIECR provide the requirements for a licence application to import or export controlled nuclear substances, controlled nuclear equipment, or controlled nuclear information. They also set out exemptions from licensing for certain import and export activities. These regulations apply to every CNSC licensee's and applicant's import and export activities.

  Safeguards-related amendments to these regulations are currently under development. Consultation in the *Canada Gazette*, Part I is expected in the 2020–21 fiscal year.

- *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*

  These regulations set out the regulatory fees for providing information, products and services, and they prescribe the method for calculating the fees that may be charged for a licence or a class of licence. These regulations apply to all nuclear facilities and CNSC licensees and applicants.

  Policy analysis is currently in progress to review these regulations and identify potential amendments. Pre-consultation is planned for the 2020–21 fiscal year.

- *Canadian Nuclear Safety Commission Rules of Procedure*

  These rules define the procedures for CNSC public hearings and opportunities to be heard; they apply to the CNSC.

- *Canadian Nuclear Safety Commission By-laws*

  The by-laws define and apply to the management and conduct of Commission affairs, meetings and panels, and to the procedures to be followed in proceedings other than those prescribed in the *Canadian Nuclear Safety Commission Rules of Procedure*.

E.2.2.3 Regulatory and guidance documents

The NSCA and its associated regulations set out requirements, while regulatory documents provide the basis for regulatory guidance, expectations and decisions. The CNSC develops regulatory documents under the authority of paragraphs 9(b) and 21(1)(e) of the NSCA. Regulatory documents are a key part of the CNSC's regulatory framework for nuclear activities in Canada. They explain to licensees and applicants what they must achieve in order to meet the requirements set out in the NSCA and its regulations.

Regulatory documents generally include two kinds of information: requirements and guidance. When included in the licensing basis, requirements are mandatory and must be met by any licensee wishing to obtain (or retain) a licence or certificate to use nuclear substances or to operate a nuclear facility. Guidance provides direction to licensees and applicants on how to meet requirements. It also provides more information about approaches used by CNSC staff to evaluate specific problems or data during the review of licence applications. Licensees are expected to review and consider guidance; if these are not being followed, the licensees should explain how the alternate approach they have chosen still meets regulatory requirements.

Each regulatory document aims to disseminate objective regulatory information to stakeholders that include 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/eng/acts-and-regulations/regulatory-documents.

As outlined in REGDOC-3.5.3, *Regulatory Fundamentals*, the CNSC maintains an efficient and streamlined regulatory framework by making appropriate use of industry and international standards, 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. CSA Group standards are also an important part of the CNSC’s regulatory framework and complement regulatory documents.

The CNSC maintains a five-year forward regulatory framework plan that is updated annually. CNSC staff are currently re-organizing regulatory documents into the following categories:

- regulated facilities and activities
- safety and control areas
- other regulatory areas

A complete list of regulatory documents is available at http://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm. Annex 1 includes a list of the CNSC’s regulatory documents published since the Sixth Review Meeting.

The CNSC regulatory documents related to radioactive waste management and decommissioning are as follows:

- **REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada* –** The CNSC published this regulatory document in December 2018. It provides information on the framework for radioactive waste management and decommissioning in Canada. It describes the philosophy that underlies the CNSC’s approach to regulating the management of radioactive waste and the decommissioning of facilities, and explains the principles taken into account in CNSC regulatory decisions.

- **REGDOC-2.11.1, *Waste Management, Volume II: Management of Uranium Mine Waste Rock and Mill Tailings*** – The CNSC published this regulatory document in November 2018. It superseded RD/GD-370, *Management of Uranium Mine Waste Rock and Mill Tailings* and P-290, *Managing Radioactive Waste*. This regulatory document sets out the requirements of the CNSC for the sound management of mine waste rock and mill tailings during the site preparation, construction, operation and decommissioning of new uranium mine or mill projects and/or new waste management facilities at existing uranium mines and mills in Canada to ensure the protection of the environment and the health and safety of people.

- **REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* –** The CNSC published this regulatory document in May 2018. It helps applicants for new licences and licence renewals assess the long-term safety of radioactive waste management. This document will be superseded REGDOC-2.11.1, *Waste Management, Volume III: Assessing the*

Long-Term Safety of Radioactive Waste Management, Version 2. While originally planned for publication in early 2020, a high level of public interest resulted in requests for additional consultation activities (undertaken in early 2020), pushing the planned publication date to later in the year.

- **Regulatory Guide G-219, *Decommissioning Planning for Licensed Activities* –** The CNSC published this regulatory guide in June 2000. It provides guidance on preparing decommissioning plans for activities licensed by the CNSC in Canada. It also provides the basis for calculating the financial guarantees discussed in Regulatory Guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities*, which will be superseded by REGDOC-2.11.2, *Decommissioning*. While originally planned for publication in early 2020, a high level of public interest resulted in requests for additional consultation activities (undertaken in early 2020), pushing the planned publication date to later in the year.

- **Regulatory Guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities* –** The CNSC published this regulatory guide in June 2000. It provides guidance on establishing and maintaining measures to fund the decommissioning of activities licensed by the CNSC. This document will be superseded by REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*. While originally planned for publication in early 2020, a high level of public interest resulted in requests for additional consultation activities (undertaken in early 2020), pushing the planned publication date to later in the year.

The process for developing a regulatory document follows five key steps:

1. Analyze the issue
2. Develop a draft of the document for public comment
3. Consult with stakeholders
4. Revise the draft document for Commission approval and publication
5. Publish the regulatory document

The consultation process for draft documents has two steps:

1. Consultation: The draft document is posted to the CNSC website. The public, licensees and interested organizations are invited to comment within a defined period.
2. Invitation to provide feedback on comments received: All comments received during the first consultation period are posted on the CNSC website. All the stakeholders have an opportunity to view these comments and provide additional feedback.

E.2.3 Comprehensive licensing system for spent fuel and radioactive waste management activities

E.2.3.1 Overview of the licensing process

The CNSC initiates the licensing process once it receives an application from an applicant. The *Canadian Nuclear Safety Commission Rules of Procedure* require the application to be filed with the Commission Secretary, along with the prescribed fee set out in the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*.

For major resource projects, such as new uranium mines or reactor facilities, NRCan's Major Projects Management Office (MPMO) coordinates the work of all the federal departments and agencies that have a role in the regulatory review of the project. The MPMO has published the *Guide to Preparing a Project Description for a Major Resource Project* to assist applicants, and more information is available on the MPMO website.

The licence application contains the identity of the applicant, a project description and a proposed schedule for completing the licensing process. Applicants are also encouraged to submit a schedule of submissions for all required information.

Section 3 of the GNSCR lists information that must be included in all licence applications. For example, applications must cover:

- management structure
- radiation protection
- security
- waste management

CNSC staff conduct technical assessments of the information submitted by an applicant to determine whether it meets the regulatory requirements of the NSCA and regulations, CNSC requirements and expectations, international and domestic standards, and the applicable international obligations. The CNSC's assessment includes input from other federal and provincial government departments, including those responsible for regulating health and safety, environmental protection, emergency preparedness and the transportation of dangerous goods.

Once the assessment of an applicant's information is complete, CNSC staff make recommendations on the licence application to the Commission or a designated officer. Each decision to license is based on information that demonstrates that the activity or the operation of a given facility can be carried out safely and that the environment is protected.

A licence application may be subject to other legislation and regulations. For example, an impact assessment under the IAA may be required for a designated project regulated under the NSCA and described in the *Physical Activities Regulations*, or an environmental protection review may be carried out under the NSCA for projects not listed in the *Physical Activities Regulations*. Further information on environmental reviews can be found in section E.2.3.5.1.

Once a licence is issued, the CNSC carries out compliance activities to verify that the licensee is complying with the NSCA, associated regulations and its licence.

E.2.3.2 Licensing process for Class I nuclear facilities

The CNSC's licensing process for Class I nuclear facilities follows the stages laid out in the CINFR, progressing through each stage in their lifecycle. The regulations list the information required to support an application to conduct the following activities:

- prepare a site
- construct
- operate
- decommission
- abandon

If the necessary applications are filed with the required information, the Commission may, at its discretion, issue a licence that includes multiple activities (e.g., a licence to prepare site and construct, or a licence to construct and operate). A single licence may also be issued for multiple facilities, each at a different stage in their lifecycle.

Specific information regarding licence applications for each stage in the lifecycle of a Class I nuclear facility can be found in REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*.

E.2.3.3 Licensing process for uranium mines and mills

The UMMR list the required information to support an application to conduct the following activities:

- prepare a site and construct
- operate
- decommission

If the necessary applications are filed with the required information, the Commission may, at its discretion, issue a licence that includes multiple activities (e.g., one licence to prepare a site, construct, operate and decommission). A single licence may also be issued for multiple facilities, each at a different stage in their lifecycle.

Specific information regarding licence applications for each stage in the lifecycle of a uranium mine and mill can be found in REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*.

E.2.3.4 Involving stakeholders in the licensing process

E.2.3.4.1 Pre-licensing engagement

The CNSC gives applicants the option to engage in pre-licensing activities to facilitate discussion between stakeholders, the CNSC and any other relevant government bodies prior to submitting a licence application. These interactions may facilitate the understanding of regulatory requirements, the environmental review process, the licensing process and the information that must be included in a licence application. Pre-licensing and pre-certification activities can only inform a licensing or certification process; they do not result in the issuance of a licence or certificate under the NSCA and in no way fetter the Commission's decision-making authority.

Pre-licensing engagement can vary in complexity from process-related questions to technical assessments that provide feedback to a potential applicant. An example of a pre-licensing technical assessment is the CNSC review of a proposed facility design to identify problems and the means to resolve them.

Early communication enables the CNSC to plan for consultation with various interested parties, including Indigenous peoples. Applicants are also encouraged to present the proposed projects as early as possible to local communities and Indigenous peoples in order to address any potential interests and concerns. Early engagement in the planning and design stages of a proposed project can benefit all concerned by enhancing relationships, building trust and improving the understanding of the proposed project and its objectives.

E.2.3.4.2 Public participation in the licensing process

The NSCA establishes a legislative requirement for the Commission to hold public hearings, with respect to exercising its authority to licence. The *CNSC Rules of Procedure* allow the Commission to vary the public hearing requirement to ensure that a matter before it is dealt with as informally and expeditiously as the circumstances and the considerations of fairness permit. The NSCA also requires that applicants, licensees and anyone named in or subject to an order have the opportunity to be heard. The *CNSC Rules of Procedure* set out the requirements for matters, such as notifications of public hearings and the publication of decisions from public hearings.

All Commission proceedings are open to the public. These proceedings allow affected parties and the public to learn about nuclear facilities and projects, and give them an opportunity to be heard before the Commission. The Commission publishes on its website and sends advance notices of hearings or meetings to a list of more than 4,000 subscribers. In addition, the Commission may offer financial support through its Participant

Funding Program (PFP) on a case-by-case basis to help members of the public offset the costs associated with participating in a hearing or meeting. In most cases, the notices posted online and sent to subscribers also provide information about the availability of PFP funding.

Documents submitted for a public hearing or meeting are available for download from the CNSC's website in advance of the proceedings. The Commission publishes a record of decision, including detailed reasons for decision, to explain the basis for its licensing decisions. The Commission also publishes minutes to record the outcome of Commission meetings. Complete written transcripts of all public proceedings are posted online within days of a hearing or meeting – a best practice confirmed through benchmarking analyses. These documents, along with other information about the Commission's proceedings and decisions, are available to the public at nuclearsafety.gc.ca/eng/the-commission/hearings/documents_browse.

During a public hearing, simultaneous interpretation in Canada's official languages (English and French) is provided. The CNSC produces and publishes verbatim transcripts on its website.

In addition to attending a hearing in person, the public can watch and participate in Commission proceedings in other ways. The Commission offers live webcasts of all of its public proceedings on the CNSC's external website. Archived webcasts of past hearings and meetings are also available online for a minimum of three months following the end of the proceedings. In addition to following the live webcast, registered participants may use videoconferencing as a cost-effective way to make oral submissions.

Public hearings that include oral submissions usually take place in one or two parts; most decisions involving major nuclear facilities are made following the two-part public hearing process. For a one-part hearing, the Commission hears all of the evidence from the applicant, CNSC staff and interveners in a single hearing session, generally completed over one or more consecutive days. For a two-part hearing, the first part is reserved to hear the applicant and the CNSC staff submissions and recommendations. The second part is reserved to hear interventions and is typically held approximately 60 days after the first part to permit stakeholders to review the application and recommendations before the deadline for their submissions. Commission hearings are normally open to the public, but some parts of a public hearing may be held in a closed session to consider protected information. For example, certain protected security-related information cannot be discussed in a public forum.

A public hearing based only on written submissions may also be held for less significant licence amendments. They generally deal with applications to the Commission that are more administrative in nature and where little or no public interest is expected in the matter being considered. A notice of a public hearing in writing is published on the CNSC website and contains similar information to that contained in notices for other types of public hearings. Following the deliberations of the Commission, a record of decision is published on the CNSC's website.

To encourage public participation, the Commission may also decide to hold licensing hearings and Commission meetings in the communities that will be most affected by the decision at hand. As an example, in January 2018, the CNSC held a public hearing in Pembroke, Ontario on CNL's licence renewal application for CRL in Chalk River, Ontario. This public hearing took place over three days during which the Commission considered oral and written submissions from a total of 88 interveners, 53 of which made oral presentations.

The total number of Commission hearing and meeting days is flexible to ensure that all interested interveners have an opportunity to contribute. As long as the request to participate relates to the matter before the Commission, a request to intervene is generally accepted. From April 1, 2017, to March 31, 2020, the Commission held 15 public hearings over 31 hearing days, and it held 22 public hearings in writing. A total of 951 interveners participated in those hearings through written and oral submissions. In all, the Commission spent 24 days in local communities conducting public hearings and meetings from April 1, 2017, to March 31, 2020.

E.2.3.4.3 Indigenous peoples' participation in the licensing process

The CNSC's approach to involving Indigenous peoples includes commitments to uphold the honour of the Crown (federal, provincial and territorial governments) through relationship-building and information-sharing, and to meet the CNSC's legal obligations under section 35 of the *Constitution Act, 1982*. Since 2004, the Supreme Court of Canada has held that the Crown has a duty to consult and accommodate, where appropriate, when it contemplates conduct that might adversely impact potential or established Indigenous and/or treaty rights and related interests, including Indigenous title.

The CNSC respects these commitments by informing Indigenous peoples of proposed projects, consulting with potentially impacted Indigenous communities and encouraging participation throughout the licensing process. Indigenous peoples are also encouraged to bring their concerns to the Commission. The CNSC ensures that all recommendations or decisions pertaining to licensing decisions under the NSCA and environmental reviews under the IAA consider the potential or established rights of Indigenous peoples, pursuant to the *Constitution Act, 1982*.

E.2.3.4.4 Participant Funding Program

The CNSC administers its PFP which gives the public, Indigenous peoples and other stakeholders an opportunity to request funding to participate in matters related to licensing for major nuclear facilities. The CNSC determines both whether to offer participant funding and the maximum amount available for each offering. The objectives of the PFP are to:

- enhance Indigenous, public and stakeholder participation in the licensing process
- help stakeholders bring valuable information to the Commission through informed and topic-specific interventions related to aspects of licensing

E.2.3.5 Application assessment by CNSC staff

When the CNSC receives a licence application, staff evaluate it to determine whether the proposed safety and control measures described in the application and the documents needed to support the application meet the applicable requirements.

The documents needed to support the licence application are those that demonstrate that the applicant is qualified to carry out the licensed activity and that appropriate provisions will be made to protect worker and public health and safety, protect the environment, and maintain the national security and measures required to implement international obligations to which Canada has agreed. Examples include detailed documents that support the design, safety analyses and all aspects of operation to which the applicant makes reference, documents describing the conduct of operations and documents describing the conduct of maintenance.

Regulatory documents and industry standards may be referenced in the information supplied by the applicant in support of its licence application and are used by CNSC staff to evaluate the application. These regulatory documents and standards become part of the licensing basis when referenced in the licence application or its supporting documentation or when directly referenced in a licence.

Information submitted in support of an application must demonstrate that the proposed safety and control measures will meet or exceed CNSC expectations. All submissions must be supported by appropriate analytical, experimental or other suitable evidence. When deciding whether to renew an existing licence, the Commission also considers past performance by verifying compliance history.

Technical assessments are conducted by CNSC staff to support licensing, compliance, regulatory decision making and development of regulatory positions. CNSC staff perform these assessments based on the best available science (such as technical knowledge and analytical methods), taking operating experience into consideration. Technical assessments determine whether submitted documents and supporting evidence presented to the CNSC by any stakeholder have a sound technical basis, measured against the CNSC regulatory framework. These assessments address the completeness (coverage and adequacy), comprehensiveness (depth), and the validity of the rationale and technical justification provided in submissions, and are also used to verify licensee compliance with regulatory requirements. The expertise of CNSC staff covers a broad range of engineering and scientific disciplines.

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
- 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 the measures required to implement the international obligations to which Canada has agreed

If CNSC staff conclude that an application is not complete or satisfactory, the applicant is asked to submit additional information. Normally, a decision is not made until staff are satisfied with the application.

The comprehensive assessment that takes place during the licensing process may define additional programs and criteria as conditions of the licence. Once they are satisfied that all requirements of the NSCA and its associated regulations have been met and that the applicant's documentation is complete and acceptable, CNSC staff prepare a licence recommendation for submission to the Commission or designated officer for a decision. The recommended licence may include any conditions identified as necessary during the assessment, including the documentation references submitted in support of the application.

E.2.3.5.1 Environmental review

An application for a licence may be subject to other legislation and regulations. For example, an impact assessment under the IAA may be required for a designated project regulated under the NSCA and described in the *Physical Activities Regulations* or an environmental protection review may be carried out under the NSCA for projects not listed in the *Physical Activities Regulations*. All types of environmental review evaluate potential interactions between projects or activities and the environment. In all cases, the CNSC ensures that the public has an opportunity to participate in the environmental review, and Indigenous consultation and engagement activities are integrated into the review process to the extent possible. Only after a positive decision is made on the environmental review (if one is required) can the Commission proceed with a licensing decision.

E.2.3.5.2 Timelines for regulatory reviews of licence applications for Class I nuclear facilities and uranium mines and mills

A regulatory review is initiated once the Commission has determined that the applicant has submitted sufficient information to begin the review. A notice that the regulatory review has begun is then provided to the applicant and posted on the CNSC's website. An initial application may not include all the required information, and the balance may be submitted based on a schedule determined by the applicant.

Table E.1: Timelines for regulatory review of licence applications for Class IB nuclear facilities

Licensing stage	Timeline (months)
Licence to prepare site	24
Licence to construct	24
Licence to prepare site and construct	24
Licence to construct and operate	30
Licence to operate	20
Licence to decommission	24

Table E.2: Timelines for regulatory review of licence applications for uranium mines and mills

Licensing stage	Timeline (months)
Licence to prepare site and construct	24
Licence to operate	20
Licence to decommission	24

E.2.3.6 Joint regulatory review process

Although the nuclear sector is subject to federal jurisdiction through the NSCA, the CNSC uses a harmonized or joint review approach with other federal, provincial or territorial departments in such areas as health, environment, transport and labour. The CNSC expects 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 process 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 the Environment (MOE) and the Ministry of Labour Relations and Workplace Safety (Labour) in the administration of the CNSC's regulatory regime. The involvement of the MOE and Labour in the regulation of Saskatchewan's uranium mines and mills helps to better protect the health, safety and security of Canadians and their environment, and to harmonize the CNSC, MOE and Labour regulatory requirements and regulatory activities.

E.2.3.7 Licensing decisions

Licensing decisions include the issuance, refusal, amendment, renewal, suspension, revocation, replacement or transfer of a licence. The CNSC's decision-making independence and transparency are supported by fair, open, transparent and predictable regulatory processes. Commission hearings provide stakeholders with the opportunity to be heard, and the Commission takes stakeholder input into consideration in its decision-making processes. In addition, the Commission recognizes the role of professional judgement, particularly in areas where no objective standards exist.

The Commission is the overall decision-making authority for all licensing matters. Under section 37 of the NSCA, the Commission can delegate 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 under the legislation. This can include issuing various types of licences, such as licences for radioactive WMFs not defined as Class I nuclear facilities. When a designated officer is delegated this responsibility, no public hearing occurs unless the officer refers the decision back to the Commission using a risk-informed approach. In this case, the Commission evaluates the need to conduct a public hearing as part of its decision-making process.

CNSC staff make recommendations to the Commission, and the Commission considers them along with input from external stakeholders (including the applicant or licensee) in its decision making. The Commission or the designated officer issues the licence, adding conditions as appropriate.

If the Commission deems it in the public interest to do so, the licensing decision involves public hearings before the Commission. Commission proceedings are open to the public and are webcast live on the CNSC website.

Before granting the licence, the Commission must be satisfied that the applicant is qualified to carry on the activity that the licence will authorize and that the applicant will make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of Canada's national security and international obligations.

Once a licence is issued, CNSC staff are responsible for administering the Commission's decision, which includes developing and implementing a compliance verification program (see section E.2.5.2) to ensure that licensees continue to meet their legislative and licence obligations.

E.2.3.7.1 Public hearings

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 hearings, such as the one pictured in figure E.3, give organizations and interested members of the public a reasonable opportunity to comment on matters before the Commission. The *Canadian Nuclear Safety Commission Rules of Procedure* apply to these proceedings and set forth the requirements for matters, such as notifying the public advance of public hearings and publishing decisions after public hearings.

A public hearing may take place in one or two parts in a public hearing room or by written submissions only (see section E.2.3.4.2). Most major Commission decisions are made following a two-part public hearing process. The hearing days in Part 1 and Part 2 are generally at least 60 days apart; they take place over two or more days and may be held in one or more locations. The time interval between Part 1 and Part 2 of the hearings gives interveners time to review the application and the CNSC staff recommendations presented during Part 1 of the hearing and submit their interventions for Part 2 of the hearing. The objective, as set out in the NSCA, is to ensure that Commission proceedings are dealt with as informally and expeditiously as the circumstances and the considerations of fairness permit.

Figure E.3: BWXT licence renewal public Commission hearing 2020

E.2.3.7.2 Panels

The NSCA authorizes the President of the CNSC to establish panels of the Commission consisting of one or more members. The panel, as directed by the President, may exercise any or all of the powers, duties and functions of the Commission. The only exceptions are that a panel cannot make by-laws or regulations and it cannot review a decision or order of the Commission, because all members of the Commission are required for these actions. Other than these exceptions, an act of a panel is deemed to be an act of the Commission.

Figure E.4: Commission members at a public hearing

E.2.3.8 Licence

Section 26 of the NSCA describes activities that no one may carry out, except in accordance with a licence. The NSCA gives the Commission the power to grant licences for these activities.

All applicable licence conditions are reflected in the respective licence, including conditions that require the licensee to ensure that qualified personnel carry out the licensed activities and that adequate provision is made for the protection of the environment, the health and safety of persons, and the maintenance of Canada's domestic and international arrangements.

The licence refers to the applicant's documentation, which legally compels the applicant to comply with its own procedures and programs, making it subject to the CNSC's compliance verification and enforcement program.

Licences or licence conditions handbooks 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 the 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 taken from specific licence conditions, such as the derived release limits. The CNSC may also adopt other standards that have been established by organizations like the CSA Group and the American Society of Mechanical Engineers.

E.2.3.8.1 Licensing basis

The licensing basis sets the boundary conditions for a regulated activity and establishes the basis for the CNSC's compliance program for that regulated activity.

All licensees are required to conduct their activities in accordance with the licensing basis, which is defined as a set of requirements and documents for a regulated activity which comprises:

1. the regulatory requirements set out in the applicable laws and regulations

2. the conditions and safety and control measures described in the licence, and the documents directly referenced in that licence

3. the safety and control measures described in the licence application and the documents needed to support that licence application

The documents needed to support a licence application are those that demonstrate how the applicant is qualified to carry out the licensed activity and those that show how appropriate provisions are in place to: protect workers, public health and safety; protect the environment; and maintain national security and the measures required to fulfill the international obligations to which Canada has agreed. These include detailed documents that support design, safety analyses and all aspects of operation to which the licensee makes reference, documents describing the conduct of operations and documents describing the conduct of maintenance.

E.2.3.8.2 Licence periods

Typical licence periods for radioactive WMFs vary from five to 10 years. However, a licence may contain any term or condition that the Commission or designated officer considers necessary to meet the requirements of the NSCA, including the licence period granted.

In 2002, the CNSC introduced flexible licence periods to allow for the enhanced risk-informed regulation of spent fuel and radioactive WMFs. Factors that influence licence periods are 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. Along with the assignment of longer licence periods, CNSC staff report to the Commission in public meetings at a predetermined frequency (such as annually or biannually) on the facilities’ operations and performance in regulatory oversight reports (RORs).

CNSC staff recommend licence periods based on a set of consistent factors. These factors include facility-related hazards, the development and implementation of safety programs, the implementation of an effective monitoring and maintenance program, licensee experience and performance, the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations* and the facility’s planning cycle.

E.2.3.9 Licence conditions handbook

The CNSC’s licensing regime includes the licence conditions handbook (LCH) which is a companion piece needed to interpret a licence. The general purpose of the LCH is to clarify the regulatory requirements and other relevant parts of the licensing basis for each licence condition.

The LCH should be read in conjunction with the licence; it provides compliance verification criteria that the licensee must follow to comply with licence conditions, operational limits and information on delegation of authority and applicable versions of documents referenced in the licence. The LCH also provides non-mandatory recommendations and guidance on how to comply with licence conditions and criteria.

The LCH was developed as a tool that can more easily be updated as the licensees’ programs are revised to align with operations. Amendments to the LCH, when delegated by the Commission, can be approved by CNSC staff.

E.2.4 System for prohibiting the operation of a spent fuel or radioactive waste facility without a licence

Under section 26 of the NSCA, no person shall, except in accordance with a licence:

(a) possess, transfer, import, export, use or abandon a nuclear substance, prescribed equipment or prescribed information

(b) mine, produce, refine, convert, enrich, process, reprocess, package, transport, manage, store or dispose of a nuclear substance

(c) produce or service prescribed equipment

(d) operate a dosimetry service for the purposes of this Act

(e) prepare a site for, construct, operate, modify, decommission or abandon a nuclear facility

(f) construct, operate, decommission or abandon a nuclear-powered vehicle or bring a nuclear-powered vehicle into Canada

E.2.5 System of institutional control, regulatory inspection, documentation and reporting

E.2.5.1 Graded approach to regulation

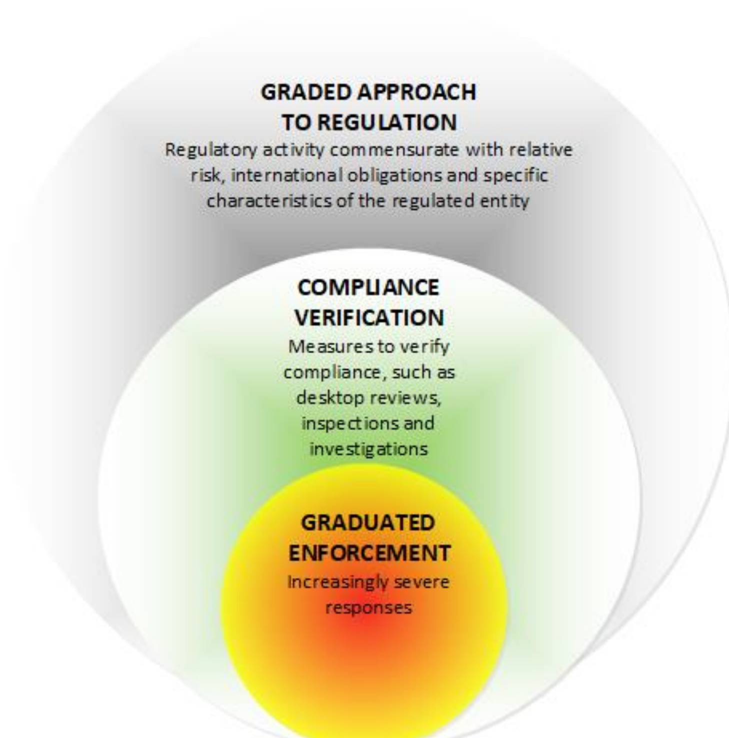
Assuring compliance with legislation, regulations and licensing requirements is one of the CNSC's core business processes, carried out through compliance verification and enforcement. Together, these activities enable the CNSC to make assurances to Canadians about the continuing compliance and safety performance of licensees.

The CNSC uses a systematic, risk-informed, graded approach when applying resources to oversee licensed activities and verify compliance with regulatory requirements. With the graded approach, elements like level of analysis, depth of documentation and scope of actions necessary to verify compliance are commensurate with:

- relative risks to health, safety, security and the environment
- any impact on Canada's international obligations
- particular characteristics of the given nuclear facility or licensed activity

Figure E.5 below illustrates the CNSC's graded approach to regulation.

Figure E.5: CNSC's graded approach to regulation



The licensee bears the primary responsibility for safety at all times, including compliance with regulatory requirements. The CNSC undertakes necessary and reasonable measures to ensure compliance. These measures include influencing compliance awareness, verification and enforcement.

The CNSC holds information sessions and communicates with licensees regularly to give licensees a better understanding of their responsibilities and to promote compliance.

E.2.5.2 Compliance verification

Verifying compliance is one of the CNSC's core regulatory activity areas. It consists of processes and procedures established to confirm that all licensees and other individuals or corporations that are subject to the NSCA have an acceptable safety and security performance and continuously comply with regulatory requirements.

There are four principal components to the CNSC's approach to verifying compliance:

- planning compliance verification activities
- influencing compliance awareness and verifying the extent of compliance
- responding to non-compliance
- reporting on compliance

The CNSC's compliance planning process ensures that compliance activities are carried out in a systematic and risk-informed manner.

The CNSC verifies compliance through site inspections and the review of operational activities and licensee documentation. The CNSC requires licensees to report routine performance data and unusual occurrences. In addition, CNSC staff investigate unplanned events or accidents that involve nuclear materials or substances. CNSC staff also collect samples and subsequently analyze them in the CNSC's own laboratory.

The frequency, scope, type and depth of these inspections and reviews are risk-informed. Where regulatory oversight overlaps with that of other regulatory bodies, the CNSC coordinates its verification activities to optimize efficiency and reduce the administrative burden for the licensees.

E.2.5.2.1 Regulatory inspection

Inspection is the process by which CNSC staff gather data directly at the site of a licensed activity and analyze that data for the purpose of determining whether a licensee is compliant with the requirements of the regulatory framework.

Figure E.6: Compliance verification taking place at the Deloro site

CNSC inspections are led by designated inspectors under section 29 of the NSCA.

The main purposes of CNSC inspections (combined with enforcement) are to ensure that:

- the licensee's activities, facilities, equipment and work performance meet regulatory requirements
- licensing basis documents are adhered to
- workers have the competence needed to effectively perform their functions
- deficiencies and deviations are identified by the licensee and corrected or justified without undue delay
- any lessons learned are identified by the licensee and communicated to stakeholders
- the licensee is managing safety properly

Figure E.7: Compliance verification taking place at the Nordion manufacturing facility, Kanata

CNSC inspections do not diminish the licensee's prime responsibility for safety or substitute for the control, supervision and verification activities that the licensee must carry out.

The fundamental principles of CNSC inspections are as follows:

- Inspections are consistent and transparent
- Inspection activities are open to formal scrutiny
- Inspections are planned, coordinated and controlled activities
- Inspection standards for performance and methodology are defined
- Inspections conducted follow approved inspection procedures
- Inspection objectives and criteria are defined and communicated to the licensee
- Inspections are conducted within the safety and control area framework
- Roles and responsibilities for conducting inspections are defined
- Inspections are documented in official and timely reports
- Inspection processes and procedures are subject to continuous improvement

Figure E.8: Compliance verification taking place at Port Granby

The following is the process flow used to conduct CNSC inspections:

- Plan inspection and confirm scope
- Compile inspection criteria
- Notify licensee
- Start inspection

- Collect inspection facts
- Analyze inspection facts and develop preliminary findings
- Communicate preliminary summary of findings
- Conduct final analysis
- Prepare and issue final inspection report
- Follow up

Inspections can be either Type I or Type II inspections, baseline or reactive, and announced or unannounced. In a Type I inspection, the purpose is to verify the licensee's programs, processes or practices. In a Type II inspection, the purpose is to verify the results of licensee's processes, not the processes themselves. For baseline inspections, the inspection trigger will have been predetermined in the compliance plan. Reactive inspections can be triggered by desktop reviews, technical assessments, events or the occurrence of rare or unplanned regulated activities. When the likelihood that the inspection outcome will be affected by advance notification is low, announced inspections are conducted. When the likelihood that the inspection outcome will be affected by advance notification is high, unannounced inspections are conducted.

Figure E.9: Compliance verification taking place at the Welcome WMF

E.2.5.2.2 Desktop reviews

Desktop reviews generally entail considering items like quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures. Licensees are required to provide information to the CNSC through baseline reporting (scheduled) and event reporting. They are also expected to notify the CNSC of changes to operating processes, procedures or programs, and to submit written requests for these changes. In all cases, the CNSC assesses this information to ensure that operations remain within the licensing basis.

E.2.5.3 Documentation and reporting

CNSC staff report to the Commission, the public, licensees, the Government of Canada, the IAEA and other interested parties on the results of compliance verification and enforcement activities.

CNSC annual reports from 2006 through to 2019 can be found on the CNSC public website (http://www.nuclearsafety.gc.ca/eng/resources/publications/reports/annual-reports/index.cfm). The CNSC annual reports provide an overview of Canada's nuclear industry and the regulatory activities that the CNSC undertakes to ensure the safety of Canadians. It highlights the organization's many accomplishments during the fiscal year at home and internationally and explains how the CNSC is meeting its day-to-day responsibilities and positioning itself for the future. It reinforces the CNSC's commitment to become the world's best nuclear regulator.

Each year, the CNSC publishes regulatory oversight reports, which offer information on the safety performance of Canadian licensees who are authorized to use nuclear substances. The reports evaluate licensees based on their safety procedures and adherence to regulatory policy. Key issues and emerging changes in regulation are also highlighted. Licensees are categorized by sector, as follows:

- nuclear power generating sites (including on-site WMFs)
- uranium mines and mills
- use of nuclear substances
- uranium and nuclear substance processing facilities
- research reactors and particle accelerator facilities

E.2.6 Graduated enforcement

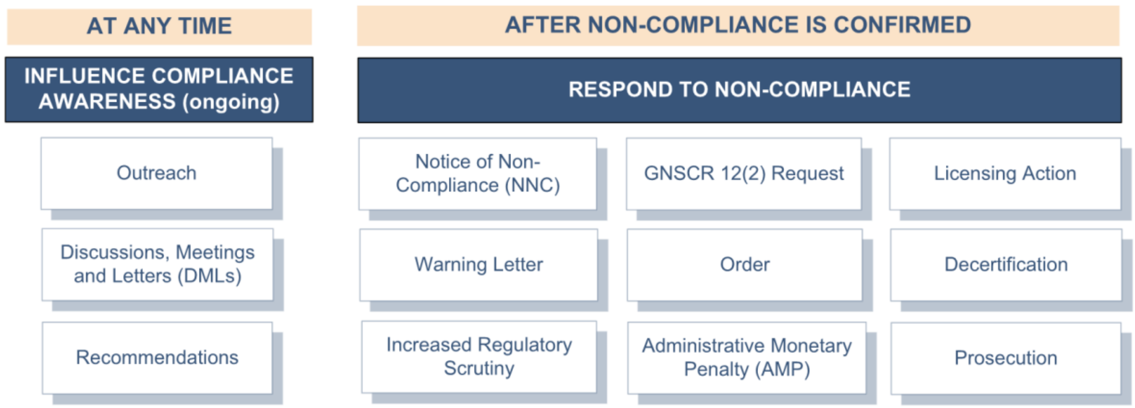
Under the NSCA and its regulations, the CNSC can take various levels of regulatory action to correct a licensee's non-compliance and protect the health, safety and security of Canadians and the environment.

The CNSC's graduated enforcement strategy is built on the following fundamental principles:

- flexibility – the effectiveness of the CNSC's graduated enforcement strategy relies on a risk-informed approach to response flexibility and the application of expert judgement in selecting the most appropriate response(s) in a given situation
- timeliness – the CNSC manages compliance issues in a timely manner, taking regulatory significance into account
- transparency – in the spirit of its commitment to transparency, the CNSC maintains open and engaged communication and makes information on its enforcement activities available to the public, as appropriate

The CNSC has established an integrated set of tools for influencing compliance awareness and responding to non-compliance. With this approach, CNSC staff are able to choose the appropriate instrument or combination of instruments to address the issues raised in any specific situation. Figure E.10 below illustrates how the components of the CNSC's graded enforcement strategy fit together.

Figure E.10: Components of the CNSC's graded enforcement strategy



Regulating requires consistent interaction with the regulated parties. Even before a licence or certificate is issued, the CNSC uses several measures to foster open communication with the applicant or proponent so that it can influence their understanding of the need to comply with all regulated requirements. Regulated parties who engage in open communication with the CNSC from the outset typically have a clearer understanding of the regulatory requirements and a better compliance record. This proactive interaction continues after the licence or certificate is issued through outreach, regular interaction (in the form of discussions, meetings and letters) and recommendations.

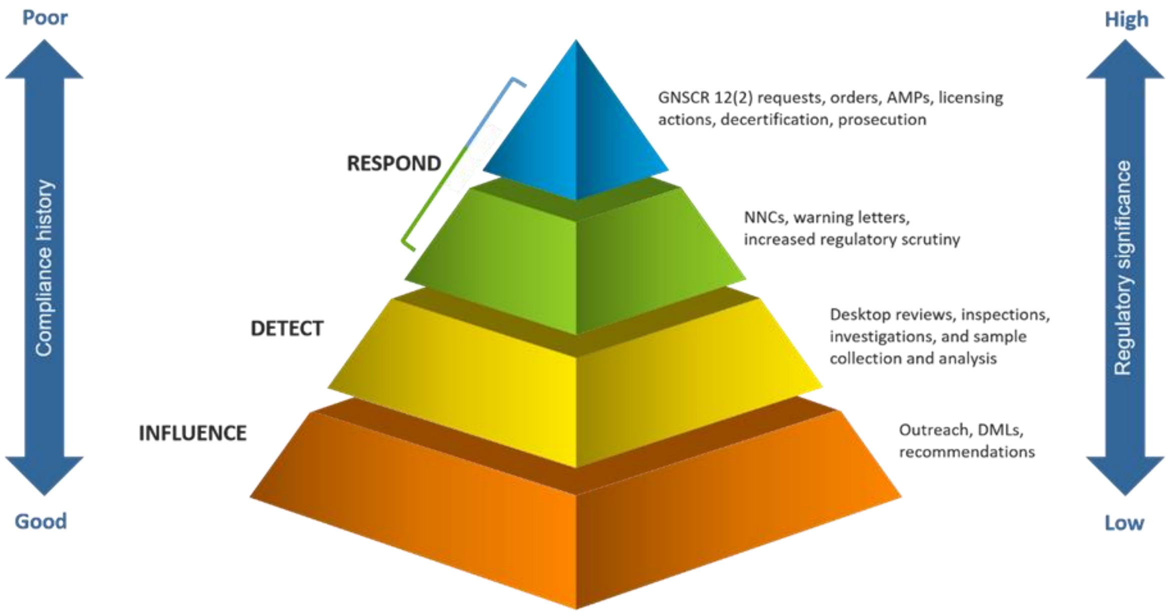
A regulatory response is required when non-compliance with regulatory requirements is confirmed through objective evidence obtained from reliable sources and based on verifiable facts.

The CNSC's graduated approach to enforcement provides a dynamic continuum of regulatory response options that begins with making the licensee aware of non-compliance and giving them the opportunity to correct it.

CNSC staff use regulatory judgement to determine the most appropriate response to a given situation. In all cases, the goal is to restore compliance, maintain continued safety and deter future non-compliance. All measures taken in response to non-compliance become part of the regulated party's compliance history.

In responding to non-compliance, the CNSC can use a progression of responses to restore compliance as quickly as possible. CNSC staff can select or recommend any of the available tools listed in figure E.11 at any time, as appropriate to the situation. The response or combination of responses that would likely be most effective in restoring compliance is determined by the person making the decision.

Figure E.11: CNSC toolbox continuum



When determining which response is most appropriate, the goal is to determine the response(s) that would most likely result in restoring compliance as quickly and effectively as possible, taking the following considerations into account:

- the regulatory significance of the non-compliance
- the circumstances that led to the non-compliance
- the entire compliance history of the regulated party
- any operational and legal constraints
- any industry-specific factors

E.2.7 Clear allocation of responsibilities

Canada is a confederation of 10 provinces and three territories, administered by the Government of Canada. The provinces and territories are self-governing in the areas of legislative power assigned to them in the Canadian Constitution, as expressed in the *Constitution Acts, 1867 to 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 it declares 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 NEA 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, including:

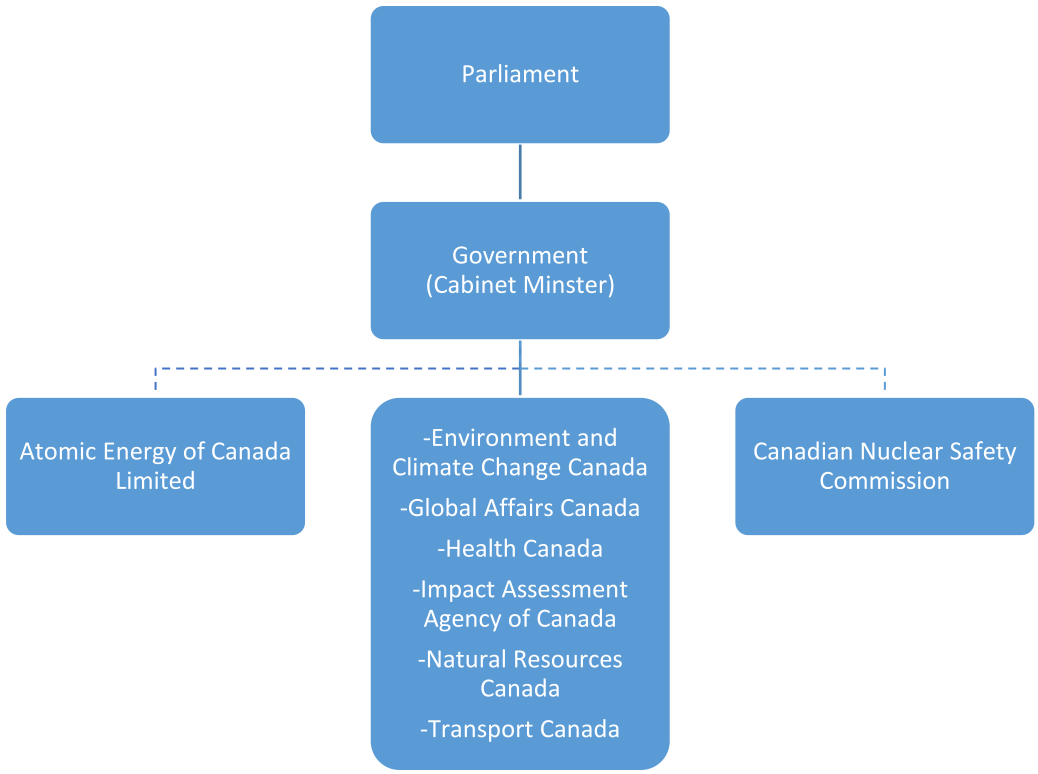
- occupational health and safety
- the regulation of boilers and pressure vessels
- coordination of the federal response to nuclear emergencies
- environmental protection

Under the Constitution of Canada, 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 has been to avoid redundancy 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 successfully led to 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 licences from the regulatory body – the CNSC – to perform any of the nuclear-related activities otherwise prohibited by the NSCA. In addition, the NSCA authorizes 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 departments and agencies of the Government of Canada involved in the Canadian nuclear sector are shown in figure E.12.

Figure E.12: Government departments and agencies responsible for the management of radioactive waste in Canada



E.2.7.1 Natural Resources Canada

NRCan is the lead government department responsible for developing and implementing federal nuclear energy policy across the nuclear supply chain, from uranium mining to the final disposition of waste. This includes making uranium and radioactive waste policy, developing and implementing legislation, and the establishing and managing a nuclear civil liability and compensation regime. NRCan also provides expert technical, policy and economic information and advice to the Minister of Natural Resources 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

NRCan administers, on behalf of the Minister of Natural Resources, the *Radioactive Waste Policy Framework* which provides the basis for ensuring that the long-term management of radioactive waste is carried out in a manner that is safe, environmentally sound, comprehensive, cost-effective and integrated. In Canada's approach to radioactive waste management, the 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's Uranium and Radioactive Waste Division is the organizational unit responsible for administering the NFWA and the NLCA. Part of the Division'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.

E.2.7.2 Canadian Nuclear Safety Commission

The CNSC is Canada's independent nuclear regulatory body, created by the Governor in Council under the NSCA. The CNSC's mandate is to "regulate the use of nuclear energy and materials to protect health, safety, security, and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public." The CNSC reports to the Parliament of Canada through the Minister of Natural Resources. It is not part of NRCan; however, the Minister of Natural Resources can seek information from the CNSC about its activities. Under the NSCA, the Governor in Council may issue directives to the Commission that are of general application on broad policy matters. The Governor in Council cannot give direction to the Commission on specific licensing matters.

The CNSC is a federal regulatory agency and an independent administrative tribunal set up at arm's length from the government, with no ties to the nuclear industry. To serve Canadians, the ultimate outcome of the CNSC's work must be to establish safe and secure nuclear installations and processes solely for peaceful purposes and to instill public confidence in the nuclear regulatory regime's effectiveness. In keeping with the Government of Canada's Smart (specific, measurable, attainable, realistic and timely) Regulation Initiative to improve regulatory performance and reduce the administrative burden on businesses, the CNSC engages in extensive consultation and information sharing 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 is an independent entity. This independence is critical so that the CNSC can maintain an arm's-length relationship with government when making legally-binding regulatory decisions. The CNSC is not an advocate for nuclear science or technology. Its mandate and responsibility is to regulate users of nuclear energy or materials to ensure that their operations will not pose unreasonable risks to Canadians. The people of Canada are the sole clients of the CNSC. The CNSC's regulatory decision process is fully independent of the Government of Canada.

The CNSC is responsible for working collaboratively with the IAAC to conduct integrated impact assessments for nuclear projects under the IAA. For ongoing projects initiated under the now repealed CEAA 2012, the CNSC is also responsible for conducting and making decisions on environmental assessments. The IAA contains provisions to allow these projects to continue under their current processes. In some parts of northern Canada, environmental assessment processes are established under land claim agreements, and the IAA does not apply. In these cases, the CNSC acts as technical advisor throughout the environmental assessment process.

The CNSC's regulatory document REGDOC-3.5.3, *Regulatory Fundamentals* 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 for assuring the public that these responsibilities are properly discharged.

E.2.7.3 Atomic Energy of Canada Limited

AECL is a Crown corporation whose sole shareholder is the Government of Canada. For more than 60 years, AECL has been a world leader in developing peaceful and innovative applications of nuclear technology. Its mandate is to enable nuclear science and technology, and manage the federal government’s decommissioning and radioactive waste liabilities. Following a restructuring process that was completed in September 2015, AECL now delivers its mandate through a long-term contract with the private sector for the management and operation of its sites under a GoCo model. CNL manages AECL’s sites which includes operating the nuclear laboratories and delivering decommissioning and waste management activities. Activities related to decommissioning and waste management are necessary to address liabilities and reduce hazards that are the result of decades of nuclear research at AECL sites. AECL is also responsible for the cleanup and safe, long-term management of historic LLW at other sites across Canada for which the Government of Canada has accepted responsibility. This includes the PHAI and the activities associated with the Low-Level Radioactive Waste Management Office.

For its part, AECL was re-created as a small purpose-built Crown corporation with a view to ensuring it has the necessary expertise and capabilities to oversee the GoCo agreements. AECL’s objective is to leverage the GoCo model to deliver on its mandate. Its role is to monitor and incentivize the performance of CNL to meet AECL’s objectives. To help in its own transition to the GoCo model and in fulfilling its oversight role, AECL has retained the services of international experts who bring their significant experience in managing similar arrangements, from both a government and a contractor perspective.

AECL’s efforts focus on overseeing CNL’s activities in two main areas: decommissioning and waste management, and nuclear laboratory science and technology. With respect to decommissioning and waste management, the objective is to safely and efficiently reduce the Government of Canada's radioactive waste liabilities, including the associated risks to health, safety, security and the environment. The focus is on enabling CNL to significantly advance infrastructure decommissioning, site remediation and waste management for Canada.

E.2.7.4 Impact Assessment Agency of Canada

The IAAC is responsible for administering the IAA, the primary federal legislation that defines the requirements for assessing the environmental, health, social and economic impacts of proposed projects (see section E.2.1.5 for a further description of the IAA). Under the IAA, the IAAC leads reviews of major projects and collaborates with the CNSC to review projects that are also subject to regulation under the NSCA. Nuclear projects to be assessed under the IAA are subject to an integrated impact assessment carried out by a review panel.

E.2.7.5 Global Affairs Canada

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

Implementing these agreements requires that Canadian domestic law 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. Global Affairs Canada is responsible for implementing the *Chemical Weapons Convention* and the *Comprehensive Nuclear-Test-Ban Treaty*. In addition, it oversees foreign policy, which includes global security issues, and is a required interlocutor in dealings with other governments.

E.2.7.6 Health Canada

Health Canada is the federal department responsible for helping the people of Canada maintain and improve their health. In the area of radiation protection, Health Canada contributes to maintaining and improving the health of Canadians by investigating and managing the risks from natural and artificial sources of radiation. It accomplishes this mission by:

- maintaining the Canadian Radiological Monitoring Network (CRMN)
- developing guidelines for exposure to radioactivity in water, food and air following a nuclear emergency
- providing advice and assistance for environmental assessments and reviews, as required by the IAA and its regulations
- providing a full range of dosimetry services to workers through the National Dosimetry Services, National Dose Registry, 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 CRMN is a national network that routinely collects samples of air particulate, precipitation, external gamma dose, drinking water, atmospheric water vapour and milk for radioactivity analysis. These surveillance activities of the network serve to establish background radiation levels in Canada.

Health Canada has complemented its CRMN with another monitoring system called the Fixed Point Surveillance (FPS) network. The FPS functions as a real-time radiation detection system designed to monitor the public dose from radioactive materials in the air, including atmospheric emissions associated with nuclear facilities and activities, nationally and internationally. The monitoring stations continuously measure gamma radioactivity levels from ground-deposited contaminants (groundshine) and airborne contaminants. More information can be found here: https://www.canada.ca/en/health-canada/services/health-riskssafety/radiation/understanding/measurements.html.

The National Dosimetry Services, operated through Health Canada, provide occupational monitoring for ionizing radiation to Canadians. The services offered include whole-body and extremity dosimetry services, as well as neutron dosimetry services and dosimetry. The National Dosimetry Services are licensed by the CNSC.

The National Dose Registry is a centralized radiation-dose record system managed by Health Canada. It contains occupational radiation dose records for all monitored radiation workers in Canada dating back to the 1940s.

E.2.7.7 Environment and Climate Change Canada

Environment and Climate Change Canada's mandate is to:

- preserve and enhance the quality of the natural environment, including water, air, soil, flora and fauna
- conserve Canada's renewable resources
- 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 and Climate Change Canada administers the CEPA. It also runs the National Pollutant Release Inventory (NPRI). The NPRI is Canada's public inventory of releases, disposals and transfers. Facilities that meet the reporting thresholds must report releases from the facilities to air, water or land to the NPRI.

E.2.7.8 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 establishes policies, regulations and standards to protect the safety, security and efficiency of Canada's rail, marine, road and air transportation systems. Its oversight covers the transportation of dangerous goods, such as nuclear substances, and assurance that related developments can be sustained.

Transport Canada administers the *Transportation of Dangerous Goods Act*.

E.2.8 Considerations when deciding whether or not to regulate radioactive material as radioactive waste

Section E.3.1 indicates that the CNSC is authorized under the NSCA to regulate nuclear substances in order to protect human health and the environment. REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada* defines radioactive waste as any material (liquid, gaseous or solid) that contains a radioactive nuclear substance, as defined in section 2 of the NSCA, and which the owner has declared to be waste. In addition to containing nuclear substances, radioactive waste may also contain non-radioactive hazardous substances, as defined in section 1 of the GNSCR.

Subsection 5.1(1) of the NSRDR states that a person may, without a licence, abandon or dispose of a radioactive nuclear substance if the activity or the activity concentration of the substance does not exceed

(a) its exemption quantity

(b) its conditional clearance level or

(c) its unconditional clearance level

Schedule 1 of the NSRDR sets out exemption quantities for radioactive nuclear substances. Schedule 2 of the NSRDR sets out unconditional clearance levels for radioactive nuclear substances. The NSRDR define conditional clearance levels as an activity concentration that does not result in an effective dose greater than 1 mSv in a year due to a low probability event referred to in the IAEA Safety Standard RS-G-1.7 or greater than 10 µSv in a year.

E.3 Regulatory body (Article 20)

This section addresses the obligations under Article 20 of the Joint Convention.

ARTICLE 20. REGULATORY BODY

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.
2. Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.

E.3.1 Establishment of the CNSC

E.3.1.1 Authority of the CNSC under the NSCA

Subsection 8(1) of the NSCA states: "there is hereby established a body corporate to be known as the Canadian Nuclear Safety Commission." Section 9 of the NSCA states "the objects of the Commission are

(a) to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to

  (i) prevent unreasonable risk, to the environment and to the health and safety of persons, associated with that development, production, possession or use,

  (ii) prevent unreasonable risk to national security associated with that development, production, possession or use, and

  (iii) achieve conformity with measures of control and international obligations to which Canada has agreed; and

(b) to disseminate objective scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use referred to in paragraph (a)."

The NSCA also sets out the responsibilities and powers of the Commission.

E.3.1.2 Canadian Nuclear Safety Commission in the government structure

In the Canadian system of parliamentary government, the decision to introduce government legislation like the NSCA into Parliament is made by the federal cabinet on the advice and recommendation of the appropriate minister. The NSCA establishes the CNSC as a departmental corporation, named in Schedule II of the Government of Canada's *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 NSCA. This designate is currently the Minister of Natural Resources. The CNSC is a departmental corporation, which is an independent agency, not part of any government department.

The NSCA requires the Commission to comply with any directives of general application on broad policy matters with respect to the objects of the Commission 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 decisions in specific cases. One example of such a directive is the government-wide commitment to the SMART (specific, measurable, attainable, realistic and timely) Regulation Initiative.

CNSC staff routinely interact with the 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 on this is provided in section E.2.7.1

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, including:

- AECL, the federal nuclear research and development company
- nuclear operators of provincially owned electrical utilities (OPG, NB Power and H-Q)
- Canadian universities
- hospitals and research institutions

The CNSC regulates the health, safety, security and environmental impacts of the nuclear activities conducted by these organizations in the same manner and according to the same standards as required of privately owned companies or operations.

E.3.1.3 Organizational structure

The CNSC consists of the president (who is also the chief executive officer of the CNSC), the federally appointed members of the Commission, and approximately 900 staff members (as of the end of March 2020). As defined in the NSCA, the CNSC's organizational structure consists of two components:

- the Commission, which refers to the organization's tribunal component
- the CNSC, which refers to the organization and its staff in general

E.3.1.3.1 The Commission

The Commission is an independent quasi-judicial administrative tribunal and a court of record. It can consist of up to seven permanent members. Commission members are appointed by the Governor in Council of Canada for terms not exceeding five years and may be reappointed. In addition, the Governor in Council may appoint temporary members for a term not exceeding three years. A temporary member may be reappointed in the same or another capacity. Appointed members may not directly or indirectly engage in any activity, have any interest in a business, or engage in any employment that is inconsistent with their duties as Commission members. Each Commission member must be both independent of all possible influences and independent of each other. Commission members commit to the highest ethical standards, guard against conflicts of interest and carry out their duties impartially. The president of the CNSC is a full-time Commission member. Other members generally serve on a part-time basis.

The Commission's key roles are to:

- establish regulatory policy on matters relating to health, safety, security and the environment
- establish classes of licences
- make legally binding regulations
- make independent decisions on licensing nuclear-related activities in Canada
- issue, renew, suspend in whole or in part, amend, revoke or replace a licence, or authorize its transfer
- require an applicant to provide a financial guarantee in a form that is acceptable to the Commission and authorize the application of the proceeds of any financial guarantee in a manner it considers appropriate

The Commission makes its decisions fairly and transparently, guided by clear rules of procedure. The Commission takes into account the views, concerns and recommendations of CNSC staff, interested parties and interveners when establishing regulatory policy, making licensing decisions and implementing programs.

The Commission 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's meeting process. Decisions on the licensing of major nuclear facilities are made through public hearings.

Public hearings, both written only or with both oral and written submission, are the public's primary opportunity to participate in the licensing process. CNSC staff participate in all public hearings to make recommendations to and advise the Commission. The Commission operates independently of CNSC staff and the Commission Secretary serves as liaison between CNSC staff and the Commission.

In addition to public hearings, the Commission also holds public meetings. The Commission publishes a notice in advance of each meeting inviting the public to attend. The opportunity for interventions on specific meeting items is determined by the Commission, case by case. Meetings are webcast live, and both a written transcript and archived webcast are posted on the CNSC's external website following the meeting. Minutes of the meeting are approved by the Commission members and also posted on the CNSC's external website.

Commission meetings consider a wide range of topics related to the nuclear regulatory process, and in certain cases, they serve as the vehicle for making legislative, policy or administrative decisions on matters of particular or general application. Meeting items may include subjects like annual industry reports, licensee performance reports, technical briefings, event reports and requests for approval of regulatory documents.

The Commission Secretariat supports the Commission by planning its business, publishing notices, agendas, decisions and meeting minutes, and offering technical and administrative support to the president and other members. As a court of record, the Secretariat is also the official registrar of Commission documentation.

E.3.1.3.2 CNSC staff

The Commission employs the staff it considers necessary for the purposes of the NSCA.

The CNSC has highly skilled scientific, technical, professional and administrative personnel who carry out the work necessary to fulfill the Commission's mandate. CNSC staff perform several functions, such as:

- conducting expert research and analysis
- verifying licensee compliance with regulatory requirements
- conducting activities to enforce licensee compliance, when necessary
- preparing material for the Commission known as Commission member documents, and appearing before the Commission at proceedings to answer questions
- carrying out a wide range of internal activities that enable the success of the CNSC's core operational work

The Commission may also enter into contracts for services to receive advice and assistance in the exercise or performance of any of its powers, duties or functions under the NSCA.

CNSC staff are primarily located at the organization's headquarters in Ottawa. An office of the Uranium Mines and Mills Division is located in Saskatoon, Saskatchewan, close to Canada's major uranium mining operations. CNSC satellite offices are located at each of the four operating NPPs in Canada and at AECL's CRL. Staff at regional offices located in the provinces of 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.

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 Internal Audit.

There are four major branches of the CNSC: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services. For more information about each of the four branches, see annex 2.

E.3.1.4 Financial resources

The CNSC is a departmental corporation listed in Schedules II and V of the *Financial Administration Act.* The NSCA stipulates that the CNSC reports 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. The Commission 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 *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*, and secondarily through an annual appropriation from Parliament. The CNSC has revenue-spending authority, which means it uses the revenues collected to fund activities that are cost-recoverable under these 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.3.1.5 Human resources and competent personnel

During the reporting period, the CNSC’s human resource management efforts continued to focus on maximizing organizational flexibility while maintaining a highly skilled and engaged workforce, supported by modern management practices and tools. Since the last report, the CNSC has leveraged its enhanced strategic and operational workforce planning capability, for example, by using quarterly workforce analytics information to better understand the risks it faces in protecting core organizational capabilities and competencies essential to carrying out its mandate.

Given the changing landscape of the Canadian nuclear industry and its scientific, technical, math and engineering labour market, the retirement of experienced senior regulatory and technical employees remains the greatest workforce risk that the CNSC faces between now and 2025. To mitigate this risk, the CNSC has initiated action centered on organizational design, workforce recruitment and renewal, learning and leadership development, and employee engagement and retention. To this end, the CNSC focused on five workforce strategies: organizational design, recruitment and renewal, building capability, engagement and retention, and workplace wellness.

The goal of the CNSC’s organizational design strategy was to encourage competency development among employees and career progression. This has been accomplished in part by: establishing CNSC- and Directorate-level workforce profiles to guide resourcing and development planning; building capability within the management cadre to enable talent management discussions; and continuing to identify opportunities to work more effectively. A key pillar of the organizational design strategy was the implementation of key behavioural competencies in all human resource management practices. These competencies were integrated into all resourcing, onboarding and learning practices, and the CNSC staffing policy framework was updated to help ensure the principles of competency development and organizational agility are clearly outlined in CNSC governance documents. Two final components rounded out the activities in this strategy: the development of a knowledge management strategy for the organization, including a compendium of tools, resources and training, and the promotion of activities to build a healthy regulatory safety culture. To achieve the latter, the CNSC began the now regular practice of holding town-hall meetings to give employees an opportunity to ask questions and share concerns with their senior leaders. In parallel, the CNSC conducted a regulatory safety culture assessment and created an action plan to address the findings. The organization has since published its Regulatory Safety Culture Policy, which was shared with all staff in 2019.

With respect to recruitment and workforce renewal, to ensure that the CNSC has timely access to qualified and needed talent, it established a plan to protect critical capabilities in which it identified critical roles and resource vulnerabilities, produced a catalogue of nuclear safety-related capabilities, and developed resourcing plans to address risks, including identifying successors. To ensure the quality of CNSC hires, the CNSC built assessment tools in line with our new key behavioural competencies and trained hiring managers on their use. To ensure consistency of assessment and promote effective talent conversations, the CNSC launched a director general talent management community that conducted collective assessments of candidates for entry-level executive positions. Recruitment strategies were aligned with workforce plans within the organization to secure future needed capabilities by developing recruitment forecasts and identifying sourcing strategies for critical and hard-to-fill positions. Finally, the CNSC affirmed its employment brand; it was named in late 2019 as one of the National Capital Region’s top 25 employers.

E.3.1.6 Management System

The CNSC’s management system – *How the CNSC Works: Our Navigator Manual* – integrates the key elements of the CNSC’s work into the holistic framework of programs and activities through which the CNSC achieves its goals.

The CNSC’s management system is aligned with the requirements and guidance set out in both the IAEA’s general safety requirements for integrated management systems, *Leadership and Management for Safety* (GSR Part 2), and the Government of Canada’s framework for management excellence, the Management Accountability Framework.

To help continually strengthen the management system, the CNSC’s Internal Quality Management Division coordinates all priority improvement initiatives for better corporate alignment and integration throughout the organization.

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

- coherently and consistently bringing together and managing all of the organization’s regulatory and 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
- providing support for approved and accessible processes and practices throughout the organization
- clarifying roles, responsibilities and authorities across all areas and all levels
- providing a consistent, robust platform for enabling continual improvements

As described in the CNSC’s regulatory philosophy, the primary responsibility for safety rests with the person or organization responsible for the facility or activity. At the same time, as the regulator, the CNSC remains mindful of the potential impact that CNSC decisions, actions and behaviours have on the safety of CNSC employees and on the CNSC’s ability to ensure that all licensees maintain safety across their operations.

As the top-tier document, *How the CNSC Works: Our Navigator Manual* summarizes the integrated management system and provides a strong base for aligning management system-related documents like policies, processes, procedures, work instructions, criteria, forms and guides. These internal documents are developed on a priority basis and are driven by the need for additional guidance and direction for staff, management, licensees and other key stakeholders. This practical approach helps the CNSC to continually strengthen its management system so that it remains comprehensive, well-documented and seamlessly implemented.

E.3.1.7 The CNSC's regulatory approach

The CNSC regulates to prevent unreasonable risk to the environment, to the health and safety of persons, and to national security. The CNSC has established a licensing and compliance system to ensure that all persons who use or possess nuclear substances and radiation devices do so in accordance with a licence, and that regulated parties have safety and security provisions in place that ensure compliance with regulatory requirements.

E.3.1.7.1 Regulatory philosophy

The CNSC's regulatory philosophy is based on the following:

- licensees are directly responsible for managing regulated activities in a manner that protects health, safety, security and the environment, and that conforms with Canada's domestic and international obligations on the peaceful use of nuclear energy
- the CNSC is accountable to Parliament and to Canadians for assuring that these responsibilities are properly discharged

The CNSC therefore ensures that regulated parties are informed about requirements and provided with guidance on how to meet them, then verifies that all regulatory requirements have been and continue to be met.

E.3.1.7.2 Continuous improvement

The CNSC is committed to the continuous improvement of both its internal operations and its regulation of the Canadian nuclear industry. Consequently, the CNSC requires licensees to strive to further reduce the risks associated with their licensed activities, on an ongoing basis. It assesses how licensees manage risk during both normal operations and in response to potential accident conditions, applying concepts such ALARA and defense in depth. In its assessments, the CNSC considers how licensees continuously evaluate, manage and further reduce uncertainties with respect to hazards and safety issues. This also includes assessing how licensees consider additional safety and mitigation options as techniques and technologies evolve.

E.3.1.7.3 Graded approach

The graded approach is a systematic method or process by which elements, such as the level of analysis, depth of documentation and scope of actions necessary to comply with requirements are commensurate with:

- the relative risks to health, safety, security, the environment and the implementation of the international obligations to which Canada has agreed
- the particular characteristics of a nuclear facility or licensed activity

The CNSC applies the graded approach to licensing and compliance activities. This approach is driven primarily by assessing the risk associated with the activities being regulated and the performance history of the licensee.

The degree of oversight is also informed by:

- the complexity and potential harm posed by the licensed activity
- technical assessments of submissions
- relevant research
- information supplied by parties for Commission proceedings

- international activities that advance knowledge in nuclear and environmental safety
- cooperation with other regulatory bodies

When applying the risk-informed approach:

- regulatory requirements must be met
- sufficient safety margins must be maintained
- defense in depth must be maintained

If a licensee cannot achieve the required level of safety, it will not be permitted to continue conducting its licensed activities.

E.3.1.7.4 International obligations

The CNSC participates in international forums to provide global nuclear leadership and to benefit from international experience and best practices. It also participates in undertakings implemented by the IAEA (for example, IAEA peer reviews), the ICRP and other international organizations, as well as activities under certain treaties, such as the Joint Convention.

These international activities help inform the CNSC's decision-making processes to:

- understand and compare various ways of evaluating and mitigating risks
- share research and operational experience

E.3.1.8 CNSC research and support program

The CNSC integrates the best available science into its decision making. The CNSC maintains research initiatives and programs to ensure it keeps abreast of new scientific information, develops its own knowledge base and shares its research findings with stakeholders and scientists in Canada and abroad.

Research is carried out on a wide range of topics, from health studies on nuclear workers and host communities, to research on the long-term management of nuclear waste in geological repositories.

The CNSC funds an external research program to gain the knowledge and information needed to support its regulatory mandate. The CNSC's research is often completed with the support of independent third parties and/or in collaboration with national and international partners, providing access to valuable expertise, state-of-the-art facilities and the best available data. The outcome of these research activities helps the CNSC understand and address new or emerging safety and security issues; gain third-party perspectives on nuclear science; and share scientific knowledge with the nuclear industry and the public at large. The research results are available on the CNSC's website and help support the CNSC's mandate to disseminate objective, scientific, technical and regulatory information to the public about the activities of the Commission and the industry it regulates.

E.3.1.8.1 Geological repository research

Understanding the environmental, safety and security impacts of long-term solutions for the disposal of waste is an important area of interest to the CNSC. The CNSC has been performing research on geological repositories since 1978. In 2008, to support the review of Canadian deep geological repository (DGR) initiatives, the Coordinated Assessment and Research Program (CARP) was implemented. Through this program, the CNSC collaborated with different Canadian and international organizations to obtain experimental data and develop mathematical models, investigate properties of bentonite as a sealing material, and verify some aspects of geosphere stability in order to assess the long-term performance of the host rock and the engineered barriers. In 2020, the CARP became the Strategic Research Agenda for Deep Geological Repositories (DGR-SRA). The DGR-SRA is integral to ensuring that the CNSC continues to build and maintain the independent scientific knowledge required to assess current and future licence applications and the ensuing safety case by proponents, and make science-based licensing recommendations to the Commission. The DGR-SRA continues to play an important role in CNSC staff preparation for the next licensing stages of geological disposal projects.

Areas of geological repository research interest include:

- **Stability of the geosphere.** Investigating the long-term tectonic stability of the geosphere in southern Ontario is currently relevant for Canadian DGR initiatives. Constraints on faulting at strategically chosen sites in Ontario are obtained by mapping brittle tectonic structures, assessing their deformation mechanisms and acquiring geochemical data and absolute ages of fracture-fill minerals.

- **Long-term performance of the host rock and engineered barriers.** The long-term performance of barriers will be affected by many perturbations, including radiogenic heat, excavation of the repository and future geological events like seismicity and glaciation. These perturbations result in complex thermal-hydraulic-mechanical-chemical (THMC) processes that need to be understood through experimentation and mathematical modelling. The CNSC is collaborating with Canadian and international partners, especially those with access to underground research laboratories (URLs), to obtain experimental data for developing and validating models of coupled THMC processes in the geological and engineered barriers.

- **Safety assessment modelling capabilities.** Understanding the long-term interaction of various components of a DGR, as well as those features, events and processes (FEPs) pertinent to long-term safety is integral to reviewing a safety case for a DGR. The CNSC continues to build its long-term safety assessment modelling capabilities so that it can independently verify that acceptance criteria at proposed DGRs will be met, and gain further insight into the extent that safety significant FEPs will have on the overall system performance of a disposal facility.

- **Natural analogues.** Experiments conducted at research facilities or URLs are of short duration (hours to years), while the time frame of safety assessment is hundreds of thousands to millions of years. The spatial scale from those experiments (metres to tens of metres) is also small compared to the typical spatial scale in safety assessments (kilometres). This can be addressed by studying natural analogues, such as uranium deposits. Uraninite, the most abundant uranium-bearing mineral in most uranium deposits, is similar in many ways to the uranium dioxide in spent nuclear fuel. The use of these deposits as natural analogues helps bridge the spatial-temporal gaps between laboratory experiments and the long-term safety assessment of DGRs, and it builds confidence in understanding the performance of the components of the multi-barrier system. Canada is uniquely positioned to complete a series of natural analogue studies on Canadian uranium-bearing formations deposited and existing under a wide range of geochemical and geological conditions.

E.3.1.8.2 International collaboration

The CNSC participates in several international cooperative programs that carry out research in geological repositories, including:

- DECOVALEX-2023 (development of coupled models and their validation against experiments) – This project challenges researchers to model the experimental behaviour of events that may occur in a geological repository.

- TENOR – This project conducts URL experiments of water and/or gas transport in bentonite and fractured rock, and on interpretation by mathematical modelling. It is managed by the Institut de radioprotection et de sûreté nucléaire (IRSN) in France.

- SITEX Network – Coordinated by the IRSN, this initiative aims to sustain a network for independent technical expertise on radioactive waste disposal.

E.3.1.8.3 Mine waste

The most significant challenge for conventional mining is the long-term management of the uranium tailings produced from milling the ore. Safety cases associated with tailings are strongly linked to the mineralogical and leaching behaviour of tailings particles as they age. The presence of aged tailings in historical above-ground tailings facilities and the now 20-plus year history of operation for modern below-ground tailings facilities provides the opportunity to test the theoretical predictions associated with the long-term management of tailings, both empirically and mathematically.

Areas of mine waste research include:

- **evaluating original model predictions** – Using geochemical data accumulated from tailings monitoring programs over the last two decades, it is now possible to verify earlier predictions of contaminant behaviour. Predictions that differ from the actual outcome present an opportunity to determine what processes may be causing contaminants to mobilize.

- **investigating the mobility of contaminants in subaqueous uranium mine tailings** – Historic uranium mine sites have been remediated, depositing uranium tailings under permanent water cover to limit interaction with the surrounding environment. These sites provide ideal locations for hydrogeochemical and mineralogical studies to improve our understanding of speciation and mobility in saturated environments.

E.3.1.8.4 Spent fuel safety

In the wake of the Fukushima Daiichi accident, the CNSC assembled a group of experts to study the capability for modelling the behaviour of spent fuel held in a CANDU irradiated fuel bay, should the water held in the bay be partially or totally drained. The group made recommendations on how this severe accident scenario could be modelled. The report was completed on March 31, 2017; it concluded that a sufficient understanding of the phenomena existed and provided direction to develop a fuel-bay accident analysis computer code. This computer model is now under development by CNL and is expected to be complete in 2021.

E.3.2 Independence of the CNSC

E.3.2.1 Separation of the CNSC and organizations that promote and use nuclear energy

The NSCA is distinct and comprehensive legislation for the regulation of nuclear activities and the separation of the regulatory body's functions from those of organizations that promote or use nuclear energy. The CNSC's mission (see section E.3.1.1) focuses clearly on the health and safety of persons and the protection of the environment, and it does not extend to economic matters. The CNSC operates at arm's length from, and reports directly to, the Parliament of Canada.

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." Any political directives given to agencies (such as the CNSC), however, must be of a general nature and cannot fetter the Commission's decision-making authority in specific cases. In addition, all directives must be published in the *Canada Gazette* and placed before each House of Parliament."

E.3.1.2 Values and ethics

The CNSC has a firmly-entrenched regime of values and ethics which serves to strengthen governance and support ethical leadership. The CNSC's Office of Audit and Ethics (OAE) administers five related programs, as follows:

- The Values and Ethics Program provides employees with counselling and techniques for strengthening relationships in the workplace and with stakeholders, as well as practical tools for ethical decision-making.
- The Internal Disclosure Program helps employees safely and constructively disclose wrongdoing and it protects them from reprisal.
- The Conflict of Interest and Post-employment Program gives the CNSC and employees tools to prevent and avoid situations that could create the appearance of a conflict of interest or result in a potential or actual conflict of interest.
- The Political Activities Program offers guidance to employees who seek to participate in political campaigns and reviews requests to run for office in federal, provincial and municipal elections.
- The External Complaints Program offers members of the public and the industry an opportunity to voice their concerns to a neutral CNSC entity.

The External Complaints Program was established in September 2015. Its purpose is to ensure all external complaints are first reviewed by a neutral CNSC entity and to respond consistently to allegations and plaintiffs. It provides a single external complaints window, ensures that all files are monitored to closure and provides annual reporting.

Through this program, members of the public, licensees’ employees and licensees’ site contractors can make complaints concerning: power plant design, construction, operation and maintenance; radiation protection, safeguards and security; wrongdoing or harassment, intimidation, retaliation or discrimination related to raising safety concerns; concerns related to the CNSC’s mandate; and misconduct associated with CNSC employees.

The external complaint process starts when a person contacts the CNSC by telephone, email or regular mail to make an allegation. The first staff member to receive the information completes the external complaint form.

The OAE conducts a preliminary analysis of the nature of the allegation. The OAE forwards complaints of a technical matter to the appropriate director general, but it keeps the file when allegations are associated with fraud, values and ethics, conflicts of interest or disclosures that involve CNSC management or staff. The following steps are then taken:

- The appropriate director general assesses the issue or the OAE conducts a fact-finding mission.
- The appropriate director general determines the next steps (e.g., inspection, regulatory actions).
- The appropriate director general monitors file progression, responds to complainants and closes the file.
- Finally, the appropriate director general compiles a list of the complaints for annual reporting.

Subject to applicable legislation, regulations and policies, the External Complaints Program adheres to the principles of fairness and equity toward alleged wrongdoers and complainants, the protection of the complainant’s identity and the confidentiality of information provided.

The process, the timing and in some cases, the way complaints are handled are now being monitored by the appropriate director general and the OAE. This provides assurance that files receive the appropriate attention, follow-up and closure.

SECTION F

Other general safety

Section F – Other General Safety Provisions

F.1 Responsibility of the licence holder (Article 21)

This section addresses the obligations under Article 21 of the Joint Convention.

> **ARTICLE 21. RESPONSIBILITY OF THE LICENCE HOLDER**
>
> 1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.
> 2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

In Canada, the primary responsibility for the safety of spent fuel and radioactive waste management is the licensee's under the NSCA and its associated regulations, and may not be delegated by the licensee to other persons or organizations. This responsibility includes providing adequate human and financial resources (see section F.2).

In addition, REGDOC-3.5.3, *Regulatory Fundamentals* outlines the CNSC's regulatory philosophy and states that:

- licensees are directly responsible for managing regulated activities in a manner that protects health, safety, security and the environment and that conforms with Canada's domestic and international obligations on the peaceful use of energy
- the CNSC is accountable to Parliament and to Canadians for assuring that these responsibilities are properly discharged

Licensees are required to comply with regulatory requirements, including applicable acts and regulations, the licence and the licensing basis at all times. Licensees are expected to review and consider regulatory guidance; if they choose not to follow it, they should explain how their chosen alternate approach meets regulatory requirements.

F.2 Human and financial resources (Article 22)

This section addresses the obligations under Article 22 of the Joint Convention.

> **ARTICLE 22. HUMAN AND FINANCIAL RESOURCES**
>
> Each Contracting Party shall take the appropriate steps to ensure that:
>
> (i) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;
>
> (ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;
>
> (iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

F.2.1 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. Paragraph 44(1)(k) of the NSCA provides the legislative basis for the qualification, training and examination of staff. Paragraphs 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.

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 that follow outline the licensees' initiatives to develop sufficient human resources to ensure the long-term sustainability of the workforce.

F.2.1.1 University Network of Excellence in Nuclear Engineering

Established in 2002, 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, research and development capability in Canadian universities. 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 and university-based education, and by encouraging young people to choose a career in the nuclear sector. More information is available at unene.ca.

The alliance consists of a number of Canadian universities, government entities (NRCan and the CNSC) and industry partners, including OPG, COG, BP, CNL, SNC Nuclear, Amec Foster Wheeler and the NWMO.

With funding provided by all industry partners, the Natural Sciences and Engineering Research Council and the CNSC are committed to supporting education and research in nuclear science and engineering at:

- McMaster University
- Ontario Tech University
- Queen's University
- Royal Military College of Canada
- University of Guelph
- University of New Brunswick
- University of Toronto
- University of Waterloo
- Western University

UNENE funding creates industrial research chairs in specialized areas at these universities through which students in master's degree and PhD programs are trained. In addition, UNENE sponsors collaborative research of topical interest to industry. It also supports a master of nuclear engineering degree program, delivered jointly by participating universities and intended for the employees of industry partners, which can be taken on a part-time basis.

Some current projects undertaken by UNENE include work in high-temperature aqueous chemistry, corrosion and stress-corrosion research relating to reactor materials, nuclear safety analysis and thermalhydraulics.

F.2.1.2 CANTEACH

The CANTEACH program was established by AECL, OPG, COG, BP, McMaster University, École polytechnique de Montréal 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 educational and training documents. The CNSC and other industry members also contribute to the program. More information is available at canteach.candu.org.

F.2.1.3 Ontario Power Generation

OPG's Nuclear Waste Management Division currently comprises approximately 210 full-time employees. Staffing demand fluctuates, depending mostly on attrition through retirements. OPG employs a "centre-led" model, in which support groups – including engineering, radiation protection, health and safety, and environment – are managed under a corporate reporting structure. Staff within each of those groups are dedicated to supporting the Nuclear Waste Management Division and add to the core employee count. Staff for skilled and semi-skilled trades are typically recruited from within OPG and acquired through the external labour marketplace, as required.

OPG's Nuclear Waste Management Division uses the following recruitment and retention strategies, wherever possible:

- **succession management** – OPG assesses the leadership capabilities and succession/replacement planning for all leadership positions.
- **advance hiring** – Critical positions within the organization are identified in OPG's succession-management program, and advance hiring is applied where feasible.
- **development and co-op student program** – University and college students are recruited in technical and business streams for work terms ranging from 4 months to 15 months.
- **participation in workforce planning within OPG** – To ensure adequate recruitment in advance of hiring needs, staffing demand within the Division is often satisfied through OPG's internal selection and placement processes. The Division focuses on the skilled operator and maintenance positions with an induction process to provide core skills training.
- **semi-skilled labour** – When required, labourers are directly hired from community impact areas.
- **knowledge management** – Managing critical knowledge and the associated knowledge risk when people exit positions (or leave OPG) is a key focus given workforce demographics, impending retirements, role transitions and the training and development required for specialized roles. It is imperative that employees' critical knowledge and expertise are sustained to support ongoing operations.

The Division uses OPG's knowledge management toolkit and its strategies, tools and resources to identify and mitigate knowledge risks and sustain critical knowledge within the Division, culminating in the development of knowledge management plans.

With continued emphasis on succession management, knowledge management, workforce planning and staff development, OPG's Nuclear Waste Management Division is positively positioned to meet its qualified staffing requirements for both the short and long term.

F.2.1.4 Bruce Power

BP's integrated talent management framework is aligned with its corporate strategy and goals to ensure qualified staff are available as needed for safety-related activities during the operating lifetime of its spent fuel and radioactive waste management programs. BP is focused on ensuring it has the right skillsets and behaviours to achieve excellence and to make sure it achieves its vision: "Safe. Reliable. Securing Tomorrow."

This process involves completing calibrated talent reviews for employees at all management levels, including individual contributors, having robust succession plans for the positions of mid-manager and above, and establishing personalized development plans based on intensive leadership assessments, while leveraging career maps to drive next moves. Its talent management review process connects directly into its solid suite of leadership development programs, where talent data is used to identify the need for and develop leadership development programs and subsequently populate class rosters based on development needs. The integration of these programs and the commitment of the senior leadership team have allowed BP to maintain a focus on developing a strong pool of qualified candidates to meet its organizational priorities and continuously focus on driving business results.

F.2.1.5 Nuclear Waste Management Organization

After the Government of Canada selected the APM approach in 2007, the NWMO began its transition from a small study-based group to a sustainable corporation with full responsibility for implementing the approach.

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 one year later, and to 186 by early 2020. The initial influx of staff was due to the transfer of OPG personnel who had been working on both the NWMO programs and OPG's Deep Geologic Repository project for its L&ILW. One significant benefit of this arrangement was acquiring the experience of an established radioactive waste management and repository team.

Over the past three years, the NWMO has continued to hire staff and contractors to support its site selection process. Increasingly, the NWMO has also hired staff to support its development from a technical organization to a nuclear organization capable of holding a CNSC licence. The NWMO also has local offices in the communities participating in preliminary assessments of site suitability.

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

Research also helps to shape development of the site preparation process and continues to support its implementation. The NWMO has contracts with more than 15 Canadian universities to support its research capability.

The organization works with an extended group of experts from across Canada and internationally to support its design, siting and confidence-building activities. The NWMO also has contacts with many international organizations and has exchange agreements with national radioactive waste management organizations in Sweden, Finland, Switzerland, France, Japan, the Republic of Korea and the United Kingdom. This ensures that international best practices are observed.

F.2.2 Financial resources

Canada applies the "polluter pays" principle to spent fuel and radioactive WMFs; the principle states that waste owners are financially responsible for managing their radioactive waste, and the Government of Canada has set in place mechanisms to ensure this financial responsibility does not fall on the Canadian public. This position was reaffirmed in the Government of Canada's *Radioactive Waste Policy Framework* (see section B.1.2). In 2002, under the NFWA, the owners of spent fuel were specifically required to establish segregated funds to fully finance long-term spent fuel waste management activities.

F.2.2.1 Historic waste

In some instances, remedial actions are required on properties not owned by the federal government, but whose original owner no longer exists. In these situations, the federal government may make a determination to accept responsibility for managing the wastes on a case-by-case basis. In March 2001, the Government of

Canada and the local municipalities in Ontario's Port Hope area entered into an agreement on community-developed proposals to address the cleanup and long-term management of the bulk of Canada's historic wastes, thereby launching the Port Hope Area Initiative (PHAI). In 2012, the Government of Canada announced $1.28 billion in funding to implement the PHAI. The management of these wastes, as well as other designated historic wastes across Canada, are the responsibility of AECL and are being managed by CNL under a GoCo model.

F.2.2.2 Financial guarantees

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

Subsection 24(5) of the NSCA provides the legislative basis for this requirement. Paragraph 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." CNSC regulatory guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities,* covers the provision of financial guarantees for decommissioning activities. This regulatory document will soon be replaced by REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*, which was subject to public consultation in 2019. Regulatory guide G-219, *Decommissioning Planning for Licensed Activities* provides guidance on preparing plans for decommissioning activities licensed by the CNSC. This regulatory document will soon be replaced by REGDOC-2.11.2, *Decommissioning*, which was also subject to public consultation in 2019. These guides can be found at cnsc-ccsn.gc.ca/eng/acts-and-regulations/regulatory-documents.

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 a licensee covers the costs of spent fuel only once, the money in the trust funds set up under the NFWA is considered part of that licensee's total financial guarantee to the CNSC.

The CNSC must be assured that it (or its agents) can access adequate funding measures on demand if a licensee is not available to fulfill its decommissioning obligations. 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 (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 established so that the financial vehicle can be drawn upon only with the approval of the CNSC and so 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 times, to fund the decommissioning plans for which they are intended.

- **continuity** – The funding measures required for decommissioning should be maintained continually. This may require the periodic renewal, revision and replacement of securities provided or issued for fixed terms. For example, during licence renewal, the preliminary decommissioning plan may be revised and the financial guarantee updated accordingly. Where necessary, to ensure there is continuity of coverage, funding measures should include provisions for advance notice of termination or intent to not renew.

The CNSC has requirements for financial guarantees for all licensees, from large complex facilities to users of sealed sources and radiation devices (see section J.1.3.7).

F.3 Quality assurance (Article 23)

This section addresses the obligations under Article 23 of the Joint Convention.

ARTICLE 23. QUALITY ASSURANCE

1. Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

F.3.1 Management system requirements

The regulations made under the NSCA require licensees to prepare and implement a management system for activities, including measures to promote and support safety culture programs for nuclear facilities. The licensees of spent fuel and radioactive WMFs submit their management system manual and programs to the CNSC before they begin their planned activities. The organization responsible for a facility must establish and implement a management system for the items and services the facility supplies. The management system covers the licensed spent fuel and radioactive waste management activities for more than one site. After a licence is granted, the licensee implements, assesses and continually improves the management system. The licensee must demonstrate the effectiveness of the management system.

CSA Group standard N286-12, *Management system requirements for nuclear facilities* integrates the requirements from other management system standards, such as quality, health and safety, environment, economics and security. The standard applies to top management with overall accountability for the nuclear facility. CSA N286-12 applies to all nuclear facilities, including spent fuel and radioactive WMFs at NPPs and uranium mines and mills. The requirement for a management system to meet this standard emphasizes the paramount importance of safety in guiding decisions and actions. This standard, in addition to generic requirements, also lists specific requirements for the lifecycle activities of radioactive WMFs.

The licence application describes how the main features of the applicant's management system are compliant with the relevant requirements in CSA N286-12 and how the management system will be implemented. The licence application is reviewed by CNSC staff. Specific waste management activities are performed under specific programs accepted by the CNSC.

F.3.2 Management system assessments

CNSC staff review the licensee's program documentation against the criteria established in the requirement documents and standards that are referenced in the licence and LCH to assess the effectiveness of the licensee's management system. CNSC staff also examine the results of the licensee's internal reviews and assessments. After the management system documentation is accepted, the CNSC plans and carries out a compliance verification to ensure the licensee is complying with its provisions. When deficiencies are detected, the CNSC produces detailed reports of the findings and forwards them to the licensee for its response and corrective actions. Based on the no-surprise approach that CNSC staff practice, the preliminary findings are presented to the licensees to take immediate corrective actions, as necessary. It is the responsibility of the CNSC to verify and enforce compliance. The CNSC uses a graduated enforcement strategy that is built on three fundamental principles: flexibility, timeliness and transparency. Enforcement includes all activities conducted to compel a licensee to return to compliance and to deter further non-compliance with the NSCA and its regulations, and any licences, decisions, certificates and orders issued by the CNSC.

F.4 Operational radiation protection (Article 24)

This section addresses the obligations under Article 24 of the Joint Convention.

ARTICLE 24. OPERATIONAL RADIATION PROTECTION

1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

   (i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

   (ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and

   (iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

   (i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

   (ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

F.4.1 Keeping radiation exposures and doses as low as reasonably achievable

Operations at Canada's spent fuel and radioactive WMFs must be carried out in a manner that ensures radiation exposures and doses to workers, the public and the environment are below the CNSC regulatory dose limits and kept as low as reasonably achievable (ALARA), taking social and economic factors into account. This approach is legislated through the NSCA and the RPR. Radiation exposures and doses are kept ALARA by implementing a radiation protection program with the following elements:

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

Note that social and economic factors are considered in ALARA to determine suitable technical approaches and methods, rather than for social and economic development.

To ensure that licensees consistently apply the ALARA requirement, the CNSC has issued regulatory guide G-129 (revision 1), *Keeping Radiation Exposures and Doses “As Low as Reasonably Achievable” (ALARA)* to provide further details on regulatory expectations.

F.4.2 Dose limitation

The CNSC establishes effective and equivalent dose limits in the RPR for a nuclear energy worker, a pregnant nuclear energy worker and non-nuclear energy workers.

Section 13 of the RPR requires that every licensee ensure that the following effective dose limits are not exceeded:

- 50 mSv in a year and 100 mSv in a five-year dosimetry period for a nuclear energy worker
- 4 mSv for a pregnant nuclear energy worker for the balance of pregnancy (which is the period from the moment a licensee is informed in writing of the pregnancy to the end of the pregnancy)
- 1 mSv per year for a person who is not a nuclear energy worker

Section 14 of the RPR requires that every licensee ensure the following equivalent dose limits are not exceeded:

- 150 mSv in a one-year dosimetry period for the lens of an eye of a nuclear energy worker, and 15 mSv in a calendar year for the lens of an eye of any other person
- 500 mSv in a one-year dosimetry period for the skin and for the skin of the hands and feet of a nuclear energy worker, and 50 mSv in a calendar year for the skin, hands and feet of any other person

Section 15 of the RPR details regulatory requirements related to exposures of persons who form part of the licensee’s response organization during the control of an emergency.

F.4.3 Action levels

In terms of occupational radiation protection, paragraph 3(1)(e) of the GNSCR requires a licence application to include the measures proposed for ensuring compliance with the RPR. Paragraph 3(1)(f) of the GNSCR also requires any proposed action level for the purpose of section 6 of the RPR to be included with the application.

Section 6 of the RPR defines an action level as “a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken.” When an action level is reached, the licensee must take the following actions:

- Notify the CNSC.
- Conduct an investigation to determine the cause of the events leading to the action level.
- Take action to restore the effectiveness of the radiation protection program.

Action levels are designed to alert licensees before regulatory dose limits are reached; they are established as part of licensees’ radiation protection programs. Licensees are responsible for identifying the parameters of their program that serve as timely indicators of potential losses of control of their program. For this reason, action levels are facility-/activity-specific and may change over time, depending on operational and radiological conditions. By definition, if an action level is reached, a loss of control of some part of the associated radiation protection program may have occurred, and specific action is required. When an action level is reached, the specified actions under the RPR consist of establishing the cause for reaching the action level, restoring the effectiveness of the radiation protection program, and notifying the CNSC within a specified period of time. The CNSC’s regulatory guide G-228, *Developing and Using Action Levels* provides further details on regulatory expectations.

F.4.4 Dosimetry

The CNSC requires that every licensee ascertain and record the magnitude of radiation exposure to workers by direct measurement or monitoring, or where this is not possible, by estimation. The RPR stipulate that a nuclear energy worker has a reasonable probability of receiving an effective dose of greater than 5 mSv in a one-year dosimetry period. The licensee is required to use a CNSC-licensed dosimetry service. Standards for licensed dosimetry services in Canada are found in regulatory standard S-106 rev.1, *Technical and Quality Assurance Requirements for Dosimetry Services*, published in March 2006. Licensed dosimetry services must report the dose results of each nuclear energy worker in Health Canada's National Dose Registry.

F.4.5 Preventing unplanned releases

The nuclear sector reduces the risk of unplanned effluent releases of radioactive material into the environment by: installing multiple barriers; having reliable components, systems and competent staff; and detecting failures and correcting them.

Due to the robust design of the storage facilities that house high-risk materials like spent fuel, the potential for a significant release is present mainly when materials are handled. Such operations are closely monitored by the licensee, 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 on dedicated transit routes which are physically controlled during transfer, and prohibiting the transfer of spent fuel during inclement weather, including high winds and periods of rain or snow. Packages used in the transport of radioactive materials are designed to withstand accidents during transportation to ensure containment, and are inspected and tested routinely to confirm their integrity.

In the event of an uncontrolled release into the environment, competent licensee staff are available for an initial cleanup and containment exercise to prevent the further spread of radioactive contaminants. If necessary, the stored radioactive waste may be retrieved and held in a more secure manner. Depending on the magnitude and severity of the release, emergency procedures and emergency preparedness plans may be activated.

F.4.6 Protection of the environment

Environmental protection is one of the 14 safety and control areas (SCA) (see annex 3 for a description of all 14 SCAs) the CNSC considers when evaluating how well its licensees meet regulatory requirements and expectations to prevent unreasonable risk to the environment in a manner consistent with Canadian environmental policies, acts and regulations, and Canada's international obligations. The environmental protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances. It incorporates the key concepts of pollution prevention and continuous improvement. It also covers the effects on the environment and human and non-human biota from facilities or as the result of licensed activities.

CNSC regulatory document REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures,* version 1.1 (published in April 2017) sets out the CNSC's regulatory requirements for and expectations of programs related to environmental protection. More precisely, REGDOC-2.9.1 describes:

- the CNSC's principles for environmental protection for all nuclear facilities or activities that interact with the environment
- the scope of an environmental review, including the roles and responsibilities associated with this review

- the CNSC’s requirements and guidance to applicants and licensees for developing environmental protection measures, including an environmental risk assessment (ERA) where required, for both new and existing facilities or activities

REGDOC-2.9.1 clarifies the CNSC's expectations of applicants and licensees for the entire nuclear fuel cycle and provides guidance for the environmental protection measures licensees should have in place to ensure the protection of persons and the environment. The necessary measures for environmental protection are determined on a facility- or activity-specific basis. Not every facility or activity is required to have every environmental protection measure described in this regulatory document. The CNSC allows the applicant or licensee to address certain requirements by demonstrating that a particular measure is not necessary or does not apply to that facility or activity. In this scenario, a licence application that describes the nature of the proposed licensed activities is considered sufficient for ensuring protection of the environment, provided CNSC staff conclude the facility or activities do not have significant interactions with the environment.

F.4.6.1 Environmental management system

An environmental management system (EMS) refers to the management of an organization’s environmental policies, measures and procedures in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection and continuous improvement by:

- identifying and managing environmental risks associated with a facility or activity
- identifying, implementing and maintaining pollution control activities and technologies
- monitoring releases
- monitoring contaminants and their potential effects in the environment

The EMS serves as the management tool for integrating all of the applicant’s or licensee’s environmental protection measures in a documented, managed and auditable process by:

- identifying and managing non-compliance and corrective actions within the activities, through internal and external inspections and audits
- summarizing and reporting the performance of these activities, both internally (licensee’s management structure) and externally (to the Commission and the public)
- training the personnel involved in these activities
- ensuring the availability of resources (such as qualified personnel, organizational infrastructure, technology and financial resources)
- defining and delegating roles, responsibilities and authorities essential to effective environmental management

The EMS may be implemented within the licensee’s integrated management system. CAN/CSA ISO 14001, *Environmental management systems – Requirements with guidance for use* (2004 edition or successor editions), specifies the requirements for an EMS that licensees can use to enhance environmental performance. Licensees are required to ensure that the scope of the EMS is consistent with the definition of environment, environmental effects and pollution prevention. They must conduct internal audits and an annual management review.

Within the EMS, the licensee should address reporting requirements for potential or real emergency situations. In addition, the EMS should address environmental emergency preparedness and response in terms of:

- the proposed measures to prevent accidental releases of nuclear and hazardous substances or mitigate the effects of any releases on the environment
- the proposed measures to ensure that environmental monitoring instruments are available and accessible during emergencies
- environmental monitoring instruments and equipment layouts included in emergency plans

F.4.6.2 Environmental risk assessment

Under REGDOC 2.9.1, licensees must conduct an environmental risk assessment (ERA). An ERA is a systematic process that identifies, quantifies and characterizes the risk posed by releases of nuclear and hazardous substances and physical disturbances (stressors) on representative human and non-human biota in the environment. It is a practice or methodology that provides science-based information to support decision making and to prioritize the implementation of mitigation measures.

The ERA provides the basis for the scope and complexity of monitoring programs, including effluent and environmental monitoring programs. An ERA can help inform an effluent monitoring program by identifying and prioritizing specific radioactive and non-radioactive contaminants, physical stressors and the sources or release points from the nuclear facility or licensed activity.

An ERA is an evergreen tool that is updated periodically as new information is gathered. If an ERA indicates that the nature, extent and significance of environmental effects are greater than predicted, several actions may be taken, including re-evaluating the environmental effects in terms of risk, investigating mitigation measures as necessary, and identifying any changes needed to the effluent and environmental monitoring programs.

CSA Group standard N288.6, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* addresses the design, implementation and management of an ERA program.

F.4.6.3 Protection of the public

Under the NSCA and associated regulations, the licensee must demonstrate that the health and safety of the public are protected from exposures to nuclear and hazardous substances released from the nuclear facility. REGDOC-2.9.1 states that a human health risk assessment is completed as a sub-element of an ERA; it estimates the nature and probability of adverse human health effects as a result of releases of nuclear and hazardous substances from the nuclear facility and other physical stressors, such as noise.

In addition, releases of nuclear and hazardous substances are controlled and monitored by the effluent and emissions control and monitoring program and the environmental monitoring program. Licensees are required to report to the appropriate authorities, including the CNSC, any releases above regulatory limits and any unauthorized releases of nuclear or hazardous substances to the environment (for example, spills). Licensees are also required to submit a follow-up report detailing the results of the investigation and any corrective actions taken to prevent a reoccurrence.

F.4.6.3.1 Estimated dose to the public

Licensees are required to demonstrate that the estimated dose to the public from their licensed activities is below the regulatory limit of 1 mSv per calendar year. Some licensees achieve this by entering the results of their effluent monitoring and control activities into an environmental transport model, as described in CSA Group standard N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*; they use this model to calculate the estimated dose to the public as a result of the licensed activity. Other licensees conduct fence-line monitoring using thermoluminescent dosimeters (TLDs) or active monitoring during the execution of licensed activities.

F.4.6.3.2 Studies on health effects from exposures to ionizing radiation

The health effects from exposure to ionizing radiation have been studied for decades.[1] There are two broad categories of health effects from exposure to radiation: tissue effects and stochastic effects. Tissue effects are changes in cells that are certain to occur after an acute dose of radiation in excess of a threshold value (typically above 1,000 mSv). The severity of health effects – such as skin reddening, burns and hair loss – increases with the radiation dose received. Stochastic is a term used to group radiation-induced health effects (such as cancer or inheritable diseases) which have a statistical risk. Stochastic effects are of primary concern at low and moderate doses (below 1,000 mSv). For these diseases, the probability of their occurrence increases proportionally to the radiation dose received. In other words, the higher the dose, the higher the probability of occurrence. However, at no time, even for high doses, is it certain that cancer or genetic damage will result, due to the body's ability to repair damaged DNA. Of note, heritable effects have not been observed in humans, only in plant and animal studies. Attributing a health effect directly to a radiation exposure is difficult at doses lower than about 100 mSv, due to the high frequency of illness and disease in all populations in the absence of radiation exposure.

The current understanding of tissue and stochastic effects is based on the life span studies (LSS) of the atomic bomb survivors.[2] Numerous studies published in Canada and abroad support the findings of the LSS studies. Select examples where Canadian populations are considered include: studies of medical patients, nuclear energy workers (including medical workers), and people living in the vicinity of nuclear facilities.[3-16] Together, these studies confirm that at current environmental or occupational exposure levels, no adverse health effects are expected.

As stated, in Canada, spent fuel and radioactive waste are contained in interim storage facilities. As currently managed, all radioactive waste inventories contribute to less than 1 µSv of dose each year to the public (1,000 times lower than the public dose limit), and less than a few mSv each year to those who work with such wastes. At these operational levels, there is no significant health risk.[17]

Given that there are no geological repositories in Canada, and few in the world, limited information exists about public radiation exposures resulting from the operation of this type of facility. However, public exposure during existing (or normal) and emergency situations have been modelled, and the doses are expected to be lower than the public dose limit of 1 mSv per year for normal operations and about than 1 mSv per year or lower for emergency situations that are considered very unlikely events.[18]

Human health risk assessments have generally focused on the risk of cancer, the primary health effect associated with low dose radiation exposures. However, lessons learned from past nuclear accidents and other types of disasters have shown that psychosocial impacts are an important health factor. Although there is no widely agreed definition, psychosocial describes the interaction between social aspects (such as interpersonal relationships and social connections, social resources, social norms, social values, social roles, community life, spiritual and religious life) and psychological aspects (such as emotions, thoughts, behaviours, knowledge and coping strategies) that contribute to overall well-being.

An example where psychosocial impacts were considered was during the 2012 Joint Review Panel (JRP) established to review OPG's environmental impact statement in support of its application for a licence to prepare site for and construct a DGR for its L&ILW. During the 2013 public hearings, the CNSC commissioned a study by Dr. William Leiss looking at the stigmatization of place.[19] The word "stigma" refers to some kind of mark that could be placed on a person in order to signify shame, disgrace and disapproval. Stigmatization of place refers to contaminated places or sites where there is a high perception of risk, inequitable distribution of risk and long-lasting severe consequences for the local communities that are in close proximity to such places. The study by Dr. Leiss concluded that a siting strategy centred on a willing host community is likely to become the preferred option around the world. The JRP also recommended that monitoring stigma form part of the overall follow-up monitoring program. A successful monitoring framework should include the community to establish a process whereby that community can be informed about the design and results of follow-up monitoring.

As the national nuclear regulator, the CNSC will ensure that all wastes as currently managed and any proposed future operations meet all regulatory standards and requirements, thereby protecting the health and safety of all Canadians.

F.4.6.4 Effluent and emissions control and monitoring

The CNSC regulates releases to the environment through licensed release limits which are values that, if exceeded, indicate that the licensee is operating outside of its licensing basis during normal operation, which is a point of non-compliance. The objectives of a licensed release limit are to:

- protect human health and the environment
- ensure that pollution prevention and control technologies are implemented
- drive continuous improvement
- ensure that the licensee is operating within their approved licensing basis

Licensees establish controls on environmental releases to protect the environment and abide by the principles of sustainable development and pollution prevention. Licensees are encouraged to set action levels to provide assurance that the licensed release limits will not be exceeded. This is done by providing an early indication of a potential loss of control of part of the environmental protection program. Action levels are also used to ensure licensees demonstrate adequate control of their facility based on their approved facility design, environmental protection programs and radiation protection programs. CSA Group standard N288.8, *Establishing and implementing action levels for releases to the environment from nuclear facilities* (published in 2017) provides guidance on developing and implementing action levels for releases from nuclear facilities.

Although specific to radiation protection, CNSC regulatory guide G-228, *Developing and Using Action Levels* provides useful generic guidance on the principles that underlie action levels. These principles should be used to develop targets for environmental performance along with the ALARA principle, as outlined in regulatory guide G-129, *Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable* (ALARA)".

In conjunction with specific regulatory monitoring requirements, the ERA provides the technical foundation and structure to identify the need for effluent and emissions monitoring and its details. The design of the site-specific effluent and emissions monitoring program is based on the characterization of the locations, the anticipated volume, chemistry and flow rate of releases, and the proposed maximum quantities and concentrations of nuclear and hazardous substances (including their physical, chemical and radiological characteristics). CSA Group standard N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* (published in 2011) addresses the design, implementation and management of an effluent monitoring program that meets legal and business requirements.

Effluent and emissions monitoring is not required for facilities and activities with no significant measurable releases to the environment. In such cases, the licensee should demonstrate (through engineering or scientific methods) that appropriate barriers and practices are implemented, monitored and maintained to prevent releases to the environment.

Monitoring is also not required for facilities and activities where the releases are of low risk, as identified in the ERA, or the quantities are too low or too difficult to measure using industry best practices and/or equipment. If measuring is not feasible or is too difficult, the licensee may estimate emissions based on site-specific process chemistry and engineering principles.

F.4.6.4.1 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 pathways, such as:

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

For nuclear substances, the CNSC's licensed release limits are known as derived release limits (DRLs). A DRL is a sub-type of a licence limit that is derived using the methodology in CSA Group standard N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*. For most facilities, a DRL is based on achieving a radiological dose equal to the regulatory annual dose limit of 1 mSv/yr to a potential receptor from the airborne and liquid releases of a facility during normal operations. Instead of using the regulatory dose limit, some facilities calculate their DRLs so that they achieve a lower dose constraint. The nuclear sector sets operating targets or administrative limits that are typically a small percentage of the DRLs. These targets are based on the ALARA principle; they are unique to each facility and depend 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.

Doses received by members of the public through routine releases from Canadian nuclear facilities are very low and constitute a small fraction of the CNSC regulatory dose limits. The CNSC is currently drafting REGDOC 2.9.2, *Controlling Releases to the Environment from Nuclear Facilities*. This regulatory document formally describes the process for establishing and implementing licensed release limits for releases to the environment and sets expectations for using CSA Group standard N288.8 to derive environmental action levels.

F.4.6.4.2 Conditional clearance levels

Some licensees have conditional clearance levels for releases to the municipal sewer system that are derived using the methodology in IAEA-TECDOC-1000, *Clearance of Materials Resulting from the Use of Radionuclides in Medicine, Industry and Research*, which was published in 1998.

The discharge limits are based on two main groups of pathways: those resulting from the retention of radionuclides in sewage sludge at the waste water treatment plant (WTP), and those from the waste water treatment plant effluent discharged to a river. Discharge limits are calculated separately for both groups of pathways; namely those resulting from the retention of radionuclides in sewage sludge and those from the WTP effluent discharged to a river. The limits are calculated so that the annual effective dose to the receptor is 10 µSv from each of the two groups of pathways. The smaller of the two limits calculated in this manner is rounded to the nearest multiple of 10 and selected as the discharge limit for the radionuclide. These limits are found in appendix R of REGDOC-1.6.1, *Licence Application Guide: Nuclear Substances and Radiation Devices*.

F.4.6.5 Environmental monitoring

Under REGDOC 2.9.1, and in keeping with regulatory monitoring requirements and the ERA, the environmental monitoring measures that licensees establish and implement are in line with CSA Group standard N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*. This standard addresses the monitoring of both nuclear and hazardous substances, and their potential effects on human and non-human biota.

Environmental monitoring consists of a risk-informed set of integrated and documented activities to sample, measure, analyze, interpret and report one or all of:

- the concentration of nuclear and hazardous substances in environmental media to assess the exposure of receptors to those substances and/or the potential effects on human health, safety and the environment
- the intensity of physical stressors and/or their potential effect on human health and the environment
- the physical, chemical and biological parameters of the environment normally considered when determining what environmental monitoring is needed to help interpret the results, for example, data for transport (such as wind velocity), or toxicity assessment (such as organic carbon or hardness), or measurements at reference stations (where incorporated in the monitoring)

Data from the environmental monitoring program is used to inform future revisions of the ERA. The CNSC has implemented its Independent Environmental Monitoring Program (IEMP) to confirm that the public and environment around CNSC regulated nuclear facilities are safe. The IEMP is a tool that complements the CNSC's ongoing compliance verification program. The IEMP involves taking samples from public areas around the sites and measuring and analyzing the amount of radiological (nuclear) and hazardous substances in those samples. CNSC staff collect the samples and send them to the CNSC's laboratory for testing and analysis. As an exception, due to logistics, samples collected in northern Saskatchewan are sent to a contractor laboratory. A summary of the results is available on the CNSC's IEMP website at nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/iemp/index-iemp.cfm.

Figure F.1: CNSC staff taking water samples at Elliot Lake

F.4.6.6 Groundwater protection and monitoring

Under the NSCA and its regulations, licensees are required to ensure that groundwater is protected through an inter-related system of initiatives, processes and activities that seeks to protect the quality and quantity of groundwater. This system minimizes interactions between the environment and activities associated with a nuclear facility to help manage groundwater resources effectively. Groundwater protection is a specialized element of the overall environmental protection measures. As flow and associated contaminant transport of groundwater can be more difficult to detect and delineate than those of surface water, specific requirements and guidance are provided in REGDOC-2.9.1 and CSA Group standard N288.7, *Groundwater protection programs at Class I nuclear facilities and uranium mines and mills*.

F.5 Emergency preparedness (Article 25)

This section addresses the obligations under Article 25 of the Joint Convention.

> ARTICLE 25. EMERGENCY PREPAREDNESS
>
> 1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.
> 2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

F.5.1 Nuclear emergency preparedness and response in Canada

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

In keeping with IAEA guidance, responsibilities for nuclear emergency response are subdivided into two basic areas: on-site and off-site. The response activities and strategies in these two areas may involve and require different stakeholders; however, they are not independent of each other. Therefore, an effective and efficient response to a nuclear emergency must be coordinated between all levels of government, the CNSC and the licensee.

All organizations that play a role in nuclear emergency response, including the CNSC and its licensees, must have a nuclear emergency response plan in place, as well as operational facilities that are equipped and appropriately staffed to coordinate and direct their responses to the nuclear emergency.

From June 3 to 13, 2019, the IAEA carried out an Emergency Preparedness Review (EPREV) at the Government of Canada's request, making Canada the first G7 country to request an EPREV mission, highlighting its commitment to protecting the health and safety of Canadians. The mission focused on preparedness for emergencies originating from events at Emergency Preparedness Category I facilities, as defined in IAEA Safety Standards Series No. GSR Part 7, *Preparedness and Response for a Nuclear or Radiological Emergency* which includes emergencies taking place at NPPs, irrespective of their initiating events. For further information on the EPREV mission, see section K.5.

F.5.2 Types of nuclear emergencies

With respect to nuclear accident mitigation, emergency planning includes both on-site and off-site consequences, as described below:

- **on-site nuclear emergencies** – events that occur within the physical boundaries of a CNSC-licensed nuclear facility. The operators of those nuclear facilities are responsible for their on-site emergency planning, preparedness and response, but must also have plans and procedures in place to assist with any potential off-site consequences of an on-site emergency at their facility

- **off-site nuclear emergencies** – 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 may require intervention from provincial, territorial or municipal authorities operating outside of the licensed facility or activity, likely requiring support from the licensee and possibly the Government of Canada through the Federal Nuclear Emergency Plan (FNEP)

The licensees' nuclear emergency plans include measures to address on-site emergencies, as well as measures that support planning, preparedness and response for off-site emergencies. The response to off-site emergencies takes a hierarchical approach that involves the licensee, the local municipal government, the provincial/territorial government and the federal government.

F.5.3 Responsibilities in the event of a nuclear emergency

In the event of a nuclear site or facility accident with potential off-site consequences, the off-site response would follow a tiered process that involves:

- the licensee
- municipal government
- provincial/territorial governments
- federal government

The provincial governments are responsible for:

- overseeing public health and safety, and the protection of property and the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to the municipalities they designate to do the same
- managing the off-site response by supporting and coordinating the efforts of organizations that have responsibility in a nuclear emergency
- coordinating support from the nuclear site or facility licensee and the Government of Canada during preparedness activities and during the response in a nuclear emergency

Federal government support and response for potential off-site impacts are required for addressing areas of federal responsibility, including the effects of an incident that extend beyond provincial or national borders. Likewise, federal assistance, when requested by an affected province, needs to be coordinated. Some provinces have agreements with the federal government for the provision of specific types of technical support. Federal responsibility also encompasses a wide range of contingency and response measures to prevent, correct or eliminate accidents, spills, abnormal situations and emergencies, and to support provinces and territories in their responses to a nuclear emergency. The Government of Canada is also responsible for:

- 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

Public Safety Canada was created in 2003 to ensure coordination across all federal departments and agencies responsible for national security and the safety of Canadians. It is responsible for coordinating the overall federal government response to emergencies in support of provinces, including nuclear emergencies. The *Emergency Management Act* (EMA) which entered into force in 2007, replacing the former *Emergency Preparedness Act,* recognizes the roles that all stakeholders must play in Canada's emergency management system. It sets out the leadership role and responsibilities of the Minister of Public Safety and Emergency Preparedness, including coordinating emergency management activities among government institutions and in cooperation with the provinces and other entities. The responsibilities of other federal ministers are also set out in the EMA.

Canada's federal government is dedicated to working collaboratively with provinces and territories to support communities when disasters strike. To this end, *An Emergency Management Framework for Canada* was revised and approved by federal, provincial and territorial ministers in 2011. The framework establishes a common approach for a range of collaborative emergency management initiatives in support of safe and resilient communities. It can be viewed at publicsafety.gc.ca/cnt/rsrcs/pblctns/mrgnc-mngmnt-frmwrk/index-eng.aspx.

Public Safety Canada is the lead authority for the Federal Emergency Response Plan (FERP). Health Canada is the lead authority for the FNEP and also has responsibilities related to radiation protection. Health Canada administers both a federal interdepartmental and a federal–provincial nuclear emergency management committee.

Other federal organizations with responsibilities in nuclear emergency preparedness and response include the CNSC, Transport Canada, Environment and Climate Change Canada (ECCC), NRCan and the Public Health Agency of Canada (PHAC):

- NRCan is responsible for providing emergency radiation mapping and surveying services, providing policy advice and coordinating federal actions in relation to nuclear liability, including administering the NLCA.
- Transport Canada is responsible for the Canadian Transport Emergency Centre (CANUTEC).
- Internationally, Health Canada and the CNSC serve as national competent authorities to the IAEA.
- ECCC operates a regional specialized meteorological centre that comes under the World Meteorological Organization and provides atmospheric modelling services to the IAEA as part of its emergency response functions.
- PHAC is the national authority for reporting to the World Health Organization under the *International Health Regulations.*

The Government of Canada is also responsible for establishing and 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 NLCA. Operators of nuclear installations designated under the NLCA are absolutely and exclusively liable for any civil damages caused by an incident at that installation, and are required to have financial security in place to cover their liability. In the event of a serious incident, the NLCA provides special compensation measures that may be imposed by government to replace the normal court process. NRCan is the lead department responsible for ensuring that the process of compensation is well coordinated and administered in Canada.

The CNSC has a dual role in nuclear emergency response. Under the mandate established by the NSCA, the CNSC maintains regulatory oversight of the on-site nuclear emergency response activities of its licensees. As a federal agency, the CNSC also participates in the whole-of-government response to a nuclear emergency in accordance with the requirements of both the FERP and the FNEP.

The CNSC requires licence applicants to assess the impacts their proposed activities have on health, safety, security and the environment. It also requires that they propose and implement measures to prevent or mitigate the effects of accidental releases of nuclear or hazardous substances. Once the CNSC has reviewed and accepted the application, then issued a licence, these measures become binding upon the licensee. Due to the variety of risk among CNSC licensed facilities in Canada, some facilities require detailed emergency preparedness and response plans that must be coordinated with mutual aid organizations, while others may require only internal emergency procedures. Following the events in Fukushima, all major radiological and nuclear facilities in Canada were required to review their emergency planning basis, taking into account severe accidents and multi-event scenarios (e.g., loss of power coinciding with a release of radioactive material) to determine whether their current preparedness measures were still appropriate and whether additional measures needed to be incorporated into their plans.

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

Health Canada coordinates federal operations with provincial and territorial operations as required. The FNEP includes provincial annexes for Ontario, Quebec and New Brunswick, as they have nuclear power stations, and for Nova Scotia and British Columbia, as they have ports which are visited by nuclear-powered vessels. The FNEP also supports the provinces and territories without specific annexes, as required.

F.5.4 CNSC assessment of licensee emergency management programs

Applicants, including those for spent fuel and radioactive WMFs, must submit their emergency plans as part of their licence application. CNSC staff review and evaluate those plans according to regulatory criteria and guidance documents, such as REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response,* Version 2 (2016) and CSA Group standard N393-13, *Fire protection for facilities that process, handle, or store nuclear substances*. Once an applicant has been issued its licence, CNSC staff regularly review and perform audits of that licensee's emergency plans.

NPP and WMF licensees have emergency preparedness programs that identify the concepts, structures, roles and resources needed to implement effective nuclear emergency response capabilities and maintain them. The programs establish how nuclear facilities and other concerned organizations prepare for and plan to respond to emergencies (including nuclear or radiological emergencies, both on-site and off-site), in order to protect workers, the public and the environment. An effective emergency preparedness program contains arrangements to ensure a timely, coordinated and effective response to any emergency.

Each licensee's response capability is captured in its nuclear emergency plan, which encompasses both emergency preparedness and emergency response measures. The plan ensures that the appropriate emergency response capabilities have been developed and are being maintained so that the licensee can respond effectively in the event of a nuclear emergency. It is based upon the licensee's planning basis for both design-basis and beyond-design-basis events. Note that OPG has a single Consolidated Nuclear Emergency Plan that governs both the Darlington and Pickering sites and includes the WMFs.

The licensees' nuclear emergency plans include measures to address on-site emergencies, as well as measures that support planning, preparedness and response for off-site emergencies. The response to off-site emergencies takes a hierarchical approach that involves the licensee, the local municipal government, the provincial/territorial government and the federal government.

As part of their emergency preparedness programs, the licensees conduct emergency preparedness training, drills and exercises annually to ensure that their sites have adequate and robust emergency notification and response capability from their own staff and/or nearby emergency services with which they have memoranda of understanding or agreements. The following full-scale exercises were conducted within the review period:

- On December 6 and 7, 2017, OPG conducted a full-scale exercise (Exercise Unified Control) at the Pickering NGS, which tested the preparedness and response capabilities and capacities of more than 30 organizations, including the CNSC and some non-government agencies. The CNSC participated at its Emergency Operations Centre at headquarters, the Site Management Centre at OPG and the Provincial Operations Centre at the Office of the Fire Marshall and Emergency Management in Toronto.

- On October 3 and 4, 2018, NB Power conducted a full-scale exercise (Exercise Synergy Challenge) at Point Lepreau, which tested the preparedness, response and recovery capabilities and capacities of more than 35 organizations, including the CNSC and some non-government agencies.

- From October 20 to 23, 2019, BP held a full-scale exercise (Exercise Huron Resilience) at BP. This exercise tested and validated emergency preparedness, response capabilities and the collaborative and consultative processes of BP and its stakeholders. The final day of the exercise focused on the recovery phase which the CNSC observed, even though these proceedings were not formerly evaluated. This was an opportunity for BP to conduct a tabletop exercise of its business continuity procedures.

F.5.5 International arrangements

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

- *Canada–United States 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 for dealing with peacetime radiological events that involve Canada, the U.S. or both countries. The 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, 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, developed under the auspices of the IAEA, defines when and how the IAEA will notify the signatories associated with an international event that could have an impact on their respective countries

F.6 Decommissioning (Article 26)

This section addresses the obligations under Article 26 of the Joint Convention.

ARTICLE 26. DECOMMISSIONING

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that:

(i) qualified staff and adequate financial resources are available;

(ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;

(iii) the provisions of Article 25 with respect to emergency preparedness are applied; and

(iv) records of information important to decommissioning are kept.

F.6.1 Decommissioning in Canada

In accordance with CNSC regulatory guide G-219, *Decommissioning Planning for Licensed Activities* (to be replaced in 2020 by REGDOC-2.11.2, *Decommissioning*), Class I nuclear facilities and uranium mines and mills licensees are required to keep decommissioning plans up to date throughout the lifecycle of a licensed activity. The CNSC also requires licensees to prepare a PDP and detailed decommissioning plan (DDP) for approval.

The PDP must be filed with the CNSC as early as possible in the lifecycle of the activity or facility, and must be reviewed and updated:

- every five years
- when operational experience is gained or technological advancements are made
- when requested by the Commission or person authorized by the Commission

In the case of nuclear facilities, specific requirements for decommissioning planning are set out in CNSC regulations for Class I and Class II nuclear facilities and for uranium mines and mills.

The PDP documents the preferred decommissioning strategy – whether it is prompt decommissioning, deferred decommissioning or *in situ* confinement – selected by the licensee, along with objectives at the end of decommissioning. The plan should be sufficiently detailed to assure the proposed approach is technically and financially feasible. It must also be in the interest 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 DDP is filed with the CNSC prior to decommissioning activities and is required for appropriate licensing action (i.e., licence to authorize decommissioning). The DDP refines and adds procedural and organizational detail to the PDP.

Industry standard CSA Group standard N294, *Decommissioning of facilities containing nuclear substances* complements CNSC regulatory guide G-219 by providing direction on decommissioning that is consistent with Canadian and international recommendations. The standard incorporates current best practices and existing regulatory requirements, and it draws on the decommissioning experience of the Canadian nuclear industry. The second edition, CSA standard N294-19, *Decommissioning of facilities containing nuclear substances*, was published in 2019. Changes to this edition include:

a) guidance added on the transition to decommissioning and storage with surveillance (SWS)

b) guidance added on *in situ* decommissioning

c) regulatory administrative provisions removed from the standard

d) terminology updated to align with REGDOC-3.6, *Glossary of CNSC Terminology* and international terminology, as much as is practical

e) revisions made to align with regulatory documents

f) annex on costing removed

g) new clause added on land use remediation

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

Current decommissioning activities in Canada are listed in table D.12 and annex 8.

F.6.1.1 Operational radiation protection, discharges, unplanned and uncontrolled releases

Throughout the entire lifecycle of a facility, including decommissioning, the licensee is required to implement and maintain a radiation protection program to ensure that radiation exposures and doses to persons are below CNSC regulatory dose limits and kept ALARA by implementing:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual situations

Additionally, licensees are required to ascertain the quantity and concentration of any nuclear substance released as a result of a licensed activity, and implement measures to protect the environment and prevent or mitigate the effects of unplanned releases.

F.6.1.2 Emergency preparedness

An emergency response plan is still required for nuclear emergency management during the decommissioning phase. However, the extent of the plan will be commensurate with the risks associated with the facility at the time of decommissioning.

F.6.1.3 Records

As part of the decommissioning planning process, records are reviewed and relevant aspects are incorporated into the documentation required to obtain formal approval of both the PDP and DDP. A PDP serves as the basis for the decommissioning financial guarantees provided by the licensee. The CNSC requires that the PDP and financial guarantee be in place before construction and operations begin. A detailed decommissioning plan must be developed as operations near completion; this serves as the basis for subsequently licensing the decommissioning activities. The DDP 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 on-site staff diminishes. Reports submitted to regulatory agencies will be retained in accordance with the respective agencies’ procedures.

For example, the CINFR require that every licensee who operates a nuclear facility keep a record of the following:

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

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

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

The CINFR can be viewed on the CNSC's website at nuclearsafety.gc.ca/eng/acts-and-regulations.

SECTION G

Safety of spent fuel management

Section G – Safety of Spent Fuel Management

G.1 General safety requirements (Article 4)

This section addresses the obligations under Article 4 of the Joint Convention.

ARTICLE 4. GENERAL SAFETY REQUIREMENTS

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

(i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

(ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

(iii) take into account interdependencies among the different steps in spent fuel management;

(iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

(vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generations;

(vii) aim to avoid imposing undue burdens on future generations.

G.1.1 Criticality and removal of residual heat

Under CNSC regulatory document REGDOC-2.4.3, *Nuclear Criticality Safety*, criticality safety requirements must address both normal and abnormal conditions. This document clarifies the minimum physical constraints and limits on fissionable materials in order to ensure nuclear criticality safety during the construction, operation, decommissioning or abandonment of the licensed facility, and with respect to the handling, storing, processing and transport of certain fissionable materials. This document also provides guidance on how requirements for nuclear criticality safety may be met. The information set out in this document applies to operations with fissionable materials outside nuclear reactors, except for the assembly of these materials under controlled conditions (such as in critical experiments). A criticality safety analysis must be performed when "large quantities of fissionable materials" are stored or handled. The analysis must clearly demonstrate that the storage and handling of the radioactive waste is safe, and that therefore, an inadvertent criticality cannot occur under normal or credible abnormal conditions. The analysis must consider the off-site consequences for low-probability, high-consequence inadvertent criticality events, and it must demonstrate that the consequences of these events do not encroach upon the public evacuation criteria established in international standards and the *Canadian Guidelines for Intervention during a Nuclear Emergency*.

G.1.2 Radioactive waste management principles

As stated in REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada*, when making regulatory decisions about the management of radioactive waste including spent fuel, the CNSC considers the extent to which the owners of the waste have addressed the following six principles:

- The generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices.
- The management of radioactive waste is commensurate with the waste’s radiological, chemical and biological hazard to the health and safety of persons, to the environment and to national security.
- The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time during which the maximum impact is predicted to occur.
- 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.
- 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 reasonable practicable.
- The trans-border effects on the health and safety of persons and the environment that could result from the management of radioactive waste in Canada are not greater than the effects experienced in Canada.

The CNSC is committed to optimizing regulatory efforts, and to consulting and cooperating with provincial, national and international agencies to:

- promote harmonized regulation and consistent national and international standards for the management of radioactive waste
- achieve conformity with the measures of control and international obligations to which Canada has agreed concerning radioactive waste

G.1.2.1 Waste minimization

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* contains requirements regarding the minimization of radioactive waste.

Further, CSA Group standard N294, *Decommissioning of facilities containing nuclear substances* contains requirements to consider the waste hierarchy, specifically, the minimization of radioactive waste.

G.1.2.2 Security

Security requirements for Canadian licensees are based primarily on the IAEA’s Nuclear Security Series guidance documents. The CNSC monitors and assesses the effectiveness of the security of nuclear facilities, nuclear material and other radioactive material. Spent fuel storage and radioactive waste systems must conform to the requirements identified in the NSR*.* Additionally, licensees must meet security requirements defined in the GNSCR and further described in REGDOC 2.12.3, *Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material, Version 2.* Some waste facilities must also overcome the threat characteristics of adversaries, as defined in Canada’s document on design basis threats for high-security nuclear facilities.

G.1.2.3 Safeguards

The CNSC is the designated competent authority for Canada responsible for implementing the requirements of the Canada/IAEA safeguards agreements within the regulatory framework established through the NSCA and its regulations. As a result of these agreements, much of the nuclear material and many of the facilities identified in this report are also subject to verification by the IAEA.

G.1.3 Protection and safety fundamentals

The main objective in regulating spent fuel and radioactive waste management is to ensure 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 three parts:

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

G.1.3.1 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.1.3.2 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.1.3.3 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.
- The physical security systems of the contents and facility components must be maintained.

G.1.4 Interdependencies

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* states that the different steps in the management of radioactive waste are often interdependent, and that consequently, in order to achieve an appropriate level of safety, each step should be evaluated both as an individual step in the process and as part of an integrated system. In addition, the interfaces of the various organizations involved should be considered.

G.2 Existing facilities (Article 5)

This section addresses the obligations under Article 5 of the Joint Convention.

ARTICLE 5. EXISTING FACILITIES

Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.

The NSCA and its regulations ensured the safety of the spent fuel management facilities that existed when the Joint Convention came into force for Canada, as all facilities were under a CNSC licence. The design, construction, operation, decommissioning and abandonment of spent fuel management facilities must be conducted in accordance with the NSCA and its regulations, and the licence conditions.

See Section H.2.1.

G.3 Siting of proposed facilities (Article 6)

This section addresses the obligations under Article 6 of the Joint Convention.

ARTICLE 6. SITING OF PROPOSED FACILITIES

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:
   - (i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;
   - (ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;
   - (iii) to make information on the safety of such a facility available to members of the public;
   - (iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.
2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

In Canada, spent fuel management facilities are considered to be Class I nuclear facilities in accordance with the definition provided in the CINFR.

The objective of the site preparation stage is to determine whether the site is suitable for the construction and operation of a nuclear facility. An application for a licence to prepare a site does not require detailed design information or specifications, but it must provide enough information to demonstrate that releases of radioactive and hazardous substances are within the limits claimed in the impact assessment, and they meet all applicable regulatory requirements.

In some cases, the IAAC and the CNSC may work collaboratively to conduct an integrated impact assessment under the IAA, before the Commission can make a licensing decision on site preparation and the construction of a new nuclear facility to manage spent fuel.

Section 4 of the CINFR, Licence to Prepare Site, states that an application for a licence to prepare a site for a Class I nuclear facility shall contain the following information in addition to the information required by section 3:

(a) a description of the site evaluation process and of the investigations and preparatory work that have been and will be done on the site and in the surrounding area

(b) a description of the site's susceptibility to human activity and natural phenomena, including seismic events, tornadoes and floods

(c) the proposed program to determine the environmental baseline characteristics of the site and the surrounding area

(d) the proposed quality assurance program for the design of the nuclear facility

(e) the effects on the environment and the health and safety of persons that may result from the activity to be licensed, and the measures that will be taken to prevent or mitigate those effects

Other requirements are stipulated in section 3 of the GNSCR.

The review of the application focuses on determining whether the site characteristics that have an impact on health, safety, security and the environment have been identified; it also looks at whether these characteristics have been taken into account and ensures that they will also be considered in the design, operation and decommissioning of the proposed facility. The technical information gleaned from external events, site-specific characteristics and supporting assessments provides input into the design of the facility for the chosen site, which is submitted in the construction licence application.

Before issuing a licence to prepare a site, the Commission must be satisfied that the site preparation activities will be carried out in a manner that will satisfy all health, safety, security and environmental protection requirements.

G.3.1 Public information program

Paragraph 3(j) of the CINFR states that a licence application must contain details about the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed.

REGDOC-3.2.1, *Public Information and Disclosure* sets out the CNSC's requirements for protocols on public information and disclosure and the associated documentation as they relate to licensed activities. A program for public information includes a public disclosure protocol for events and developments that involve their facilities and/or activities. The document also provides guidance for licensees and licence applicants on fulfilling the regulatory requirements; it provides explanatory information, process and procedural guidance, and examples of good practices currently in use in the nuclear sector. This regulatory document applies to all uranium mines and mills and Class I nuclear facilities. It also applies to a Class II facility that is required to develop and implement a public information and disclosure program as a condition of its licence.

REGDOC-3.2.2, *Indigenous Engagement*, version 1.1 identifies requirements for CNSC licensees with respect to Indigenous engagement and provides guidance and information on conducting Indigenous engagement activities. This document applies to Class I nuclear facilities and uranium mines and mills when a licensee's application has the potential to raise the Crown's duty to consult.

G.3.2 International arrangements with other Contracting Parties

While the Canadian regulatory regime does not obligate the proponents of domestic nuclear facilities that may affect the U.S. to consult with foreign jurisdictions or with their public about the proposed siting of such facilities, there are numerous arrangements in place to ensure cooperation.

The CNSC and the U.S. Nuclear Regulatory Commission have practised cooperation and consultation since the 1950s. On August 15, 1996, the two countries entered into a bilateral administrative arrangement for cooperation and the exchange of information on nuclear regulatory matters. As part of this agreement, both countries committed to exchanging certain technical information related to regulating 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 or the U.S.

Canada and the U.S. are signatories to the *International Convention on Environmental Impact Assessment in a Transboundary Context* (Espoo, Finland, February 25, 1991). The Convention, which came into force on September 10, 1997, obliges signatories to:

- take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impacts of proposed activities (including site preparation, construction and operation of nuclear installations)
- ensure that affected parties are notified of the proposed installation
- give the public in areas likely to be affected an opportunity to participate in relevant environmental impact assessment procedures for the proposed activities, and ensure 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 information available about its possible transboundary impact

Of note, the governments of Canada and the U.S., 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 set out in the *Great Lakes Water Quality Agreement* (1978), as amended by the protocol signed on September 7, 2012.

In addition, Canada's new IAA recognizes the importance of meaningful public participation; it requires that opportunities be provided through the assessment process, in accordance with legislation, regulations, policies and guidance established by the agency (please refer to section K.2.2 for more information).

Every year, the NWMO, which is responsible for implementing Canada's plan for the long-term management of its used nuclear fuel, publishes a five-year strategic plan and welcomes public input to help shape its work going forward. The implementation plan is a living document that is regularly assessed and strengthened through public feedback, advances in science and technology, insight from Indigenous knowledge, changes in societal values and evolving public policy.

G.4 Design and construction of facilities (Article 7)

This section addresses the obligations under Article 7 of the Joint Convention.

ARTICLE 7. DESIGN AND CONSTRUCTION OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;

(iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

A licence to construct allows a licensee to construct, commission and operate some components of the facility (e.g., security systems). Some commissioning activities may be allowed in order to demonstrate that the facility has been constructed in accordance with the approved design and that the structures, systems and components important to safety are functioning as intended.

An application for a licence to construct contains more detailed information about the design of the facility and the supporting safety case. The applicant must demonstrate that the proposed design of the facility conforms to regulatory requirements and that it will allow for safe operation on the designated site over the proposed life of the facility.

The applicant is expected to address all follow-up activities identified during the impact assessment, including those relevant to the design, construction and commissioning stages, and verify that any outstanding issues from the site preparation stage have been resolved.

Section 5 of the CINFR, Licence to Construct, states that an application for a licence to construct a Class I nuclear facility shall contain the following information in addition to the information required by section 3:

(a) a description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are taken into account in the design

(b) a description of the environmental baseline characteristics of the site and the surrounding area

(c) the proposed construction program, including its schedule

(d) a description of the structures proposed to be built as part of the nuclear facility, including their design and their design characteristics

(e) a description of the systems and equipment proposed to be installed at the nuclear facility, including their design and their design operating conditions

(f) a preliminary safety analysis report demonstrating the adequacy of the design of the nuclear facility

(g) the proposed quality assurance program for the design of the nuclear facility

(h) the proposed measures to facilitate Canada’s compliance with any applicable safeguards agreement

(i) the effects on the environment and the health and safety of persons that may result from the construction, operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects

(j) 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

(k) the proposed measures to control releases of nuclear substances and hazardous substances into the environment

(l) the proposed program and schedule for recruiting, training and qualifying workers in respect of the operation and maintenance of the nuclear facility

(m) a description of any proposed full-scope training simulator for the nuclear facility

Other information is required, as stipulated in section 3 of the GNSCR, including paragraph 3(d), "the proposed management system for the activity to be licensed, including measures to promote and support safety culture."

The review of the application focuses on determining whether the proposed design, the safety analysis and other required information meet regulatory requirements. The evaluation involves rigorous engineering and scientific analysis, taking into consideration national and international standards and best practices in nuclear facility design and operation. The CNSC also verifies that any outstanding issues from the site preparation stage have been resolved. The protective zone established for the licence to prepare the site is also confirmed during the review of the licence to construct.

For the latter part of construction, regulatory attention focuses on the commissioning program and associated activities to demonstrate to the extent practicable that all the structures, systems and components have been built and function as intended.

Sometimes, a single application for a licence to prepare site and to construct is submitted to the CNSC for combined approval.

G.5 Assessment of safety of facilities (Article 8)

This section addresses the obligations under Article 8 of the Joint Convention.

ARTICLE 8. ASSESSMENT OF SAFETY OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

1. before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;
2. before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

See sections G.3, G.4 and G.6 for the regulatory requirements for conducting a safety analysis in the siting, design, and operation phases of a Class I nuclear facility.

REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-term Safety of Radioactive Waste Management* describes approaches for assessing the potential long-term impact that radioactive waste storage and disposal methods may have on the environment and on the health and safety of people. This document addresses:

- covering long-term care and maintenance

- setting post-decommissioning objectives
- establishing assessment criteria
- creating assessment strategies and level of detail required
- selecting time frames and defining assessment scenarios
- identifying receptors and critical groups
- interpreting assessment results

This document addresses the assessment of long-term safety to support licence applications, and includes discussion of assessment methodologies, structures and approaches.

G.6 Operation of facilities (Article 9)

This section addresses the obligations under Article 9 of the Joint Convention.

ARTICLE 9. OPERATION OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;

(iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;

(iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility;

(v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

(vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

A licence to operate will enable a licensee to complete final commissioning activities and to operate the facility. Commissioning activities provide assurance that the facility has been properly designed and constructed, and it is ready for safe operation.

Section 6 of the CINFR, Licence to Operate, states that an application for a licence to operate a Class I nuclear facility shall contain the following information, in addition to the information required in section 3:

(a) a description of the structures at the nuclear facility, including their design and their design operating conditions

(b) a description of the systems and equipment at the nuclear facility, including their design and their design operating conditions

(c) a final safety analysis report demonstrating the adequacy of the design of the nuclear facility

(d) the proposed measures, policies, methods and procedures for operating and maintaining the nuclear facility

(e) the proposed procedures for handling, storing, loading and transporting nuclear substances and hazardous substances

(f) the proposed measures to facilitate Canada's compliance with any applicable safeguards agreement

(g) the proposed commissioning program for the systems and equipment that will be used at the nuclear facility

(h) the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects

(i) the proposed locations 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

(j) the proposed measures to control releases of nuclear substances and hazardous substances into the environment

(k) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security, including measures to

    (i) assist off-site authorities in planning and preparing to limit the effects of an accidental release

    (ii) notify off-site authorities of an accidental release or the imminence of an accidental release

    (iii) report information to off-site authorities during and after an accidental release

    (iv) assist off-site authorities in dealing with the effects of an accidental release

    (v) test the implementation of the measures to prevent or mitigate the effects of an accidental release

(l) the proposed measures to prevent acts of sabotage or attempted sabotage at the nuclear facility, including measures to alert the licensee to such acts

(m) the proposed responsibilities of and qualification requirements and training program for workers, including the procedures for the requalification of workers

(n) the results that have been achieved in implementing the program for recruiting, training and qualifying workers in respect of the operation and maintenance of the nuclear facility

Other requirements are stipulated in section 3 of the GNSCR.

The first licence to operate the facility is typically issued with conditions (hold points). All of the relevant commissioning tests completed must be satisfactory before the hold points can be removed.

G.6.1 Maintenance, testing, examination and inspection

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* states that the WMF shall be designed to facilitate the inspection and maintenance of the structures, systems and components of the facility with the minimum radiation exposure to the workers in accordance with the ALARA principle (clause 7.12.1). Further, this standard states that the design of the WMF shall allow for the monitoring of interior cavities within structures (clause 7.12.2).

CSA Group standard N292.1, *Wet storage of irradiated fuel and other radioactive materials* states that a maintenance program for the wet storage bay shall be prepared, implemented, and maintained to address predictive and preventative elements, including: cleaning requirements for the wet storage bay floors and walls; and examining, inspecting, and testing the wet storage system (clause 6.3.3.1). Further, this standard states that for Nuclear Power Plants (NPPs), in-service examination of the civil structures of the wet storage systems of NPPs shall be in accordance with the requirements of CSA standard N291, *Requirements for nuclear safety-related structures*. Finally, Clause 6.3.3.3 states that the frequency of maintenance, testing, examination, and inspection of safety-related systems and components shall be such that the level of reliability and effectiveness remains in accordance with the requirements throughout the operating life of the wet storage system (Clause 6.3.3.3).

CSA Group standard N292.2, *Interim dry storage of irradiated fuel* states that the licensee shall prepare a program of periodic maintenance, post maintenance testing, examination, and inspection of the dry storage system to prevent the degradation of its structures, equipment, systems, and related components (Clause 6.5.2.1). Further, this standard states that the frequency of maintenance, testing, examination, and inspection of safety systems and safety-related systems and components shall be such that the level of reliability and effectiveness remains in accordance with the design assumptions and intent throughout the life of the storage system (Clause 6.5.2.2).

G.6.2 Reportable events

Regulatory requirements regarding reportable events and the submission of immediate preliminary reports and 21 day full reports, including what situations require reporting and the information that shall be contained in the reports, are set out in the following sections of the NSCA and its associated regulations:

- section 45 of the NSCA
- sections 29 and 30 of the GNSCR
- section 38 of the NSRDR
- sections 32, 37, 38, 40 and 41 of the PTNSR, 2015
- section 16 of the RPR

REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants, Version 2* incorporates and expands upon requirements found in the NSCA and the regulations made under the NSCA for reports, notifications and filing of specific records to the CNSC by licensees of NPPs (which includes the spent fuel bays).

REGDOC-3.1.2, *Reporting Requirements, Volume I: Non-Power Reactor Class I Facilities and Uranium Mines and Mills* incorporates and clarifies requirements found in the NSCA and the regulations made under the NSCA for reporting. This document presents the types of reports and the applicable time frame for reporting. Licensees are required to report to the CNSC regarding situations, events and dangerous occurrences that may require short-term action by the CNSC.

G.6.3 Operating experience

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* states that processes should be put in place to allow for the feedback from and analysis of operating experience, including: initiating events, accident precursors, near misses, accidents and unauthorized acts (Clause 4.10.1.5). Further, this standard states that in order to continually improve and learn from ongoing research and development activities, gathering research and operating experience should be done on an ongoing basis (Clause 7.4.6).

CSA Group standard N292.1, *Wet storage of irradiated fuel and other radioactive materials* states that accident prevention and mitigation shall be achieved through the use of operating experience (Clause 5.2.2.2(e)).

G.6.4 Decommissioning plans

The regulatory requirement to maintain a decommissioning plan is a specific licence condition that is in all licences for operational facilities that manage spent fuel.

Regulatory Guide G-219, *Decommissioning Planning for Licensed Activities* (to be superseded by REGDOC-2.11.2, *Decommissioning*, pending approval from the Commission) provides guidance regarding the preparation of decommissioning plans for activities licensed by the CNSC in Canada.

The CNSC requires that the planning for decommissioning be completed in two phases.

The PDP is filed with the CNSC as early as possible in the lifecycle of the activity or facility. Specific requirements for planning the decommissioning of Class I nuclear facilities are set out in the CINFR. The preliminary plan documents: the preferred decommissioning strategy and end-state objectives, as appropriate; the major decontamination, disassembly and remediation steps; the approximate quantities and types of waste generated; an overview of the principal hazards and protection strategies; a cost estimate; and the method(s) used to guarantee financing for the decommissioning activities.

The initial PDP is based largely on predicted types and quantities of contamination that are expected to accumulate in different parts of a facility under normal operating conditions. During the operations phase, these predictions should be monitored and revised as necessary using actual survey data. Periodic inspections and sampling should be conducted in known or potentially contaminated areas. Similarly, all unplanned events and accidents that could lead to contamination should be thoroughly investigated and sample analyses carefully documented. The PDP should be reviewed and updated in light of operational experience and technological advances. During the facility operation stage, the CNSC may inspect the facility's operational records and PDP to ensure that the plan and financial guarantee program remain consistent with the projected scale of the decommissioning effort.

The DDP is filed with the CNSC for appropriate licensing action before decommissioning activities begin. It normally refines the preliminary plan by adding procedural and organizational details. Once approved by the CNSC, the detailed plan is incorporated into a licence authorizing the decommissioning.

Section 6.1 of G-219 provides guidance regarding the PDP, and section 6.2 provides guidance on the DDP.

CSA Group standard N294, *Decommissioning of facilities containing nuclear substances* was developed to consolidate and incorporate into one document the principles of decommissioning, the Canadian and international decommissioning experience and international guidance that could be applied to the decommissioning of all facilities and sites where nuclear substances have been used or stored. The standard is consistent with and supplements current Canadian policy and regulatory guidance. This standard applies to the decommissioning of nuclear facilities and other locations where nuclear substances are managed, possessed or stored.

G.7 Disposal of spent fuel (Article 10)

This section addresses the obligations under Article 10 of the Joint Convention.

ARTICLE 10. DISPOSAL OF SPENT FUEL

If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.

At the end of the useful life of a facility, the licensee may decide to apply for a licence to decommission. The PDP has been reviewed and updated throughout the lifecycle of the facility.

Section 7 of the CINFR, Licence to Decommission, states that an application for a licence to decommission a Class I nuclear facility shall contain the following information, in addition to the information required by section 3:

(a) a description of and the proposed schedule for the decommissioning, including the proposed starting date and the expected completion date of the decommissioning and the rationale for the schedule

(b) the nuclear substances, hazardous substances, land, buildings, structures, systems and equipment that will be affected by the decommissioning

(c) the proposed measures, methods and procedures for carrying on the decommissioning

(d) the proposed measures to facilitate Canada’s compliance with any applicable safeguards agreement

(e) the nature and extent of any radioactive contamination of the nuclear facility

(f) the effects on the environment and the health and safety of persons that may result from the decommissioning, and the measures that will be taken to prevent or mitigate those effects

(g) 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

(h) the proposed measures to control releases of nuclear substances and hazardous substances into the environment

(i) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security, including an emergency response plan

(j) the proposed qualification requirements and training program for workers

(k) a description of the planned state of the site on completion of the decommissioning

Other requirements are stipulated in section 3 of the GNSCR.

The licensee’s responsibility can be terminated when long-term monitoring confirms the successful completion of decommissioning. The Commission may issue a licence to abandon, under which the site would be released unconditionally, or an exemption from licensing which would end the licensee’s responsibility for the site and transfer responsibility for regulatory oversight or institutional control from the CNSC to the province or territory, if applicable. Information required to support the transfer agreement includes:

- the results of decommissioning work
- the results of environmental monitoring programs
- a description of requirement for long-term institutional controls
- a program to inform the public about the effects the transfer of responsibility has on the health and safety of the public and on the environment

G.7.1 History of the disposal of spent fuel in Canada

Canada does not currently have a disposal facility for spent fuel. Any proposal for the site preparation, construction, operation, decommissioning (closure and post-closure) and abandonment (i.e., release from CNSC licensing) of a disposal facility, such as a DGR, must satisfy the requirements of the NSCA and its regulations. The CNSC can make a DGR licensing decision only after a positive decision is made on the impact assessment.

Since the early days of the CANDU program, several concepts for the long-term management of spent fuel 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 the responsibility of developing a concept for placing spent fuel in a deep underground repository within the plutonic rock of the Canadian Shield. Ontario Hydro (now OPG) was assigned the responsibility of studying and developing technology to store and transport spent fuel. It was also designated as a source of 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 its environmental impact statement on the DGR concept for review by the Seaborn Panel, a federal environmental assessment panel. This review included input from government agencies, non-governmental organizations and the general public. Public hearings were conducted by the Seaborn Panel in 1996 and 1997. The *Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel* was submitted to the Government of Canada in 1998. It concluded that a DGR in crystalline rock was technically feasible, but "until broad public acceptance of a nuclear fuel waste management approach has been achieved, the search for a specific site should not proceed."

It also 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 in Canada, as set out in the CEAA, 1998.

The Government of Canada responded to the Seaborn Panel report later in 1998; it explained the steps it would require the producers and owners of spent fuel in Canada to take, and it announced the formation of the NWMO by the nuclear utilities. In 2002, the Parliament of Canada passed the *Nuclear Fuel Waste Act* (NFWA).

Under the NFWA, the nuclear energy corporations were to establish a waste management organization, the purpose of which would be to study and propose approaches for managing spent fuel, recommend an approach and 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 as well as the ethical, social and economic considerations associated with each approach. It was also to include specific economic regions where implementation would take place and plans for implementing each approach in the study. The waste management organization was to consult the general public, and in particular Indigenous peoples, on each approach.

The waste management organization was also required to create an advisory council whose members would bring a broad range of scientific and technical disciplines. The council's expertise should include public affairs, other social sciences as needed, traditional Indigenous knowledge and representatives of the local and regional governments and Indigenous communities affected by the selected approach because of their geographic locations.

Within three years after the NFWA came into force, the waste management organization was to submit a study that sets out proposed approaches for managing spent fuel and its final recommendation. The study would 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 was tasked with overseeing how the waste management organization implements the management approach and ensuring 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 five subsequent years. Canada's plan has now moved forward within this legislative framework.

Pursuant to the NFWA, the NWMO was established in 2002 by the nuclear energy corporations of OPG, H-Q and NB Power. Upon its establishment, the NWMO's first mandate was to work collaboratively with Canadians to develop 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 and consulted extensively across the country.

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 DGR built in a suitable rock formation. It provides for the continuous monitoring of spent fuel and offers the potential to retrieve the fuel 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.

Implementing the project at a flexible pace and manner allows for phased decision making, each step supported by continuous learning, research and development, and public engagement. An informed willing community will be sought to host the centralized facilities. The 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, Indigenous communities, non-governmental organizations, industry and others.

On June 14, 2007, following a review of the NWMO's study *Choosing a Way Forward*, the Government of Canada announced it had selected the APM approach for the long-term management of spent fuel in Canada. Based on this government decision, the NWMO assumed responsibility for implementing the APM approach. Information about the current status of the APM initiative can be found in section K.2.4. 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 and to the public. In March 2020, the NWMO submitted its fourth triennial report to the minister, as required by the NFWA.

To support financing of the plan, waste owners continue to make regular deposits into 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; this funding formula was later approved in 2009.

The NWMO will be required to obtain licences from the CNSC for the site preparation, construction, operation, decommissioning and abandonment (release from CNSC licensing) of the repository facilities.

SECTION H

Safety of radioactive waste management

Section H – Safety of Radioactive Waste Management

H.1 General safety requirements (Article 11)

This section addresses the obligations under Article 11 of the Joint Convention.

ARTICLE 11. GENERAL SAFETY REQUIREMENTS

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management, individuals, society and the environment are adequately protected against radiological and other hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

(i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;

(ii) ensure that the generation of radioactive waste is kept to the minimum practicable;

(iii) take into account interdependencies among the different steps in radioactive waste management;

(iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;

(vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generations;

(vii) aim to avoid imposing undue burdens on future generations.

See section G.1.

H.2 Existing facilities and past practices (Article 12)

This section addresses the obligations under Article 12 of the Joint Convention.

ARTICLE 12. EXISTING FACILITIES AND PAST PRACTICES

Each Contracting Party shall in due course take the appropriate steps to review:

(i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;

(ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

The NSCA and its regulations was ensuring the safety of the radioactive WMFs, locations and sites that existed when the Joint Convention entered into force in Canada, as all facilities, locations and sites were under a CNSC licence.

H.2.1 Past practices

Legacy radioactive wastes at AECL sites (which are managed by CNL) 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 CNL on behalf of AECL. The liabilities include spent research reactor fuel and intermediate-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 to deal with liabilities at AECL sites.

In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office within AECL as the federal agent for the cleanup and management of historic LLW in Canada. Canada's historic LLW 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. 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 PHAI.

Upon implementation of the GoCo model in 2015, federal responsibility for managing and discharging the Government of Canada's radioactive waste liabilities (including legacy and historic LLW) was transferred from NRCan to AECL. As a result, the Nuclear Legacy Liabilities Program came to an end and the activities associated with the program were included as part of CNL's scope of work under the GoCo arrangement.

When remedial actions are required at uranium mine and mill tailings facilities where the owner no longer exists, the federal and provincial governments ensure the sites are safely decommissioned. In Ontario, home of the former Elliot Lake uranium mining complex, the governments of Canada and Ontario signed a memorandum of understanding in 1996 that outlined their respective roles in the management of abandoned uranium mine and mill tailings. In keeping with Canada's *Radioactive Waste Policy Framework*, best efforts are made to identify the uranium producer or property owner. Where such an owner cannot be identified, the governments have agreed to the share costs associated with any necessary remediation. To date, these arrangements have not been necessary, as all legacy mining sites in Ontario have owners who are complying with their obligations and fulfilling their responsibilities.

H.3 Siting of proposed facilities (Article 13)

This section addresses the obligations under Article 13 of the Joint Convention.

ARTICLE 13. SITING OF PROPOSED FACILITIES

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:
   - (i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;
   - (ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;
   - (iii) to make information on the safety of such a facility available to members of the public;
   - (iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.
2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

For information regarding Class I radioactive WMFs, see section G.3.

H.4 Design and construction of facilities (Article 14)

This section addresses the obligations under Article 14 of the Joint Convention.

ARTICLE 14. DESIGN AND CONSTRUCTION OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;

(ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;

(iii) at the design stage, technical provisions for the closure of a disposal facility are prepared;

(iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

For information regarding Class I radioactive WMFs, see section G.4.

H.5 Assessment of safety of facilities (Article 15)

This section addresses the obligations under Article 15 of the Joint Convention.

ARTICLE 15. ASSESSMENT OF SAFETY OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

(i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;

(ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;

(iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

For information regarding Class I radioactive WMFs, see section G.5.

H.6 Operation of facilities (Article 16)

This section addresses the obligations under Article 16 of the Joint Convention.

ARTICLE 16. OPERATION OF FACILITIES

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;

(iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;

(iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;

(v) procedures for characterization and segregation of radioactive waste are applied;

(vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;

(vii) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;

(viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;

(ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

For information regarding Class I radioactive WMFs, see section G.6.

H.6.1 Maintenance, testing, examination and inspection

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* states that the WMF shall be designed to facilitate the inspection and maintenance of the structures, systems and components of the facility with minimum radiation exposure to the workers in keeping with the ALARA principle (clause 7.12.1). Further, this standard states that the design of the WMF shall allow for the monitoring of interior cavities within structures (clause 7.12.2).

H.6.2 Reportable events

Regulatory requirements regarding reportable events and the submission of immediate preliminary reports and 21-day full reports, including what situations need to be reported and what information needs to be contained in the reports, are set out in the following sections of the NSCA and its regulations:

- Section 45 of the NSCA
- Sections 29 and 30 of the GNSCR
- Section 38 of the NSRDR

- Sections 32, 37, 38, 40 and 41 of the PTNSR, 2015
- Section 16 of the PRP

H.6.3 Operating experience

CSA Group standard N292.0, *General principles for the management of radioactive waste and irradiated fuel* states that processes should be put in place to allow for the feedback from and analysis of operating experience, including: initiating events, accident precursors, near misses, accidents and unauthorized acts (clause 4.10.1.5). Further, this standard states that in order to continually improve and learn from ongoing research and development activities, gathering research and operating experience should be done on an ongoing basis (clause 7.4.6).

H.6.4 Decommissioning plans

For information regarding Class I radioactive WMFs, see section G.6.4

H.7 Institutional measures after closure (Article 17)

This section addresses the obligations under Article 17 of the Joint Convention.

ARTICLE 17. INSTITUTIONAL MEASURES AFTER CLOSURE

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility:

(i) records of the location, design and inventory of that facility required by the regulatory body are preserved;

(ii) active or passive institutional controls such as monitoring or access restrictions are carried out, if required; and

(iii) if, during any period of active institutional control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.

There are currently no disposal facilities for radioactive waste in Canada; however, decommissioned TMFs require long-term institutional controls. These will vary from minimal (after the current generation of in-pit TMFs, designed for future decommissioning, are closed) to ongoing monitoring and maintenance programs at older sites where tailings have been deposited in surface facilities.

Release from CNSC regulatory control occurs when the licensee has successfully decommissioned the facility and restored the site to a state that is suitable for future use (e.g., green field or brown field [industrial]). If unrestricted release has yet to be achieved (i.e., due to long-term presence of nuclear substances, contaminated systems, components or structures), perpetual licensing from the CNSC may be required, unless the risks are very minimal and oversight by another regulatory or governmental body allows the Commission to exempt the site indefinitely from CNSC licensing (determined case by case).

The CNSC requires licensees to apply for a licence to abandon or an exemption from licensing, after successful decommissioning. This submission must be supported by reports on the results of the decommissioning and site restoration activities, as well as the results of the radiological and environmental monitoring to demonstrate that the site no longer needs to be licensed under the NSCA.

H.7.1 Exemption

In order to be granted an exemption, the licensee must present a safety case that demonstrates long-term safety. The safety case must cite engineering design and barriers and/or the proposed 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, the costs and consequences of failure of the institutional controls, and the reliability of the institutional controls. REGDOC-2.11.1, *Waste Management, Volume III: 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. The regulatory document describes typical ways to assess the impacts that radioactive waste storage and disposal methods have on the environment and the health and safety of people.

H.7.2 Licence to abandon

In reviewing a submission for a licence to abandon, the CNSC must be satisfied that abandoning the site, nuclear substance, prescribed equipment or information does not pose an unreasonable risk to the environment, the health and safety of persons or national security. The abandonment must also not result in a failure to comply with Canada's international obligations.

Section 8 of the CINFR, Licence to Abandon, states that an application for a licence to abandon a Class I nuclear facility shall contain the following information:

(a) the results of the decommissioning

(b) the results of the environmental monitoring programs

Other requirements are stipulated in sections 3 and 4 of the GNSCR.

H.7.3 Records

Section 27 of the GNSCR states, "every licensee shall keep a record of all information relating to the licence that is submitted by the licensee to the Commission." Subsection 28(1) states, "every person who is required to keep a record by the Act, the regulations made under the Act or a licence shall retain the record for the period specified in the applicable regulations made under the Act, or if no period is specified in the regulations, for the period ending one year after the expiry of the licence that authorized the activity in respect of which the records are kept."

Under subsection 28(2), no person shall dispose of a record referred to in the Act, the regulations made under the Act or a licence unless the person is no longer required to keep the record by the Act, the regulations made under the Act or the licence and has notified the Commission of the date of disposal and the nature of the record at least 90 days before the date of disposal. Finally, subsection 28(3) states, "a person who notifies the Commission in accordance with subsection (2) shall file the record, or a copy of the record, with the Commission at its request."

H.7.4 Active and passive institutional controls

REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* defines institutional controls as the control of residual risks at a site after it has been decommissioned.

A submission from a licence applicant should identify the role that institutional controls play in waste management system safety, and how that role is taken into account in the safety assessment. Institutional controls can include active measures that require on-site activities such as monitoring, surveillance and maintenance, and passive measures that do not require activities on the site, such as land use restrictions and markers. Institutional controls may be part of the design of a radioactive waste management system as a necessary safety measure or to enhance confidence in the system.

Long-term management options should not rely on long-term institutional controls as a safety feature unless they are absolutely necessary. However, for some waste types in certain site-specific situations, there may be no realistic alternative to long-term institutional controls as a safety feature, even after optimizing the facility design.

As a result of the uncertainties associated with future human activities and the evolution and stability of societies, current international best practice generally limits the reliance on institutional controls as a safety feature to a few hundred years. However, it is recognized that in spite of design optimization, some facilities, such as surface impoundments for tailings, may need to rely on institutional controls for a more extended period of time. Any intention of relying on institutional controls to ensure long-term safety should be documented and justified in the long-term assessment.

REGDOC-2.11.1, *Waste Management, Volume III* contains requirements and guidance for institutional controls.

SECTION I

Transbounday movement

Section I – Transboundary Movement

I.1 Transboundary movement (Article 27)

This section addresses the obligations under Article 27 of the Joint Convention.

ARTICLE 27. TRANSBOUNDARY MOVEMENT

1. Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments:

   In so doing:

   (i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;

   (ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized;

   (iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

   (iv) a Contracting Party which is a State of origin shall authorize a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

   (v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

2. A Contracting party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal.

3. Nothing in this Convention prejudices or affects:

   (i) The exercise, by ships and aircrafts of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

   (ii) Rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;

   (iii) The right of a Contracting Party to export its spent fuel for reprocessing;

   (iv) Rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

I.1.1 Introduction

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

- NSCA and the associated NNIECR and GNSCR
- CEPA and the associated *Export and Import of Hazardous Wastes Regulations*
- *Export and Import Permits Act*
- *United Nations Act*

The export of Category 1 and Category 2 radioactive sources (as identified in table 1, annex 1 of the IAEA *Code of Conduct on the Safety and Security of Radioactive Sealed Sources*) requires a transaction-specific authorization issued pursuant to the NSCA. For authorization to export Category 3 and below radioactive sealed sources and authorization to import, use, abandon, produce, manage, store or dispose of a radioactive sealed source, applicants must provide the information required under section 3 of the GNSCR and section 3 of the NSRDR. To import and export controlled nuclear substances, separate licence requirements are prescribed under the NNIECR. Additional requirements for persons wishing to apply for a licence to transport nuclear substances are prescribed in the PTNSR, 2015.

I.1.2 Nuclear substances

Under the NSCA, the CNSC regulates the import and export of nuclear substances (as well as prescribed equipment and prescribed information). The schedule to the NNIECR identifies the "controlled nuclear substances" that require export and import authorization from the CNSC.

The following are considered controlled nuclear substances and require transaction-specific risk assessments and 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)

Global Affairs Canada regulates the export of certain types of nuclear substances under the *Export and Import Permits Act*.

The export of a radioactive sealed source of the first 16 radionuclides identified by the IAEA as a Category 1 or Category 2 radioactive sealed source (table 1, annex 1 of the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources*) requires authorization by the CNSC under the NSCA and the GNSCR.

I.1.3 Exporting state

As stated above, the CNSC and Global Affairs Canada both regulate the export of the controlled nuclear substances listed in section I.1.2. Although the regulations that both organizations use are based on the Nuclear Suppliers Group guidelines (parts 1 and 2), the regulations administered by the CNSC are slightly broader in scope and coverage, pursuant to its mandate.

In keeping with Canadian nuclear non-proliferation policy, exports of nuclear substances, equipment and information for nuclear use can go forward only to countries with which Canada has established a nuclear cooperation agreement (NCA). These treaty level agreements establish reciprocal obligations to ensure, among other things, that nuclear items 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.1.4 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 subsection I.1.2) 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/export licence or of the licensing controls under the NSCA.

I.1.5 Destinations 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 into Canadian federal law through the CEPA.

SECTION J

Disused sealed sources

Section J – Disused Sealed Sources

J.1 Disused sealed sources (Article 28)

This section addresses the obligations under Article 28 of the Joint Convention.

ARTICLE 28. DISUSED SEALED SOURCES

1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.
2. A Contracting Party shall allow for reentry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

J.1.1 Introduction

Radioactive nuclear substances in sealed or unsealed source form have many industrial, medical, commercial, academic and research applications. A wide variety of organizations makes use of nuclear substances, including universities, hospitals, industrial facilities and government departments.

Although most radioactive sealed sources are physically small (see figure J.1), their radioactivity may range from tens to billions of becquerels. When radioactive sealed sources are no longer required, or have decayed beyond their useful life and are not intended to be used for the practice for which authorizations have been granted, they become disused radioactive sealed sources. They may then be returned to the manufacturer, in Canada or the country of origin. They may also be sent to a licensed waste management facility (WMF). If a radioactive sealed source has decayed below its exemption quantity or its clearance level as defined in the NSRDR, it may be released from CNSC regulatory control, pursuant to subsection 5.1 of the NSRDR. Nuclear substances that remain within regulatory control must be managed with consideration for all existing regulations.

Figure J.1: Sealed source assembly used for industrial radiography

J.1.2 Regulatory framework for radioactive sealed sources

Under 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" means 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.

Sealed sources may be remanufactured or reprocessed by licensees for future use if doing so is within the scope of their licensed activities.

J.1.3 Radioactive sealed sources used in Canada

Through Canada's regulatory control program, the CNSC regulates activities involving radioactive sealed sources. Each licence specifies the isotope, the maximum activity (in Bq) of each radioactive nuclear substance, the maximum activity per sealed source and the regulated activities the licensee can conduct under that licence.

J.1.3.1 Safety of radioactive sealed sources

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

Licensees are required to report their inventory of sealed sources and radiation devices to the CNSC annually for Category 3, 4 and 5 sources, and more frequently for Category 1 and 2 sources. Furthermore, CNSC inspectors physically verify a licensee's inventory of sealed sources during inspections to ensure it is keeping accurate records of the sources in its possession and that it knows the whereabouts of all sources in its possession.

Canada's regulatory framework holds licensees responsible for the recovery and safety of lost, stolen and found radioactive sources. Radioactive sources that become disused while under regulatory control must be managed in consideration of all existing regulatory requirements and may be returned to the manufacturer in Canada or in the country of origin. They may also be sent to a licensed WMF.

The CNSC has internal procedures to ensure that owners of found radioactive sources not under proper regulatory control and not reported lost or stolen by licensees are identified by reviewing the National Sealed Source Registry (NSSR) data. If a radioactive source is deemed to be orphaned, CNSC staff know and understand the actions to be taken to bring the source under regulatory control. In extraordinary circumstances, the CNSC will take possession of orphaned sealed sources and radiation devices, and arrange for their proper disposal. When an owner cannot be found, the financial guarantee insurance program can be accessed to address the cost of disposal. The CNSC's internal procedures cover all steps in the management of a source, from discovery to disposal.

According to the regulations, sealed sources that are lost or found must be reported to the CNSC. Licensees that become bankrupt must also report this to the CNSC. All reports are kept in the Events Information Tracking System, an internal events management database, so that the CNSC can respond appropriately. In March 2020, the CNSC published a regulatory document, REGDOC-3.1.3, *Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices*, that clarifies the reporting requirements, provides details on the events, situation and dangerous occurrences that must be reported to the CNSC, and provides guidance on the information that must submitted with the different report types.

The Historic Artefact Recovery Program, operated by CNL, provides technical advice and assistance. It helps identify radioactive artefacts found on private and public properties across Canada. When required, the artefacts are transported to a CNSC-licensed long-term waste management storage facility.

J.1.3.2 Disposal of radioactive sealed sources in Canada

A radioactive sealed source may only be transferred in accordance with the conditions of a licence issued by the CNSC. For long-term management, radioactive sealed sources may be returned to the manufacturer in Canada or to their country of origin. In Canada, certain source manufacturers are recycling radioactive sealed sources as part of end-of-life management by either reusing decayed sources for other applications, re-encapsulating them or reprocessing them for other useful applications. The radioactive sealed sources may also be sent to a licensed radioactive WMF (such as the facility operated by CNL in Chalk River, Ontario) or transferred to a person licensed by the CNSC to possess the radioactive sealed sources. If a radioactive 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 subsection 5.1 of the NSRDR. Even though the radioactive sealed sources may no longer be under CNSC regulatory control, persons possessing them must still follow the applicable federal, provincial and/or municipal regulations.

J.1.3.3 National Sealed Source Registry and Sealed Source Tracking System

The Sealed Source Tracking System (SSTS) is a secure information management computer program used to populate the NSSR. It allows licensees to report the movements of radioactive sealed sources online throughout their complete lifecycle. The NSSR enables the CNSC to compile an accurate and secure inventory of radioactive sealed sources in Canada, starting with those that are classified as high risk. The information is as current as the reporting time frames required by the licence (e.g., reporting within two days of receipt and seven days in advance of any transfer for Category 1 and 2 sealed sources). These systems have been efficient and effective since their establishment in 2006. In 2017, the CNSC began posting data from the SSTS in machine readable format online as part of the Government of Canada's Open Government initiative.

Licensees may report their transactions through the online interface or by fax, email or regular mail. Since the initial launch of the online interface, the CNSC has redesigned it twice – once in December 2010 and once in 2012 – to keep up to date with the Government of Canada's secure system for online services. At those times, the system was also modified to comply with the Government of Canada's *Standard on Web Accessibility*. For more information on the standard, visit tbs-sct.gc.ca.

By the end of December 2019, the NSSR contained information about 134,591 radioactive sealed sources of all categories in Canada. This is a 43 percent increase over the number of sources in the NSSR at the end of December 2016. As of December 2019, the SSTS was tracking 6,904 Category 1 sources and 65,151 Category 2 sources. The remaining 62,536 sources in the NSSR were of Category 3, 4 and 5, which are subject to mandatory annual reporting.

J.1.3.4 Import and export of radioactive sealed sources

The enhancement of Canada's import and export control program for radioactive sealed 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* and the supplementary *Guidance on the Import and Export of Radioactive Sources*. Under the leadership of the IAEA, these documents were developed to improve the safety and security of radioactive sealed sources around the world. To support the IAEA and its efforts to develop a global regime to control and securely manage Category 1 and 2 radioactive sealed sources, the Government of Canada committed to meeting the provisions contained in the Code of Conduct and implementing an import and export control program, as outlined in the guidance.

As Canada's nuclear regulatory authority, the CNSC is responsible for controlling the import and export of radioactive sealed sources under the NSCA. Category 1 and 2 radioactive sealed sources are consistent with IAEA safety standard RS-G-1.9, *Categorization of Radioactive Sources*, which is based on the D-values that define how dangerous a source is. Category 1 and 2 radioactive sealed sources are defined as risk-significant radioactive sealed sources for the purpose of the CNSC import and export control program.

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

- achieve a high level of safety and security regarding Category 1 and 2 radioactive sealed sources
- reduce the likelihood of accidental harmful exposure to Category 1 and 2 radioactive sealed sources or the malicious use of such sources with intent 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

When considering an application to export Category 1 and 2 radioactive sealed sources, the CNSC must be satisfied that the importing state meets the expectations specified in paragraph 7 of the guidance regarding Category 1 sources, and paragraph 11 with respect to Category 2 sources. Where such assurances cannot be obtained and the CNSC determines that the importing state lacks the appropriate regulatory infrastructure to effectively manage the source in a safe and secure manner, the CNSC may consider denying the authorization of the export.

The CNSC import and export control program for Category 1 and 2 radioactive sealed sources is fully consistent with the provisions of the IAEA Code and Guidance. Canadian exporters are required to apply for and obtain an export licence from the CNSC prior to exporting Category 1 or 2 radioactive sealed sources. The program encompasses licensing, compliance, prior shipment notifications to importing states, post-shipment verifications, state-to-state requests for import consent to import Category 1 radioactive sealed sources, the establishment of bilateral administrative arrangements and the confirmation of receipt of radioactive sources as negotiated in several bilateral administrative arrangements.

To assist licensees and other states, the CNSC published REGDOC 2.13.2, *Import and Export, Version 2* which provides information on the CNSC import and export control program for Category 1 and 2 radioactive sealed sources. An application form and accompanying instructions for obtaining a licence to export Category 1 and 2 radioactive sealed sources are also available at nuclearsafety.gc.ca.

Since the program was implemented on April 1, 2007, the CNSC has received more than 2,820 applications to export Category 1 and 2 radioactive sealed sources to 100 countries and has controlled the export of more than 20.4 million TBq. Canada remains a global leader in the production and export of Category 1 cobalt-60 radioactive sealed sources, supplying approximately 95 percent of the global demand.

J.1.3.4.1 International harmonization through bilateral administrative arrangements

To assist in a harmonized international implementation of the IAEA Code and guidance, the CNSC has developed a model bilateral administrative arrangement with a core set of terms, definitions and procedures. The CNSC has established 12 bilateral administrative arrangements with its international counterparts to ensure that imports and exports of Category 1 and 2 radioactive sealed sources between Canada and these countries are conducted in a manner consistent with the Code and guidance. These arrangements assist in harmonizing regulatory approaches for authorizing imports and exports and facilitate the sharing of regulatory information related to such imports and exports.

Placing importance on bilateral arrangements to better harmonize controls internationally was regarded as a good practice in the IRRS review of the CNSC regulatory program in June 2009. The practice is also highly regarded internationally, as it helps other states implement the IAEA Code and guidance. The CNSC encourages the establishment and use of bilateral arrangements to assist in harmonizing regulatory approaches for authorizing imports and exports.

J.1.3.5 Radioactive sealed sources in the international community

The re-entry of previously exported radioactive sealed sources is permitted with an import licence (for controlled nuclear substances) or under a general import authorization licence issued by the CNSC. Manufacturers of sources in Canada continue to import spent sealed sources from other countries as part of the return-to-manufacturer principle.

J.1.3.6 Records

Paragraph 36(1)(a) of the NSRDR requires every licensee to keep a record of any nuclear substance in their possession. Records must include:

- the name, quantity, form and location of the nuclear substance
- the model and serial number of the source if the nuclear substance is a sealed source
- the model and serial number of the device if the nuclear substance is contained in a radiation device
- the quantity of the nuclear substance used
- the manner in which the nuclear substance was used

Paragraph 36(1)(c) of the NSRDR requires every licensee to keep a record of any transfer, receipt, disposal or abandonment of a nuclear substance. Records must 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 radioactive 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.1.3.7 Financial guarantee program for users of sealed sources and radiation devices

In 2015, the CNSC established a financial guarantee program for users of sealed sources and radiation devices. The CNSC has put in place an insurance program through a contract with a private institution. Under the program, the CNSC is the sole insured party and licensees pay an annual premium – currently equal to 0.410 percent of their total liability (up to a maximum liability of $1 million). The liability is calculated based on the number of sources over 50 MBq a licensee possesses, the number of radiation devices and Class II prescribed equipment a licensee possess, and the number of rooms where a licensee uses unsealed nuclear substances. The more sources and devices a licensee has in its inventory, whether they are in use or not, the higher their liability and the higher their annual premium will be. Licensees that choose not to participate in the program are required to establish an alternate financial guarantee that is acceptable to the Commission. This financial guarantee regime ensures adequate funds will be available for the safe termination of licensed activities in the event the licensee defaults. The financial guarantee ensures the ongoing regulatory control of radioactive sources and does not absolve the licensee of their obligations for the safe termination of licensed activities.

The CNSC has leveraged the financial guarantee insurance program on two occasions since its inception. In 2018, it was used to cover the disposal costs for a radiation device that was found at a scrapyard. The device’s ownership pre-dated the CNSC and was from a time when this particular device model was not licensed in Canada. The CNSC used the program a second time in 2019–20 to cover the costs of dismounting and disposing of eight fixed gauges that were abandoned when the licensee stopped operations and walked away from their location.

SECTION K

General efforts to improve safety

Section K – General Efforts to Improve Safety

K.1 Scope of the section

This section addresses the following:

- a summary of safety issues and planned future actions on those issues, and the challenges and suggestions identified at the Sixth Review Meeting (K.2)
- overarching issues identified at the Sixth Review Meeting (K.3)
- measures of international cooperation (K.4)
- international peer reviews (K.5)
- actions taken to enhance openness and transparency in implementing the obligations under the Joint Convention (K.6)

K.2 Safety issues and planned future actions

The following emerged from the Sixth Review Meeting as Canada's current priorities and planned measures to improve safety:

1. modernization of the waste and decommissioning regulatory framework (K.2.1)
2. implementation of the IAA (K.2.2)
3. decommissioning and remediation of AECL sites (under the management of CNL) (K.2.3)
   - identified as a challenge at the Sixth Review Meeting
4. long-term management of spent fuel and the identification of an acceptable site in a willing host community for a spent fuel repository (K.2.4)
   - identified as a challenge at the Sixth Review Meeting
5. OPG's deep geologic repository for its L&ILW (K.2.5)
6. discussion about an integrated strategy by Canada's radioactive waste owners (AECL, OPG, H-Q, NB Power) under the Radioactive Waste Leadership Forum (RWLF) (K.2.6)
   - identified as a suggestion at the Sixth Review Meeting

K.2.1 Modernize the waste and decommissioning regulatory framework

The CNSC is committed to maintaining a waste management and decommissioning regulatory framework that is modern and aligned with national and international standards and best practices.

In 2016, CNSC staff issued discussion paper DIS-16-03, *Radioactive Waste Management and Decommissioning* to solicit feedback regarding the CNSC's regulatory framework for waste management and decommissioning. Following this consultation, CNSC staff codified the existing regulatory requirements and guidance, and developed new draft regulatory documents that built on previous publications, operational experience, and national and international guidance and best practices, while taking the Canadian context into account.

As part of the development of these draft regulatory documents, CNSC staff extensively reviewed the applicable international safety standards and publications. Through this work, staff ensured that the CNSC regulatory framework is aligned with international guidance and best practices, as well as Government of Canada policies.

CNSC staff are currently in the process of completing the following five regulatory documents on waste management and decommissioning:

- REGDOC-1.2.1, *Guidance on Deep Geological Repository Site Characterization*
- REGDOC-2.11.1, *Waste Management, Volume I: Management of Radioactive Waste*
- REGDOC-2.11.1, *Waste Management, Volume III: Safety Case for the Disposal of Radioactive Waste, Version 2*
- REGDOC-2.11.2, *Decommissioning*
- REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*

The purpose of these draft regulatory documents is to provide requirements and guidance to ensure that radioactive waste is safely managed and disposed of, decommissioning is planned and executed safely, and a fund for decommissioning is established and maintained. These regulatory documents are complemented by CSA Group standards which together set out the CNSC's expectations for waste and decommissioning activities.

Once approved, these regulatory documents will supersede the following documents:

Regulatory document	Supersedes
REGDOC-1.2.1	R-72, *Geological Considerations in Siting a Repository for Underground Disposal of High-Level Radioactive Waste* (1987)
REGDOC-2.11.1, Waste Management, Volume I	N/A
REGDOC-2.11.1, Waste Management, Volume III	REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (2018)
REGDOC-2.11.2	G-219, *Decommissioning Planning for Licensed Activities* (2000)
REGDOC-3.3.1	G-206, *Financial Guarantees for the Decommissioning of Licensed Activities* (2000)

Given the high level of interest on the subjects of radioactive waste management and the decommissioning of nuclear facilities, CNSC staff conducted extensive consultations during the development of these draft regulatory documents. Staff engaged in an ongoing exchange with stakeholders, starting with the 2016 publication of discussion paper DIS-16-03. From 2018 to 2020, the five draft regulatory documents underwent a public consultation process, including workshops that were held with industry, interested members of the public and civil society organizations. After each round of consultations, the documents were revised, as appropriate, to address the feedback raised. The final drafts were presented to the Commission at a public meeting in June 2020.

These draft regulatory documents are intended to form part of the licensing basis for waste management and decommissioning activities for applicable CNSC licences. If the regulatory documents are approved by the Commission, implementation plans for each document containing requirements will be established through discussion and consultation between CNSC staff and licensees, in keeping with the CNSC's process for implementing regulatory documents. As part of the implementation plans, licensees will adopt the requirements expressed in the regulatory documents as part of their licensing basis, thereby providing the CNSC with the legal authority to enforce those requirements. A decision by the Commission is expected in the summer of 2020.

K.2.2 Implementation of the IAA

In 2015, the Government of Canada promised to review environmental and regulatory processes to address concerns about previous reforms. The government put in place interim principles for project reviews in January 2016, then launched a comprehensive process in June 2016 to review existing laws and seek Canadians' input on how to improve the environmental and regulatory system. Based on the results, the Government of Canada brought in new rules to protect the environment, recognize and respect Indigenous rights, and strengthen the economy through the new *Impact Assessment Act* (IAA), which came into force on August 28, 2019. The impact assessment process is led by the Impact Assessment Agency of Canada (IAAC) and serves as a planning tool that takes into consideration the whole range of environmental, health, social and economic effects of projects. This regime shifts away from decisions based solely on the significance of effects and focuses instead on whether the adverse effects in areas of federal jurisdiction affect the public.

In addition to the broader review of project effects, there is an emphasis on early planning and engagement with Indigenous peoples, the public and stakeholders to identify and discuss potential effects and benefits early, leading to tailored impact assessment guidelines, clarity on Indigenous and public engagement plans, and strengthened cooperation with provincial governments essential to achieving one project, one assessment.

Where projects link to regulators with responsibilities that cover the full lifecycle of a project, such as the CNSC for nuclear projects, the IAAC works collaboratively with these lifecycle regulators to draw upon their expert knowledge and ensure that safety, licensing requirements, international obligations and other key regulatory factors are considered as part of a single, integrated assessment. In October 2019, the CNSC signed a memorandum of understanding with the IAAC. The memorandum of understanding confirms the participants' commitment to work collaboratively to conduct integrated impact assessments under the IAA. The participants wish to ensure that the principle of "one project, one assessment" is followed when reviewing designated projects regulated by the CNSC, and that any reviews are conducted in an efficient and effective manner, without unnecessary delays or duplication of effort. The IAA stipulates that for designated projects, as identified in the *Physical Activities Regulations* that are also subject to lifecycle regulation by the CNSC, the assessment must be conducted by a review panel whose members must include representatives from the regulator.

The federal Cabinet will be responsible for making the impact assessment decision under the IAA. The CNSC would make the licensing decisions under the NSCA. Subsequent regulation of designated projects would be the responsibility of the CNSC under the NSCA. Non-designated projects subject to the NSCA will be assessed by the CNSC only.

K.2.3 Decommissioning and remediation of AECL sites

K.2.3.1 AECL restructuring

AECL, the federal Crown corporation responsible for enabling nuclear science and technology and managing federal radioactive waste liabilities, was restructured in 2015 when CNL was created. All federal responsibilities related to decommissioning and waste management were transferred to AECL and included as part of the scope of work to be performed under GoCo contractual agreements. As such, the Nuclear Legacy Liabilities Program, which was discussed in previous reports, ended in 2015. Decommissioning and waste management work at AECL sites is now being implemented by CNL under the GoCo model. For further information, see section E.2.7.3.

With the implementation of the GoCo model at AECL sites, CNL continues to notably accelerate decommissioning and remediation activities. Significant progress has occurred at all sites since the 6th Review Meeting:

- decommissioning and demolition of 77 structures in the supervised and controlled areas at CRL, bringing the total of removed redundant structures to 92 of the more than 120 committed from 2015 through 2026

- progress toward placing the NRU reactor in a storage-with-surveillance state (following end of operation in March 2018)
- renewal of decommissioning license for WL site for a period of five years (commencing December 2019)
- decommissioning of a further 20 redundant structures at the WL site, and completion of overall decommissioning of WL on track for 2027
- environmental assessment and licensing regulatory processes launched in 2017 for:
  - NSDF for the disposal of up to 1,000,000 m^3 of LLW at CRL. Pending regulatory approval, the proposed disposal facility will be constructed, with the forecasted date of operations in 2024
  - *in situ* decommissioning of NPD reactor at Rolphton, near CRL. Pending regulatory approval, the site is forecast to be decommissioned by 2024
  - *in situ* decommissioning of WR-1 reactor at WL
  - following extensive public consultation on the draft EISs, extensive comments and questions were received from government agencies, Indigenous communities, CSOs and members of the public. Having taken into account all the feedback, CNL submitted revised draft EIS packages for regulatory review (NSDF in December 2019, NPD and WR-1 in March 2020). Following successful completion of regulatory review, each will be considered at a CNSC public Commission hearing
- preparation of additional interim storage capacity for LLW at CRL while awaiting the start of operations of the NSDF
- evaluation of ongoing ILW storage requirements, including near- to medium-term capacity needs, given that current capacity is limited and the plan is to consolidate storage of all AECL/CNL ILW at CRL until ILW disposal becomes available
- expansion of storage capacity at CRL for dry storage canisters for spent fuel to accommodate consolidation of spent fuel storage at CRL awaiting availability at the NWMO APM facility
- completion of program for HEU fuel rod repatriation to the U.S. Department of Energy
- completion of the commissioning of the fuel packaging and storage facility and associated transfer, and drying of 96 vulnerable spent fuel packages
- major progress with the PHAI cleanup, including:
  - completion of the construction of the ECM facilities at both Port Hope and Port Granby
  - initiation of cleanup activities within the municipality of Port Hope; on track for closing and capping the Port Hope ECM facility by 2026
  - near completion of the remediation at Port Granby; on track for closing and capping the Port Granby ECM facility by 2021
- identification of the means of disposal for wastes from the cleanup of contaminated sites along the Northern Transportation Route (NTR), enabling remediation activities to be substantially complete by 2026
- ongoing progress made retrieving and processing stored liquid wastes from several buildings at the CRL site, with approximately 3 m^3 of liquid wastes removed and immobilized

For more information on the acceleration of the three projects undergoing environmental assessment (NSDF, *in situ* decommissioning of NPD and *in situ* decommissioning of WR-1), see section K.2.3.3. For more about the progress of decommissioning and environmental remediation at CRL, see annex 8.1. For information on the progress of decommissioning at WL, see annex 8.8. To learn more about the PHAI, see section K.3.4.2, as well as annexes 7.2.1 and 7.2.2.

K.2.3.2 Waste management and strategic progress for subsequent phases

An environmental assessment process was initiated in 2016 for a proposed NSDF at CRL. This ground-level facility would be built to permanently and safely dispose of AECL's LLW.

For many years, AECL (and now CNL) has safely placed waste from its operations and from Canadian hospitals and universities in temporary storage facilities at CRL. These temporary facilities have design lives that range from 25 to 50 years. The intent of the proposed NSDF is to provide a safe and permanent disposal solution for this waste.

If authorized by the CNSC, the NSDF will allow the safe and permanent disposal of:

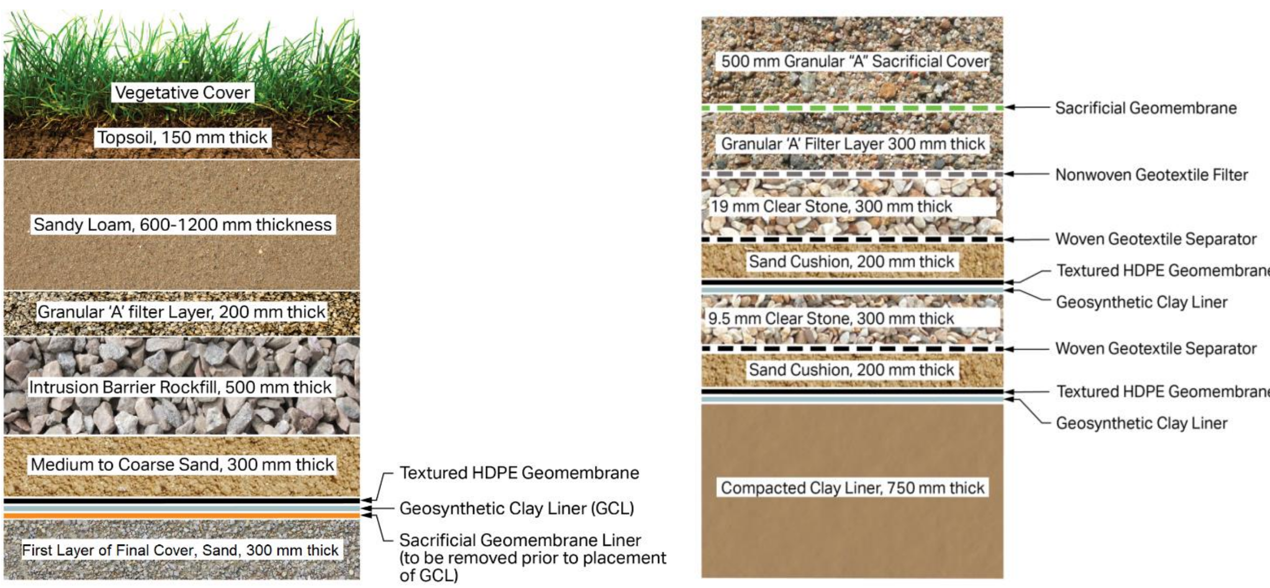
- waste from 65 years of AECL/CNL nuclear science and technology operations which is currently stored in temporary storage facilities at CRL
- future CRL operational waste materials as they are generated (i.e., waste resulting from ongoing nuclear science and technology operations)
- materials received through commercial arrangements, including waste from hospitals, universities, research entities and industry clients – all currently stored in temporary waste storage facilities at CRL
- waste from future decommissioning activities undertaken by CNL to address other liabilities owned by AECL (e.g., closing the WL and prototype reactor sites)

All waste emplaced in the proposed NSDF must follow the waste acceptance criteria defined for the facility. The waste acceptance criteria set limits on the physical (size and packaging), radiological and chemical characteristics of the waste that would be accepted for emplacement in the proposed NSDF to assure compliance with operational and long-term safety requirements. Only wastes that are deemed suitable for this method of disposal and meet the waste acceptance criteria will be accepted at the NSDF for emplacement.

The CNSC will assess the proposed NSDF to ensure that, if approved, it would meet regulatory requirements during all phases of its lifecycle, including in the construction, operation, decommissioning and post-closure periods.

Figure K.1: Artist's rendering of closed and capped NSDF

Figure K.2: Artist's rendering of NSDF liner system detail showing the multi-layer cap system (left) and the base liner system (right)



The current status of this project in the regulatory approval process is provided in section K.2.3.3.

K.2.3.3 Update on the licensing process for CNL accelerated decommissioning and remediation projects (NPD, WR-1 and NSDF)

As a key enabler to accelerating decommissioning and waste management activities, CNL is currently planning for the construction of a proposed NSDF at CRL sites (see section K.2.3.2). Environmental assessments are also currently underway for the proposed *in situ* decommissioning of two former reactors, the NPD reactor located in Renfrew County (Ontario) and WR-1 located at the WL site (Manitoba).

Each project is making its way through the regulatory approval process, and target milestone dates have been updated as follows since the Sixth Review Meeting:

- NSDF project
    - draft EIS submitted to the CNSC in March 2017
    - formal public and Indigenous communities' comment period on the draft EIS held from May to August 2017
    - comments on the draft EIS addressed by CNL between September 2017 and August 2019
    - revised draft EIS submitted to the CNSC for federal review in December 2019
    - submission to the CNSC of final EIS and responses to comments from the public and Indigenous communities anticipated in fall 2020
    - CNSC Commission hearing planned for 2021
    - CNSC Commission's environmental assessment and licence decision planned for 2021
- NPD closure project
    - draft EIS submitted to the CNSC in November 2017
    - formal public and Indigenous communities' comment period on the draft EIS held from November 2017 to February 2018
    - comments on the draft EIS being addressed by CNL, ongoing since March 2018
    - revised draft EIS submission to the CNSC for federal review anticipated in fall 2020
    - submission to the CNSC of final EIS and responses to comments from the public and Indigenous communities anticipated in 2021
    - CNSC Commission hearing planned for 2022
    - CNSC Commission's environmental assessment and licence decision planned for 2022
- *In situ* decommissioning of WR-1
    - draft EIS submitted to the CNSC in September 2017
    - formal public and Indigenous communities' comment period on the draft EIS from September 2017 to November 2017
    - comments on the draft EIS being addressed by CNL, ongoing since January 2018
    - revised draft EIS submission to the CNSC for federal review anticipated in fall 2020
    - submission to the CNSC of final EIS and responses to the comments of the public and Indigenous communities anticipated in 2021
    - CNSC Commission hearing planned for 2022
    - CNSC Commission's environmental assessment and licence decision planned for 2022

K.2.4 Long-term management of spent fuel

Momentum for implementing the long-term management approach for spent fuel has been sustained since the NWMO received its 2007 mandate to implement the APM approach approved by the Government of Canada. When the site selection process started in 2010, 22 communities expressed interest in learning more about the project.

As of March 2020, two candidate communities had been identified: one in South Bruce Municipality and one near Ignace, both in Ontario. Studies and community consultation continues within these areas. First Nation and Métis communities are also involved, as facilitated through learning agreements.

Finding an acceptable site in a willing host community for a spent fuel repository continues to be a challenge.

K.2.4.1 Assessment of options for long-term management of spent fuel

Used nuclear fuel is stored on an interim basis near or at the sites where it was produced in facilities licensed by the CNSC. This current storage method is safe, but not permanent.

The early history of the Canadian program for the long-term management of spent fuel is described in section G.7.

In 2002, following the *Nuclear Fuel Waste Act* (NFWA), the NWMO was created. In keeping with the NFWA, from 2002 to 2005, the NWMO studied approaches for the 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 the three methods specified in the NFWA as the basis for its initial assessment: deep geological disposal in the Canadian Shield, storage at nuclear reactor sites and centralized above- or below-ground storage. From the insights gained through its analysis and public consultation, the NWMO proposed a fourth option: APM.

The NWMO developed its APM recommendation with the input of technical specialists, the public and Indigenous peoples. It engaged Canadians in wide-ranging dialogue on the values, principles and objectives they believe are required of a spent fuel waste management approach for it to be socially acceptable, environmentally responsible, technically sound and economically feasible. 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 and a further 60,000 people expressed their interest by visiting the NWMO website. The final study report, *Choosing a Way Forward*, contains the detailed recommendation, as well as the NWMO's supporting assessment findings and research. It is available on the NWMO website at nwmo.ca.

K.2.4.2 Canada's plan for the long-term management of its spent fuel

APM emerged from a three-year dialogue with both specialists and the public. It is based on the values and objectives that Canadians identified as important. The outcome of these conversations was outlined in *Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel (Final Study)*, issued in November 2005.

In June 2007, the Government of Canada selected APM as Canada's plan for the long-term management of spent fuel.

APM is both a technical method (what the NWMO plans to build) and management system (how the NWMO will work with people to get it done). The technical method involves developing a DGR in a suitable rock formation to safely contain and isolate used nuclear fuel. The management system involves phased and adaptive decision-making, supported by public engagement and continuous learning.

During the past three years, the NWMO has continued to take an adaptive approach in all its work, including technical repository design, field testing, interweaving Indigenous knowledge and engagement activities for partnership and community well-being, to name a few examples.

The NWMO is guided by an ethical and social framework that was developed with the involvement of leading ethicists in Canada during the study phase of its work. It was first published in 2004. The framework continues to be used and is built upon the project advances.

The following ethical principles were incorporated in the framework:

- respect for life in all its forms, including minimizing harm to human beings and other sentient creatures
- respect for future generations of human beings, other species and the biosphere as a whole
- respect for peoples and cultures
- justice across groups, regions and generations
- fairness to everyone affected, and particularly to minorities and marginalized groups
- sensitivity to the differences of values and interpretation that individuals and groups bring to the dialogue

In 2018, the framework was updated in discussion with communities involved in the site selection process and others who expressed an interest. The updates ensure alignment with the current phase of the NWMO's work and advancement of the site selection process. For more detail, please see https://www.nwmo.ca/en/ABOUT-US/Who-We-Are/Our-Commitment/Ethical-and-Social-Framework.

The DGR uses a multiple-barrier system designed to safely contain and isolate spent fuel over the long-term. It will be constructed at a depth of approximately 500 m depending on the geology, and consists of a network of placement rooms for the spent fuel.

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

The repository will include a centralized services area, which allows for ventilation underground through three shafts located within a single, secure area. The layout also includes multiple access tunnel arms that enable technical specialists to situate placement rooms in areas with the most suitable rock.

In preparation, the NWMO has begun work on site-specific conceptual designs of the underground repository layout for potential siting areas in Ontario, based on information from geoscience assessments and initial borehole drilling. This will be an iterative process. As the NWMO acquires additional site-specific information, design of the repository will continue to evolve.

K.2.4.3 Understanding and honouring Indigenous perspectives

Since its inception in 2002, the NWMO has been striving to understand, honour and interweave Indigenous world views into all aspects of the work.

The NWMO's commitment to understand and include the perspectives of Indigenous peoples continues to be incorporated into the organization. The NWMO has Indigenous representation on its executive team, board of directors and advisory council to ensure that a strong Indigenous voice is present within the organization. The Indigenous relations team has developed meaningful policies to guide the work, including a reconciliation journey.

The Indigenous engagement team builds respectful relationships with First Nation and Métis communities. The NWMO listens to the First Nation and Métis communities with which they are working; they receive ongoing guidance and advice from the Council of Elders and Youth, an independent advisory body made up of First Nation and Métis elders and youth.

From 2017 to 2019, the NWMO continued to incorporate previously established practices into daily activities. These include marking important corporate occasions and milestones through Indigenous ceremonies, adhering to an Indigenous knowledge policy and acting on the commitment to interweave Indigenous knowledge into all aspects of the work.

In 2015, the Truth and Reconciliation Commission of Canada released its calls to action; number 92 calls upon the corporate sector to build respectful relationships with Indigenous peoples and teach management and staff about their history, including the history and legacy of residential schools.

In 2018, the NWMO took an important step in its journey towards reconciliation by acknowledging historical wrongs in Canada’s past and the need to create a better future by addressing the challenges of today. The NWMO issued a reconciliation statement which was finalized with an Indigenous pipe ceremony attended by members of the Council of Elders and Youth, the board of directors and the executive team. The statement recognizes the NWMO’s ongoing involvement, collaboration and discussions with Indigenous communities.

The NWMO took the next step and formalized a reconciliation policy in 2019, setting out how the organization will contribute to reconciliation in all of its work. As defined in the Truth and Reconciliation Commission of Canada’s final report, reconciliation is an ongoing process of establishing and maintaining respectful relationships.

As a part of this approach, the NWMO is committed to weaving Indigenous knowledge into its work. In 2018 and 2019, workshops were held to bring together Indigenous knowledge keepers and scientists to bridge the gap that exists among scientists about Indigenous knowledge and explore ways of working together. Attendees focused on elements of the multiple-barrier system – copper, clay and rock. They discussed how Indigenous knowledge that includes advice and guidance received through ceremony can be combined with digital data collection and laboratory analysis to understand an area of land from multiple dimensions.

During 2017 and 2018, the Indigenous relations team undertook consulting activities regarding plans to drill the first, second and third boreholes in the Ignace and Wabigoon Lake Ojibway Nation area. After successful consultations with five First Nations and one Métis community, the NWMO received permission to drill from the Ontario Ministry of Natural Resources and Forestry. The NWMO collaborated with a nearby Indigenous community to provide guides to help with fieldwork and conduct cultural verification studies of the proposed sites and access routes. Drilling commenced with the first borehole in 2017, and the second and third boreholes in 2019.

Figure K.3: Voyageur canoes carrying leaders, dignitaries and the NWMO Vice-President of Site Selection signaled the start of the Métis Nation of Ontario's Annual General Assembly

K.2.4.4 Social engagement

Dialogue with communities and a range of interested individuals and organizations is central to the work for advancing Canada's plan. As the siting process advances, the NWMO has broadened and deepened engagement activities with municipal, First Nation and Métis communities, as well as surrounding communities in each area. The NWMO has also maintained relationships with national and provincial Indigenous organizations, and with municipal associations.

In 2017, the NWMO engaged with nine communities and surrounding areas in the siting process. After narrowing the focus at the end of 2017, engagement activities continued in five siting areas remaining in the process, namely in Hornepayne and area, Huron-Kinloss, Ignace and area, Manitouwadge and area, and South Bruce. During the reporting period, the NWMO supported more than 800 engagement activities. A full list of engagement activities is published as a separate document and posted at https://www.nwmo.ca/reports.

The NWMO held one-on-one conversations and held presentations and discussions with groups. The NWMO engaged through meetings and briefings, conferences, tours of interim storage facilities and the NWMO's proof test facility, monthly meetings of community liaison committees (CLCs), community open houses, symposiums, drop-ins at local community offices, and community festivals and events. A municipal conference program and meetings of the NWMO's municipal forum were maintained. The NWMO also continued to hear from citizens via its website, email and social media platforms.

Safety and learning about the project remain of primary interest among communities and groups new to the project. Each year, CLCs identify a variety of safety-related topics and arrange for presentations by NWMO technical specialists, followed by discussion sessions. The NWMO has held in-depth conversations with communities in the siting process to explore additional aspects of safety, preliminary borehole drilling and the path to partnership.

In fall 2019, the NWMO initiated community surveys in the five municipal communities still involved in the siting process to better understand public awareness and continue to improve the ways of communication. The survey results will provide insight into community awareness about Canada's plan, as well as how communities would like to receive information in the future.

From 2017 to 2019, the NWMO attended more than 100 community events, powwows, open houses, learning and sharing gatherings, cultural awareness workshops, assemblies, conferences and special occasions in the area. The NWMO also facilitated dry storage tours at interim storage facilities for community members, as well as visits to the proof test facility in Oakville. Many communities accessed the NWMO's community sponsorships and donations programs for a variety of activities, such as robotics programs, rangers' camps, cultural verification, youth gatherings, wellness camps, language classes, hockey tournaments and science camps.

K.2.4.5 Site assessment

In 2010, the NWMO launched a siting process to identify an informed and willing host for a DGR for Canada's used nuclear fuel. Initially, 22 communities expressed interest in learning about the project and entered the siting process.

Over time, a series of progressively more detailed scientific, technical and social assessments resulted in narrowing the focus to fewer potential sites.

The NWMO narrowed down potential siting areas twice in 2017, from nine to seven, then to five. In 2019, the process advanced and in November, the NWMO was down to two potential siting areas.

As of March 2020, Ignace in northwestern Ontario and South Bruce in southern Ontario continue to be considered potential host areas for the project. Throughout this process, work has continued to include neighbouring First Nation and Métis communities and municipalities.

Next steps include working with municipal and Indigenous communities to conduct progressively more detailed technical site evaluations and social studies. The work will further assess safety, continue meaningful discussions around partnerships, and explore how the project can be implemented in a manner that will enhance the well-being of municipal and Indigenous communities in each area. The NWMO remains on track to identify a single preferred site by 2023.

Engagement activities have increasingly become centred on partnership, willingness and how the project could contribute to community well-being to support the implementation of Canada's plan for the safe, long-term management of spent fuel.

In late 2017 and early 2018, the NWMO shared a partnership road map to guide these discussions with communities in the siting process and to begin creating a framework to implement the project, if a preferred site were identified in the area.

In 2018, each community created a set of values and principles to guide future discussions with the NWMO to explore partnership and to consider the project in more detail.

Among municipalities, safety emerged as a pre-eminent principle. Other commonly held values included working together, transparency and honouring commitments. Communities also highlighted the importance of working regionally with other municipalities and Indigenous communities.

In 2019, communities and the NWMO began working together to develop a shared vision of the project for each area. This shared vision reflects how the project might best fit into the community and area, and the project's potential to help move toward the future envisioned by those who live there.

A key part of the site selection process is studying and identifying a site that can safely house the underground repository and its surface-level facilities. This involves activities like borehole drilling, environmental monitoring and other site investigation work, including Indigenous cultural verification.

In 2017 and 2018, the NWMO integrated findings from preliminary site assessments in the Ignace-Wabigoon, Hornepayne and Manitouwadge siting areas, and analyzed the data to support the identification of potential repository sites in each area. The NWMO identified preferred locations based on a wide range of technical studies and through extensive engagement activities with people in the siting areas, including First Nation and Métis communities.

During the reporting period, the NWMO drilled three initial boreholes to a depth of about one kilometre to study the geological conditions at a potential repository site in the Ignace-Wabigoon area. Borehole studies included a series of down-hole tests in the field and analysis of core samples in laboratories. Temporary access routes and field sites were constructed to support the drilling and testing activities. Boreholes were not drilled in Hornepayne or Manitouwadge before the areas were screened out of the process.

In the Ignace-Wabigoon area, the potential repository site is located on Crown land, and the NWMO has worked with appropriate government bodies to secure access for studies. In South Bruce, potential repository sites would be located on privately owned land. As a result, the process for accessing a potential site in this area is different.

Figure K.4: Core samples from borehole drilling near Ignace

Figure K.5: Overview of third borehole site in the Ignace-Wabigoon area

Under the Land Access Process initiated in 2019, the NWMO asked landowners in South Bruce to consider signing option agreements with the NWMO that would allow us to conduct a site investigation, and if the site is later selected, to purchase the land. In total, the NWMO is looking to aggregate approximately 1,500 acres which would accommodate the size of the underground and surface facilities. To prepare for next steps, the NWMO has developed plans and established the required support contracts for drilling initial boreholes in the area. While the NWMO continues to work with the Saugeen Ojibway Nation, other Indigenous communities and local municipalities in this area, the Land Access Process does not indicate they have provided their support for siting the repository in this area. The project will only proceed with interested municipalities, First Nation and Métis communities, and surrounding communities working together to implement it.

K.2.4.6 Engineering, safety and technical research

From 2017 to 2019, the NWMO's engineering program focused on proof testing activities to demonstrate the performance of the NWMO's engineered-barrier system (EBS) design. This includes manufacturing various components of the EBS, notably the copper-coated used fuel container (UFC), the highly compacted bentonite clay buffer box and the granular bentonite gapfill.

The NWMO will conduct a full-scale trial using a mock-up of the emplacement room at our proof test facility in Oakville, Ontario, from 2021 to 2022. This will enable us to test our ability to fabricate and demonstrate the emplacement of the EBS to meet our design requirements. During the past three years, the NWMO has been preparing for these activities by procuring raw materials and designing, fabricating, installing and commissioning equipment to support the serial fabrication of UFCs and buffer boxes, as well as the placement of the components into the emplacement room.

Figure K.6: Deep geological repository concept

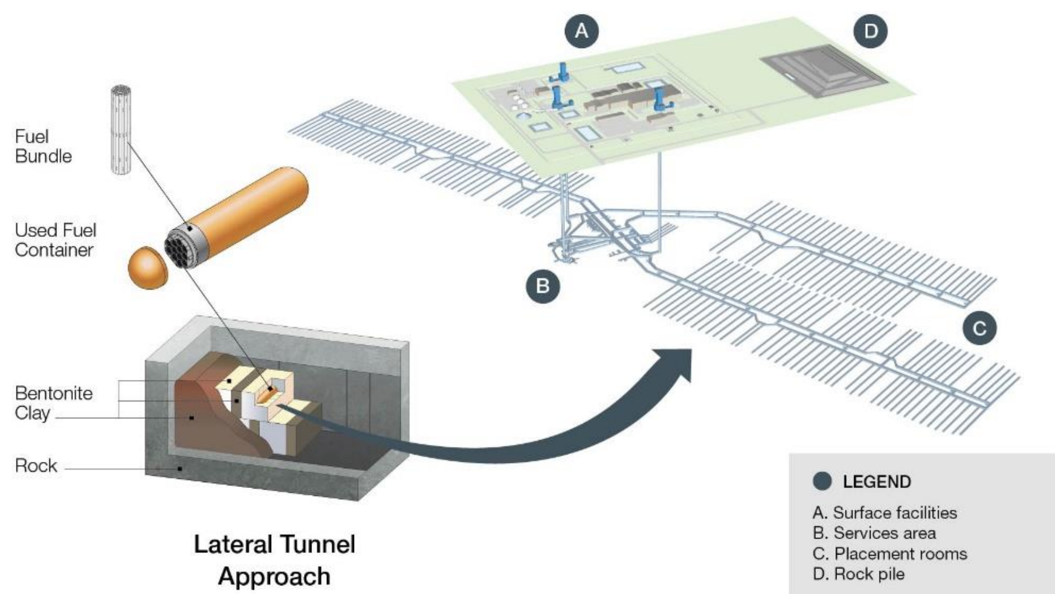


Figure K.7: Prototype used fuel container in half of a highly compacted bentonite clay buffer box

The NWMO is also developing non-destructive examination techniques and custom equipment to inspect the UFCs following the various stages of fabrication, such as welding, copper coating and machining. These inspections will ensure that UFCs meet the required specifications.

Repository safety is of paramount importance. The site, the facility's robust design and the way it is built, operated and monitored will all ensure safety. The NWMO develops detailed safety assessments, often referred to as case studies, to demonstrate that the regulatory requirements for safety will be met. The case studies address safety in both the near term (during facility operations) and the long term (post-closure, after the repository has been filled, sealed off and closed).

In the near term, safety assessments evaluate the potential impact on people and the environment due to facility operation under normal and abnormal operating conditions and for credible accident scenarios. In 2018, a preliminary analysis of accidents was completed for a generic site. A study was initiated in 2019 to review the anticipated climate change impacts on precipitation, and update the estimates of the flood potential for the regional areas under consideration as potential siting areas. The results will help improve the design basis.

Post-closure safety assessments are simulations that calculate repository performance for a million years or longer. A post-closure safety assessment is submitted in support of a licence application once a site is selected. From 2017 to 2019, the NWMO published updated post-closure case studies for both a hypothetical crystalline rock repository and a hypothetical sedimentary rock repository at https://www.nwmo.ca/reports. These updated case studies incorporate the NWMO's EBS design and emplacement room layout.

In 2019, the NWMO started to develop the next safety assessment model to support site-specific safety assessments. This model will take advantage of current developments in computing and computer models to provide a more complete representation of the repository system.

In 2019, the NWMO also began a preliminary site-specific safety assessment for a potential repository location in the Ignace-Wabigoon area. This iterative assessment will build on the methodologies developed in latest case studies and incorporate information from current site investigation work. The NWMO will extend this work to the second potential siting area in southern Ontario and update each area's case study as field data is made available.

The NWMO continues to advance its understanding of many elements of the APM project through a research and development (R&D) program. In 2018, technical research activities were reorganized to establish an internal technical research review committee to provide an information-sharing forum within the NWMO.

In 2018 and 2019, R&D requirements across all phases of the project were assessed, from current state through detailed characterization, construction, operations, decommissioning and closure. The goal was to better understand how current R&D activities support technical knowledge of repository performance and safety, and identify future R&D activities. This work culminates in an integrated R&D program report, focusing on technical research in the areas of the safety case, engineered barriers and geoscience.

From 2017 to 2019, the NWMO supported research at more than 15 universities, with the majority here in Canada. Research partnerships with universities play an important role in ensuring that the NWMO's technical work is scientifically rigorous. The NWMO, together with the Natural Sciences and Engineering Research Council, has also established industrial research chairs and collaborative R&D grants with a variety of universities.

From 2017 to 2019, NWMO scientists continued to publish technical reports, peer-reviewed journal articles and abstracts for presentation at Canadian and international conferences on radioactive waste management.

Figure K.8: Dr. Jeff Binns, a corrosion scientist at the NWMO, examines a robot used in underwater research for the effects of deep water pressure on barrier materials, conducted in partnership with Ocean Networks Canada (University of Victoria)

K.2.4.7 Collaborating internationally for a safe future

The NWMO partners with organizations around the world that are responsible for the safe management of spent fuel to learn from their experiences and knowledge and to share Canadian research and learning.

During the reporting period, the NWMO: fostered international cooperation for developing and demonstrating technology innovations; kept abreast of developments in repository design and safety cases for various host rock formations; and discussed aspects of social acceptance.

From 2017 to 2019, the NWMO also maintained participation in underground research experiments and demonstration tests at the Mont Terri project and Grimsel Test Site in Switzerland, and Posiva's ONKALO facility in Finland.

K.2.4.8 Transportation

Canada's spent fuel is currently safely stored on an interim basis in licensed facilities at reactor sites. These sites are located in Ontario, Quebec and New Brunswick, and at AECL's nuclear research facilities in Ontario and Manitoba.

The spent fuel will eventually be transported to the selected repository site. The NWMO is responsible for ensuring transportation activities are conducted safely and securely. The NWMO is studying both road and rail as potential transportation modes.

Spent fuel will be transported in specially designed transportation packages which are certified by the CNSC for meeting stringent testing and regulatory requirements.

While transportation is not expected to begin until about 2040, work is underway to ensure it will be safe and secure, with a plan that reflects public priorities and concerns.

From 2017 to 2019, the NWMO expanded its engagement with communities and interested individuals and groups to improve everyone's understanding of the social priorities and concerns that need to be addressed in planning the APM transportation program. These activities have given communities information about the NWMO's transportation program and encouraged people to raise questions and concerns.

During the past three years, transportation and engagement specialists have held information briefings and conversations with a range of communities and groups, including municipal, First Nation and Métis communities in potential siting areas, surrounding communities and broader-reaching municipal and Indigenous organizations. These conversations aimed to share safety information and discuss the requirements of a socially acceptable transportation plan.

The NWMO continues to apprise governments of plans, as they are developed, through one-on-one updates with federal and provincial representatives, as requested. In addition, the NWMO provides information to an interjurisdictional working group made up of public servants from Transport Canada, the CNSC and the respective provincial transportation ministries of Ontario, Quebec and New Brunswick.

Participation in municipal association and Indigenous trade shows and conferences is another way that the NWMO facilitates learning and dialogue with interested groups. Engagement and transportation specialists attended the conferences of the Ontario Good Roads Association and the Association of Ontario Road Supervisors, and they heard from Indigenous groups at events, such as the annual general assemblies of the Métis Nation of Ontario and Ontario Coalition of Indigenous Peoples. In the last three years, the NWMO expanded its outreach to participate in first responder and nuclear industry conferences.

Through ongoing engagement, people have identified areas of interest which have been incorporated into engagement materials, briefings and conversations. Specific topics include design and testing of the used fuel transportation package (UFTP), consideration of accident scenarios, international track record for transporting spent fuel and regulatory oversight. This type of responsive engagement helps to lay the foundation for earning broad confidence in safety.

Additionally, the NWMO has conducted public attitude research with a cross-section of people in Ontario, Quebec and New Brunswick to get a broader perspective of views on spent fuel transportation. The research has involved focus groups, workshops, larger group sessions and Indigenous dialogue sessions.

These discussions have helped increase understanding of social sensitivities, questions that will need to be addressed in the APM transportation program planning and requirements for a socially acceptable transportation plan.

On the technical side, from 2017 to 2019, work focused on exploring design concepts and key components of the used fuel transportation system, as well as assessing transportation modes, logistics and routing options for the remaining areas in the site selection process.

This work focuses on both road and rail modes of transport and considers the use of various transportation packages, in particular, the NWMO's UFTP and dry storage container transportation package for the transport of spent fuel from OPG, and the basket transportation package for the transport of spent fuel from H-Q, NB Power and AECL.

In 2018, the CNSC re-certified the UFTP. The re-certification demonstrates that the package meets the applicable requirements of the PTNSR, 2015 and the IAEA *Regulations for the Safe Transport of Radioactive Material* (IAEA SSR-6, 2012 Edition).

To further support the development of transportation packages, the NWMO undertook studies to test the material performance of stainless steels and compressible foams that may be used in their manufacture.

The NWMO has simulated and studied impact analyses of transportation packages under various regulatory test conditions and other scenarios. Further work was also completed on fire modelling of transportation packages under hypothetical accident conditions.

K.2.4.9 Organizational readiness

From 2017 to 2019, the NWMO prepared for phases of the project that will begin after the preferred site for a DGR has been selected.

As future operations come into closer view, the NWMO is building a learning organization and advancing its safety culture. Over the past couple of years, the NWMO has invested resources to further both of these aspects of the culture.

The NWMO is also investing in internal systems. The first phase of the NWMO's new Enterprise Resource Planning System was implemented in 2018 to improve workflow processes and integrate electronic systems. In 2019, a second phase was initiated: Human Capital Management.

The NWMO continues to operate an integrated management system for activities that support the long-term management of spent fuel. To sustain governance excellence, accountability and safety, the organization maintains certifications to Canadian and international standards, including:

- ISO 9001:2015 for quality
- ISO 14001:2015 for environment
- CSA Z1000:2014 for health and safety management

In addition to complying with these standards, the NWMO has augmented its management system to satisfy CSA Group standard N286-12, *Management system requirements for nuclear facilities*, which includes nuclear waste facilities.

In 2018, the NWMO began to develop the organization's mobilization resource strategy to ensure preparedness for the transition to the selected site. The strategy encompasses many logistical, partnership and people-related factors. The NWMO is creating an execution plan that can be adapted to the site eventually selected and to the partnership agreements developed with host communities.

In 2018, the NWMO started actively planning to initiate the regulatory phase of APM, which is to begin after site selection. This work entails conducting detailed analyses of the project's environmental impact, completing a formal impact assessment, submitting an application for a Licence to Prepare Site and developing the materials for a construction licence.

The NWMO closely monitored progress and discussions across Canada regarding the IAA. This legislation, now in force, establishes the requirements and process for the Government of Canada's approval of the preferred site. The NWMO notes a close alignment of the requirements in the IAA for pre-submission engagement with communities (especially Indigenous peoples) and the discussions the NWMO has been having since the site selection process was launched in 2010.

The NWMO is working with Indigenous and non-Indigenous communities on designing both baseline and assessment methods that can be used in preparing to formally launch the regulatory approvals process. Baseline environmental monitoring in potential siting areas is underway, in close collaboration with community members and Indigenous knowledge keepers. The information we develop will help the NWMO and communities engaged in the process to make good decisions.

The NWMO continues to interact with the CNSC, in keeping with the terms of a special project arrangement prior to the submission of a licence application. These activities include briefing the CNSC on the progress of APM implementation. This special project arrangement was renewed in March 2019 and will continue until the NWMO applies for the first licence.

The NWMO also began to engage with the CNSC to obtain guidance on regulatory requirements for first-of-a-kind elements of the facility's design. Initial discussions focused on design requirements for the UFCs that will be stored in the DGR. The NWMO anticipates seeking additional guidance as it prepares for the licence application.

K.2.4.10 Ensuring accountability and governance

The integrity of the NWMO's work is advanced by multiple layers of oversight and peer review. Internally, the NWMO is governed by its board of directors. Over the reporting period, the NWMO's accountability and governance was ensured through a broad framework comprising such activities as:

- annual reviews of the NWMO's progress by the Minister of Natural Resources
- participation in the Joint Convention review meetings
- ongoing technical reviews of approaches, methods and interpretation of data (e.g., the Geoscientific Review Group continues to help ensure preliminary site geoscientific assessments are conducted according to international best practices)
- annual audits of the NWMO's integrated management system; the NWMO continues to be certified compliant with Canadian (CSA Group) and international (International Organization for Standardization) management system standards

K.2.4.11 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 future 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 its mandate is fulfilled to regulate the use of nuclear energy and materials, to protect health, safety, security and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy. More information is available on the CNSC website at nuclearsafety.gc.ca/eng/waste.

K.2.4.11.1 Service arrangement between the CNSC and NWMO

The CNSC has signed special projects arrangements (service arrangements) with the NWMO to recover the cost of work since 2009. The current arrangement has been in place since April 1, 2019, and is valid until March 31, 2024. CNSC staff conduct the following activities through this arrangement:

- provide regulatory guidance to the NWMO on APM implementation

- attend NWMO engagement activities with the general public and Indigenous communities and provide information on the regulator’s role in licensing an APM facility
- conduct pre-project reviews for technical components of the APM project and provide general assessments to identify any regulatory concerns

The CNSC’s early engagement in the NWMO APM activities is important to ensure that no misunderstanding arises around the role of the CNSC and its involvement prior to the submission of a licence application and the initiation of an impact assessment. There is also international consensus that the active, independent involvement of a knowledgeable and competent nuclear regulator early in the siting process increases stakeholder confidence. The pre-licensing reviews conducted under the service arrangement do not certify a concept design, do not involve issuing a licence under the NSCA and are not required as part of the licensing process for the DGR. The conclusions of a CNSC pre-licensing review do not bind or otherwise influence the decisions made by the Commission. For more information about the service arrangement, refer to the CNSC website at nuclearsafety.gc.ca/eng/waste/high-level-waste/index.cfm#Long-term.

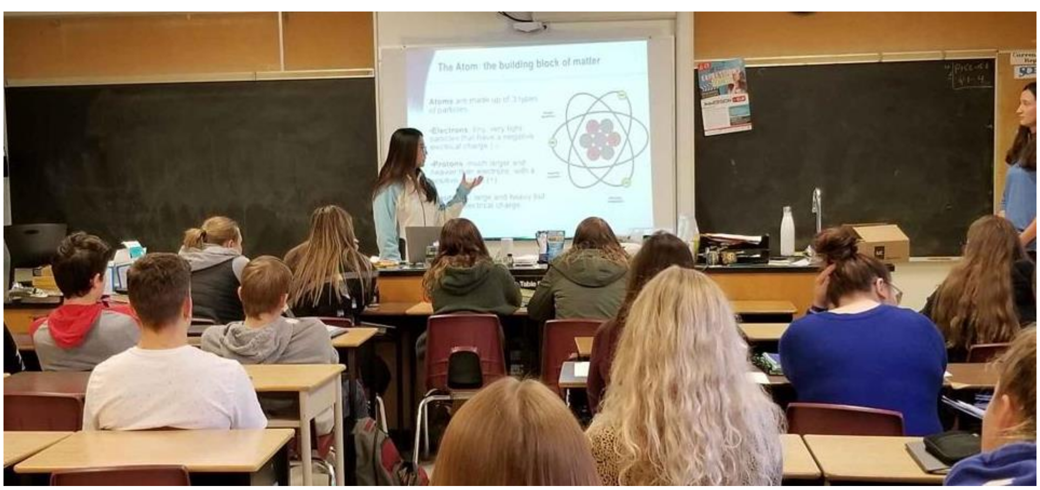
As part of this arrangement, since the last reporting period, the CNSC conducted pre-project reviews of reports that the NWMO has submitted on the design of its Mark II UFC. A summary of the CNSC pre-licensing review is available at http://www.nuclearsafety.gc.ca/eng/waste/high-level-waste/cnsc-role-in-nwmo-apm-project/index.cfm.

K.2.4.11.2 Relationship building with the public and Indigenous Groups

Throughout the reporting period, the CNSC continued to meet with the communities that have formally entered the NWMO’s siting process and it has expanded this outreach to neighbouring communities, when requested. Outreach and engagement activities have focused on relationship building with the communities and Indigenous groups, including the First Nations and Métis communities. In this reporting period, CNSC staff conducted 25 outreach activities (see figures K.9 and K.10 for examples).

At the request of community representatives (typically community liaison committees (CLCs)), additional outreach activities have been undertaken. This includes information and education sessions, which are usually initiated through a conference call with community representatives (CLC, Indigenous group, municipality, local school, etc.) to determine the objective of the event, number of participants, type of topics to be discussed and the venue for the event (presentation during a meeting, open house, local fair, online platform etc.). The CNSC then meets with the community or Indigenous group in their community (see figures K.9 and K.10), at the CNSC’s Ottawa offices (see figure K.11) or via an online platform, such as Zoom or Google Classroom.

Figure K.9: Students learn about radiation fundamentals from CNSC staff



The outreach and engagement activities are designed to provide information about the CNSC's role as Canada's nuclear regulator and to explain the organization's early role in the APM initiative. Topics addressed during the sessions include:

- the nuclear regulatory process and the factors that go into a licence application review
- the impact assessment process
- Indigenous engagement and consultation
- technical aspects of a DGR
- the CNSC's early role in the APM initiative
- opportunities for the public to get involved during Commission proceedings and impact assessments
- how the CNSC works with other regulatory bodies to fulfill its mandate when licensing nuclear facilities and activities

Meetings provide an opportunity for participants to ask questions and clarify issues of concern. Feedback from communities has been positive; they see the CNSC as a neutral, independent body with staff who are qualified to evaluate repositories for spent fuel and who are concerned with safety first and foremost. During these meetings, CNSC staff are interested in hearing and learning about the most effective ways to involve communities and Indigenous groups and how best to provide information to those who want to know more about the CNSC and other relevant matters within the scope of the CNSC's mandate.

Figure K.10: CNSC staff presenting to a community at the request of a community liaison committee

K.2.4.11.3 Relationship with Indigenous communities

Building relationships with First Nation and Métis communities who may have an interest in learning more about projects such as the APM initiative is a priority for the CNSC. As building strong relationships based on trust and mutual respect takes time, the CNSC reaches out to these communities early in the pre-licensing phase.

When an outreach event has been planned in a given area, the CNSC reaches out directly to nearby Indigenous communities to let those communities know that an independent nuclear regulator exists in Canada and that it is available to meet and provide information about the CNSC and its regulatory role.

With the signing of a memorandum of understanding between NRCan and the NWMO, the NWMO is responsible for continuing its Indigenous engagement activities prior to selecting a site, maintaining a consultation log and keeping the Crown apprised of these activities. NWMO is also keeping the CNSC informed of its activities, for example, by sharing issues and concerns that are raised related to potential and existing Indigenous and treaty rights.

Potential sites for a DGR for spent fuel have been narrowed down as the NWMO’s site selection process evolves. The CNSC will continue its Indigenous engagement activities during this time; however, greater focus will be given to working with First Nation and Métis communities who may be affected directly by the proposed project. To meet its duty to consult, the CNSC will be seeking information as to whether a future licensing decision may cause an adverse impact on any potential or established Indigenous or treaty rights.

More information on the CNSC’s Indigenous consultation can be found at http://nuclearsafety.gc.ca/eng/resources/aboriginal-consultation/index.cfm. In addition, CNSC regulatory document REGDOC-3.2.2, *Indigenous Engagement* sets out the requirements and guidance for licensees whose proposed projects may raise the Crown’s duty to consult.

Figure K.11 CNSC staff meet with an Indigenous youth group at the CNSC offices

K.2.4.11.4 CNSC independent research on and assessment of the safe long-term management of radioactive waste and spent fuel in geological repositories

Since 1978, the CNSC has carried out independent research and conducted technical assessments on the safe long-term management of spent fuel in geological repositories. Initially, these activities focused on crystalline host rocks in the Canadian Shield, and in the last 12 years, they came to include sedimentary host rocks.

The NWMO is currently looking for a voluntary community to host a spent fuel DGR at a site that is technically acceptable in either Canadian Shield crystalline rock or in sedimentary rock in southern Ontario. Concurrently, OPG had proposed a DGR project for its L&ILW, approximately 680 m deep in a sedimentary formation (for more information see section K.2.5).

It was in response to these two initiatives that the CNSC initially expanded its technical expertise to include geological disposal in sedimentary rock, as well as crystalline rock. Accordingly, in 2008, and to support the review of the OPG DGR and NWMO APM in sedimentary rock, the Coordinated Assessment and Research Program (CARP) was implemented. Within the CARP, the CNSC collaborated with different Canadian and international organizations to obtain experimental data and develop mathematical models, investigate properties of bentonite as a sealing material and verify some aspects of geosphere stability in order to assess the long-term performance of the host rock and the engineered barriers. In 2020, the CARP became the Strategic Research Agenda for Deep Geological Repositories (DGR-SRA). The DGR-SRA is integral to ensuring the CNSC continues to build and maintain the independent scientific knowledge required to assess a licence application and associated safety case in accordance with REGDOC 2.11.1, *Waste Management, Volume III: Safety Case for Long-Term Radioactive Waste Management,* and provide science-based licensing recommendations to the Commission.

CNSC's research program consists of independent scientific research conducted by CNSC staff in collaboration with national and international institutions. It also includes monitoring and reviewing state-of-the-art scientific advancements and participating in international fora to exchange information and knowledge related to DGRs.

Areas of research include investigating the stability of the geosphere, understanding the long-term performance of the host rock and engineered barriers, building the CNSC's safety assessment modelling capabilities and conducting a series of studies on natural analogues to investigate long-term processes and build confidence in the different components of the multi-barrier system for safety.

K.2.4.11.4.1 Independent advisory group

An independent advisory group composed of Canadian geoscience experts was established in 2013 to help CNSC staff prepare for the review of a future licence application from the NWMO for a DGR for Canada's spent fuel. The purpose of this group is to provide objective, independent advice to CNSC staff on the geoscience aspects of the APM initiative for the long-term management of Canada's spent fuel by reviewing and assessing both the NWMO's geoscience research program and the CNSC's independent research program. The advisory group may consider particular topics and activities related to their mandate. The membership is comprised of four professors, one government research scientist and one consultant. The expertise of the group spans the geological sciences and includes isotope and environmental geochemistry, hydrogeology, radioactive waste management, petrology, structural geology and tectonics, Canadian geology, and geomechanical, geotechnical and environmental engineering.

K.2.5 OPG's deep geologic repository for its low- and intermediate-level radioactive waste

In January 2012, the Canadian Environmental Assessment Agency (CEA Agency), which is now the Impact Assessment Agency of Canada (IAAC), and the CNSC established a JRP to review OPG's EIS in support of its application for a Licence to Prepare Site for and construct a DGR for its L&ILW. The JRP held 33 days of public hearings in 2013 and 2014, in which over 200 interveners participated. On May 6, 2015, the JRP issued its environmental assessment report which included 97 recommendations to the Minister of Environment and Climate Change for review and decision under the CEAA, 2012. In this report, the JRP concluded that OPG's DGR project is not likely to cause significant adverse environmental effects, provided it implements the mitigation measures proposed, the commitments made by OPG during the review and the mitigation measures recommended by the JRP.

On February 18, 2016, the Minister of Environment and Climate Change requested additional information from OPG and further studies on the environmental assessment for the DGR Project. The request focused on additional information about alternate locations for the project, cumulative environmental effects and mitigation commitments. On December 28, 2016, OPG submitted information pertaining to the three elements of the Minister's request.

On August 21, 2017, the Minister of Environment and Climate Change asked OPG to update the analysis of the project's potential cumulative effects on the Saugeen Ojibway Nation's cultural heritage and include a description of the potential effects of the project on the Nation's spiritual and cultural connection to the land. Further, the Minister's letter indicated that the results of the Saugeen Ojibway Nation's community process had to inform the analysis. OPG engaged with the community's leadership to establish a process; this culminated in a community vote.

On January 31, 2020, the Saugeen Ojibway Nation voted not to support the project. OPG respects the community's decision and has formally cancelled the project. OPG has withdrawn its application to construct the DGR and has also requested that the IAAC cancel the project's environmental assessment, which it was managing. Some steps remain to be taken at the proposed DGR site to close boreholes that were drilled during site characterization.

Moving forward, OPG will explore other options and engage with key stakeholders to develop an alternate site selection process. Any new site selection process would include engagement with Indigenous peoples, as well as interested municipalities and other stakeholders.

Among OPG's stakeholders are: its shareholder (the government of Ontario); OPG's regulators, like the CNSC; the public, including people in the communities where OPG operates; and industry peers and associations.

K.2.6 Discussion on options for an integrated strategy by Canada's radioactive waste owners under the Radioactive Waste Leadership Forum

Canada's largest radioactive waste owners – AECL, OPG, H-Q and NB Power – and other selected stakeholders continue to meet under the sponsorship of the CANDU Owners Group (COG) Radioactive Waste Leadership Forum (RWLF) to discuss opportunities for coordination and collaboration on long-term management matters, including relevant technologies and communication strategies.

In response to the action item for Canada from the Joint Convention ("Develop an integrated strategy for non-OPG low- and intermediate-level waste disposal"), the RWLF launched a project to produce an integrated radioactive waste strategy for Canada. This is in keeping with a principle in the radioactive waste management policy framework whereby waste owners are accountable for the full lifecycle management of the wastes they produce. The first output of this industry-led exercise on preparing an integrated radioactive waste strategy is expected in 2020. This output from waste owners will be available for inclusion in the radioactive waste policy review being led by NRCan.

K.2.6.1 Atomic Energy Canada Limited and Canadian Nuclear Laboratories

Since the Sixth Review Meeting, significant progress has been made in developing and implementing long-term solutions for L&ILW at AECL sites which will address more than half of Canada's inventory of these waste types. In addition to the long-term management facilities that have been constructed for the approximately 1.2 million m^3 of historic LLW associated with the PHAI (see section K.3.4.2 for more details), CNL continues to progress through the regulatory process for the proposed project for a NSDF at CRL with a total capacity up to 1 million m^3 for LLW (see section K.2.3.2 for more details). Pending regulatory approvals, this proposed facility is expected to be operational by 2024.

The vast majority of wastes (around 90 percent) destined for the NSDF are either already in storage at CRL or will be generated from the decommissioning of redundant facilities or future operations at CRL. The NSDF would also receive small amounts of radioactive wastes from Canadian hospitals, universities, research entities and industry clients, which is consistent with existing commercial arrangements that have been in effect for decades.

K.2.6.2 Hydro-Québec

H-Q produced a waste management strategy for decommissioning in 2016. Waste was quantified and possible disposal options were documented. H-Q is currently working on reducing these volumes to avoid filling the on-site waste storage facility and to minimize the L&ILW to be handled later on. Projects are underway to dispose of VLLW off-site.

In terms of long-term waste management, H-Q is continuing its discussions with industry partners. H-Q does not foresee developing its own site; rather, it expects to become a partner in developing a site for the final disposal of its L&ILW.

K.2.6.3 New Brunswick Power

NB Power has engaged and continues to engage with industry to understand options for the disposal of L&ILW and to ensure appropriate funds are available when required, including participating in the COG peer groups and supporting joint projects.

K.3 Overarching Issues from the Sixth Review Meeting

During the Sixth Review Meeting, overarching issues resulting from cumulative discussion within the country groups were identified. The contracting parties agreed that the following issues would be addressed within national reports highlighting the measures that have been taken to implement these issues:

1. implementation of national strategies for spent fuel and radioactive waste management (K.3.1)
2. safety implications of long-term management of spent fuel (K.3.2)
3. linking long-term management and disposal of disused sealed radioactive sources (K.3.3)
4. remediation of legacy sites and facilities (K.3.4)

K.3.1 Implementation of national strategies for spent fuel and radioactive waste management

In September 2019, Canada hosted an IAEA Integrated Regulatory Review Service (IRRS) mission which concluded that Canada has a comprehensive framework for nuclear and radiation safety, and it noted six good practices for other countries to consider. The review also included a recommendation that the government should enhance the existing policy and establish the associated strategy to give effect to the principles stated in Canada's Radioactive Waste Policy Framework.

Canada will be reviewing its existing policy for radioactive waste and considering how it can be enhanced, including establishing an associated strategy. NRCan will undertake this review as the lead government department responsible for developing and implementing federal nuclear energy policy in Canada. This work is expected to be completed before a follow-up IRRS review takes place. A follow-up mission will be held within four years to evaluate Canada's progress in addressing the review team's findings and recommended improvements.

K.3.2 Safety implications of long-term management of spent fuel

K.3.2.1 Nuclear Waste Management Organization

The technical end-point of APM is a DGR. The primary waste form will be CANDU fuel bundles from the Canadian NPPs, and the plan will address long-term waste management for spent fuel from all the Canadian utilities. This simplifies the safety case and design of the operational facility and geological repository. For example, spent fuel handling at the repository site will largely consist of transferring dry fuel bundles from transportation packages to disposal containers, then placing those containers underground.

The age of the fuel is directly relevant, as older fuel is less gamma active and less heat-emitting, which simplifies handling; in particular, bundles received can be handled without water cooling. Aging could also lead to a greater risk of the mechanical failure of the bundles. Known damaged fuel in general is expected to be canned at the stations; the NWMO plans include special cans for handling damaged fuel. However aging effects could lead to some fuel breaking during the transport to or handling at the NWMO site. The facility will be designed to accommodate such damaged fuel; however, the extent of the damage will be a factor in design optimization and safety case development for the surface fuel handling facilities.

If Canada chooses to reprocess nuclear fuel in the future, it would be a joint decision by the nuclear energy producers, the associated provincial governments and the federal government. The NWMO is responsible for implementing APM, Canada's plan for the long-term management of Canada's spent fuel. It does not have a mandate to reprocess or reuse nuclear fuel, and no utility or government has announced plans to recycle Canada's spent fuel. If such a decision was made, the NWMO would work with utilities and government to safely manage the HLW that would result from this process.

K.3.2.2 Hydro-Québec

H-Q faced major challenges following the decision to permanently shut down the Gentilly-2 NGS in 2012. Those challenges included defueling the reactor and draining contaminated systems. Further, although several employees had to be relocated to other divisions of the company, H-Q had to maintain adequate expertise at Gentilly-2 to continue early decommissioning activities safely. Once those activities were completed, a permanent organization was put in place to ensure decommissioning activities are performed during the storage-with-surveillance (SWS) preparation phase (2015–20). This organization is composed of about 70 employees, 95 percent of whom worked at Gentilly-2 while it was in operation.

In 2019, H-Q formalized the organizational structure that will be put in place to carry out the activities during the SWS phase (2021–57). This organization will be composed of a Gentilly-2 facilities director, a manager and nine employees. The structure will be gradually deployed in 2020.

K.3.3 Linking long-term management and disposal of disused sealed radioactive sources

Since the Sixth Review Meeting, Canada has placed increased focus on requiring owners of disused sealed sources to report sources for which there is no longer a foreseeable use as part of their waste inventory. Strategies for the long-term management of these materials will need to be developed by the owners.

The financial guarantee insurance program for nuclear substance and radiation device licensees is meant to discourage licensees from holding on to disused sources, as the premium paid by licensees is directly related to the number of sealed sources they have in their possession (for more information refer to section J.1.3.7)

Currently, when a licensee decides they want to dispose of a sealed source, the source is transferred to a licensed WMF for interim storage.

CNL has repatriated disused sources that are of Canadian origin, specifically sources or equipment that were sold under the previous iteration of AECL, and resided in a country that currently has no means of appropriate waste management. At CNL managed sites, disused sources are treated the same as other radioactive wastes in terms of strategy, and they are currently in storage commensurate with the activity and half-lives of the radionuclides, awaiting the availability of a suitable disposal facility. CNL's Integrated Waste Strategy, which encompasses all waste generated by CNL and/or received by CNL, has been completed since the Sixth Review Meeting and is currently being implemented.

K.3.4 Remediation of legacy sites and facilities

K.3.4.1 Management of historic low-level radioactive waste

In 1982, the Government of Canada established the Low-Level Radioactive Waste Management Office (LLRWMO) within AECL to carry out Canada's responsibilities for the management of historic LLW in Canada.

The scope of the LLRWMO covers two major programs: a historic radioactive waste program involving the cleanup and management of historic LLW across Canada, and an information program on radioactive wastes in Canada. Over the course of its existence, the LLRWMO has completed historic radioactive waste cleanups across Canada and continues to monitor several sites with historic radium or uranium contamination.

During the planning stage for the PHAI, it was determined that, due to the size and complexity of the two PHAI projects (described below), a dedicated entity should be established for their management. In August 2009, AECL, NRCan, and Public Works and Government Services Canada formed the PHAI Management Office, a tripartite organization with a mandate to plan, manage and implement the PHAI.

Since the transition to a GoCo model in September 2015, AECL is now the government organization responsible for delivering on the federal government's responsibilities with respect to the PHAI and LLRWMO. Under a GoCo contractual arrangement, CNL delivers the PHAI and LLRWMO scopes of work on behalf of AECL. The PHAI focuses on the historic wastes in Port Hope and Clarington, Ontario; the LLRWMO focuses on historic wastes elsewhere in Canada, primarily the GTA and along the NTR in the Northwest Territories and northern Alberta.

K.3.4.2 Port Hope Area Initiative

The bulk of Canada's historic LLW is located in the southern Ontario municipalities of Port Hope and Clarington. These wastes and contaminated soils amount to roughly 2 million m^3. They originate from the operation of a radium and uranium refinery in Port Hope dating back to the 1930s. Although it recognizes that there are no urgent health or environmental risks, the Government of Canada has determined that intervention measures are required so that more appropriate long-term management can be put in place 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 PHAI. The objective of the PHAI is to safely manage the historic LLW in two above-ground mounds that are being constructed in the local communities. The initiative comprises two projects: the Port Hope Project (see figure K.12) and the Port Granby Project.

Figure K.12: Visualization of proposed WMF, Port Hope Project

In January 2012, the Minister of Natural Resources announced a Government of Canada investment of $1.28 billion over 10 years for the PHAI implementation phase.

The Port Hope Project entails cleaning up the urban area and 13 major sites, and consolidating all of the wastes in Port Hope (approximately 1.2 million m^3 in total, including waste from the current Welcome WMF) at one long-term WMF, at the site of the existing Welcome WMF. The waste water treatment plant for the proposed long-term WMF was completed in 2016 and is now operational. Construction of the containment mound commenced in the summer of 2016. The first cell was completed in late 2017. On-site waste placement from the Welcome WMF began in 2017 and was followed by placement of wastes from sites within the community in 2018. The remediation of the Port Hope sites is expected to be complete in 2025–26.

The Port Granby Project involved relocating the existing Port Granby wastes (approximately 770,000 m^3) to a new above-ground long-term WMF. Construction of the Port Granby containment mound commenced in the spring of 2016. On November 1, 2016, the first truckloads of LLW were transported away from the Lake Ontario shoreline to the newly built Port Granby WMF, and the legacy waste removal was completed in February 2020. The final waste placement of lightly contaminated infrastructure materials (from haul roads, drainage ditch liners, etc.) will be completed in 2020, after which the mound's cover system will be constructed. That cover system is expected to be completed in 2021.

Information for the general public regarding either the Port Hope or Port Granby project is transmitted through newsletters, open house events, direct contact with communications specialists in the Project Information Exchange and via the official PHAI website at phai.ca.

Figure K.13: Radiological investigation at a residential property

The cleanup in Port Hope and Port Granby is slated for completion by 2023. After the emplacement of wastes and the closure of the new WMFs, the long-term monitoring and maintenance phase will begin and continue for hundreds of years.

K.3.4.3 Other historic radioactive waste sites

On behalf of AECL, CNL delivers on the scope of the LLRWMO which involves managing sites along the NTR in the Northwest Territories and northern Alberta that are contaminated with low concentrations of uranium ore and properties in the GTA that are contaminated with radium.

Wok is currently underway to quantify the extent of historic LLW liabilities across Canada (non-Port Hope sites) and develop plans for their discharge. A key objective for CNL is to significantly reduce or eliminate liabilities by 2026 by safely executing remediation projects to facilitate cost-effective long-term management of historic LLW facilities and programs; this is consistent with policy direction provided by AECL.

Since the Sixth Review Meeting, the following progress has been achieved:

- The means of disposal for wastes from the cleanup of contaminated sites along the NTR has been identified and secured.
- Additional characterization has confirmed that the majority of the contamination to be remediated at sites along the NTR is below the threshold for categorization as LLW and is NORM.
- Preparations to begin the remediation of contaminated sites along the NTR have started; the plan is to have substantially completed all identified remediations by 2026.
- Selective remediation has been undertaken in the GTA in response to requests for support from property owners.

K.3.4.4 Management of uranium tailings

Since 1995, the CNSC has required that all operating uranium mines have an approved preliminary decommissioning plan (PDP) as well as a financial guarantee to ensure funds will be available for decommissioning. For uranium mines that were closed before these requirements were put in place, the federal and provincial governments have made provisions to ensure that those sites are properly decommissioned.

Uranium mines that operated in Ontario between 1955 and 1996 represent more than 80 percent of the uranium tailings in Canada. Before 1977, the regulation of uranium mining was primarily the responsibility of the province. In 1996, the governments of Canada and Ontario entered into a memorandum of agreement that outlined their respective roles in the management of uranium mines and mill tailings in Ontario. If an owner is unable to finance the costs of decommissioning a uranium mine site, the costs will be shared by the two governments equally. To date, these arrangements have not been necessary, as all Ontario sites have now been substantively decommissioned, and the owners continue to fulfill their responsibilities.

During the late 1950s and early 1960s, uranium supplied to Canada's Cold War allies was produced in the Gunnar and Lorado mines and mills (along with several other smaller mines) in northern Saskatchewan. At the time, these mines operated under provincial regulations that did not require site decommissioning to the level that would be expected today. As a result, environmental impacts to local soils and lakes need be addressed. In addition, because the private sector companies that operated these mines no longer exist, these abandoned sites have become the responsibility of the provincial government.

In September 2006, the governments of Canada and Saskatchewan entered into a memorandum of agreement through which Canada would provide up to $12.3 million to assist the province with the remediation of these sites. In 2007, Saskatchewan entered into a contract with the Saskatchewan Research Council (SRC) to manage the remediation program. The environmental assessment for the project to remediate the Gunnar uranium mine and mill site began on June 15, 2007, and an environmental impact statement was submitted for review to the CNSC in January 2011. A revised statement was submitted for review in March 2013, and a CNSC licence for a 10-year period was issued in January 2015. Remediation work commenced in 2017 and will continue until late 2025. The Lorado tailings management site is being remediated by the government of Saskatchewan through the SRC under a 10-year CNSC licence issued in 2013. The remediation activities were completed in 2016; the site is now transitioning into the long-term monitoring phase.

K.4 International cooperation

K.4.1 Treaty on the Non-Proliferation of Nuclear Weapons

Canada is a signatory of the *Treaty on the Non-Proliferation of Nuclear Weapons*. Pursuant to that treaty, Canada signed the *Agreement Between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear*

Weapons, as well as an additional protocol to that agreement. Under 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 materials or activities in Canada.

As a result of these commitments, much of the nuclear material and many of the facilities identified in this report are also subject to the terms and conditions of the safeguards agreements, in accordance with the Joint Convention. The CNSC is the designated government authority responsible for implementing the requirements of the safeguards agreements under the regulatory framework established through the NSCA and its regulations.

K.4.2 Incident and Trafficking Database

The CNSC is home to the Canadian team that reports to the IAEA and contributes to the Incident and Trafficking Database (ITDB), identifying incidents of malicious use, theft, and missing and lost nuclear and other radioactive material. This team is located within the Nuclear Security Division. The IAEA ITDB 2020 Fact Sheet [20] describes the database as follows:

"The IAEA Incident and Trafficking Database (ITDB) system assists the IAEA's Secretariat, participating States and selected international organizations in improving nuclear security. The ITDB staff maintains a growing collection of authoritative information, reported by participating States, on incidents involving illicit trafficking and other unauthorized activities involving nuclear and other radioactive materials. This information is disseminated through the IAEA to participating States and certain international organizations. Reporting to the ITDB is voluntary. As of 31 December 2019, 139 States were participating in the ITDB programme. Comoros joined the ITDB as a participating State in 2019. The ITDB receives authoritative information on confirmed incidents as reported by States through their officially nominated Points of Contact. This Fact Sheet summarizes the details of these confirmed incidents."

The Canadian ITDB reporting team is composed of a nominated point of contact, a nominated alternate point of contact, as well as a nuclear security administrator and two staff draft access accounts. The ITDB relies heavily on incidents submitted to the CNSC duty officer, the CNSC Event Information Tracking System, intelligence contacts, and local and national law enforcement contacts.

Canada remains one of the most active and transparent participants to the ITDB program, with 357 submitted incidents. On average, Canada submits approximately 30 incidents to the IAEA each year.

In 2018, the Canadian ITDB team rolled out an information dissemination program to ensure that Canadian and relevant international ITDB event reports are shared to a restricted list of CNSC staff, other government departments and local law enforcement.

K.4.3 CNSC international collaboration on DGRs

The CNSC belongs to a number of international groups that exchange information and knowledge about DGRs. One such group is the DGR Regulators Forum (DGRRF), whereby the CNSC meets with other regulators annually to learn more about their DGR licensing process, including pre-licensing activities.

In addition, as part of the IAEA, the CNSC is a member of several working groups, including:

- Working Group of the International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF Part III)
- Working Group on the Use of Monitoring Programmes in the Safe Development of Geological Disposal Facilities for Radioactive Waste
- Underground Research Facilities Network for Geological Disposal

Furthermore, the CNSC is a member of the Organisation for Economic Cooperation and Development (OECD)–Nuclear Energy Agency (NEA) Integration Group for the Safety Case (IGSC), which helps member countries develop effective safety cases that are supported by a robust scientific technical basis. In addition to the technical aspects in all developmental stages of repository implementation, the group also provides a platform for international dialogue between safety experts to address strategic and policy aspects of repository development.

The CNSC has bilateral agreements with the Swiss Federal Nuclear Safety Inspectorate and the French Institute for Radiological Protection and Nuclear Safety, whereby DGR-related knowledge is shared across relevant areas, which range from pre-licencing and licencing activities to research activities.

The CNSC is an active member of the Development of Coupled Models and Their Validation Against Experiments (DECOVALEX) project, which is an international collaboration on research and model comparison initiated in 1992 to advance the understanding and modeling of coupled THMC processes in geological systems.

The CNSC also participates in the Sustainable Network for Independent Technical Expertise of Radioactive Waste Disposal (SITEX II) which is a forum for regulators, technical support organizations and civil society groups on the safety of radioactive waste management.

K.5 International peer reviews

Canada has hosted international peer reviews which covered spent fuel and radioactive WMFs and will continue to identify opportunities for future reviews.

K.5.1 Integrated Regulatory Review Service

In September 2019, the CNSC hosted an IAEA IRRS mission to Canada. The objective of an IRRS mission is to evaluate a Member State's regulatory infrastructure for safety against IAEA safety standards. An IRRS mission results in findings, which include recommendations and suggestions for improvement as well as good practices.

Canada previously hosted an IRRS mission in 2009 and the IRRS review team determined that Canada had a mature, well-established nuclear regulatory framework. A follow-up mission took place in 2011 to assess Canada's progress against the 2009 IRRS findings and the CNSC's response to the Fukushima Daiichi events, and to review the regulation of the transport of nuclear substances. The follow-up mission review team noted that the CNSC's response to the events at Fukushima was prompt, robust and comprehensive. All action items resulting from the 2009 and 2011 IRRS peer review missions have been completed and closed.

The scope of the 2019 mission included all activities and facilities licensed by the CNSC, including the regulation of WMFs. The only exceptions were emergency preparedness and response (module 10), as this was covered by the EPREV mission also held in 2019, and medical exposure, which falls under provincial and territorial jurisdiction in Canada.

The 2019 IRRS mission confirmed that the CNSC has a strong regulatory framework and continues to ensure the safe operation of nuclear facilities in Canada. The mission to Canada provided valuable insights for the CNSC and the other participating parties. Along with a number of good practices, the CNSC and other Canadian federal departments were presented with suggestions and recommendations to further improve Canada's oversight of the nuclear industry, including the CNSC's regulatory framework (see section K.2.1 on modernizing the waste and decommissioning regulatory framework). Most of the findings are directly related to how Canada regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and to protect the environment, which fall within the CNSC's mandate. However, a few elements highlighted in the findings are not under the CNSC's purview; they come under the oversight of other Canadian federal departments. These other departments include NRCan, which is the lead department responsible for developing and implementing federal nuclear energy policy, and Health Canada, which is responsible for promoting and protecting Canadians' health from the risks posed by exposure to natural and man-made sources of ionizing radiation in living, working and recreational environments.

The IAEA IRRS Final Report to Canada can be found at: https://www.iaea.org/sites/default/files/documents/review-missions/irrs_canada_2019_final_report.pdf.

The CNSC developed an action plan to address the findings of the 2019 IRRS mission. On February 18, 2020, the CNSC publicly shared Canada's response to each recommendation, suggestion and good practice. Measures include developing and updating some CNSC regulatory documents, and having NRCan review its existing policy for radioactive waste and consider ways to enhance it, to give effect to the principles stated in the Radioactive Waste Policy Framework, which include establishing an associated strategy. The action plan can be found at: http://www.nuclearsafety.gc.ca/eng/resources/international-cooperation/irrs/canada-response-irrs-2019.cfm.

The actions listed in Canada's response to the 2019 IRRS report show Canada's commitment to addressing the findings of the 2019 IRRS mission. These actions will be the measures used to determine whether recommendations and suggestions have been fully addressed prior to the IRRS follow-up mission.

The CNSC will continue sharing progress on continuous improvement initiatives that result from the 2019 IRRS mission in an open and transparent manner. In keeping with international best practice, a follow-up mission will be held within four years to evaluate Canada's progress in addressing the review team's findings and recommended improvements.

K.5.2 Emergency Preparedness Review

From June 3 to 13, 2019, the IAEA carried out an EPREV at the request of the Government of Canada, making Canada the first G7 country to request an EPREV mission and highlighting its commitment to protecting the health and safety of Canadians. This mission focused on preparedness for emergencies originating from events at Emergency Preparedness Category I facilities, as defined in *IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency*, which includes emergencies taking place at NPPs, irrespective of their initiating events.

The IAEA recognized Canada for several good practices that go beyond expectations in the IAEA safety standards and made some recommendations and suggestions to strengthen emergency preparedness and response.

This IAEA mission concluded that the Government of Canada is to be commended for the well-developed and mature emergency preparedness and response system in place across all levels of government. This system, consistent with the Constitution and governance system in Canada, places leadership for preparedness and response for emergencies at NPPs largely with authorities in Ontario and New Brunswick, the two provinces in which operating NPPs are located. The federal government acts in a support role, as requested by the provinces and within areas of exclusive federal jurisdiction.

The government and Nuclear Insurance Association of Canada were commended for developing a streamlined process for timely submission and processing of claims after a nuclear or radiological emergency, including a fully accessible web platform.

Canada was also commended for its implementation of the IAEA Safety Standards throughout its emergency preparedness and response program, and for exceeding them in some cases. In addition, in hosting an EPREV, the Canadian government has taken a leadership role among developed countries with mature nuclear power programs by availing itself of the IAEA emergency preparedness and response peer review service.

Canada continues to work with the IAEA to enhance its national emergency preparedness and response arrangements and has developed an action plan to implement the recommendations and suggestions in the IAEA mission report. Furthermore, Canada has committed to inviting the IAEA to carry out an EPREV follow-up mission to review its implementation actions.

The review included a recommendation that the Government of Canada should document and fully develop roles, responsibilities and arrangements for the safe management of off-site radioactive waste arising from an emergency. In response, Canada's action plan calls for formalizing a national waste management working group, outlining roles and responsibilities, and developing formal waste management arrangements for off-site radiological waste management.

The full IAEA EPREV report can be found at https://www.iaea.org/node/51147.

Canada's response to the EPREV report can be found at https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radiological-nuclear-emergencies/how-canada-prepares/international-atomic-energy-agency-emergency-preparedness-review-mission-canada-june-2019/canada-response.html.

K.5.3 International Physical Protection Advisory Service

The International Physical Protection Advisory Service (IPPAS) was established by the IAEA in 1995. The service is a fundamental part of the IAEA's efforts to help its member states establish and maintain an effective national nuclear security regime that protects against both the unauthorized removal of nuclear and other radioactive material, and the sabotage of nuclear facilities, other associated facilities and material during transport. The IPPAS fulfills this function, yet it recognizes that the ultimate responsibility for physical protection lies with the member state.

In October 2015, Canada hosted an IAEA IPPAS mission. The mission to Canada was highly successful and the IAEA team noted in their final report that Canada has a "mature and robust nuclear security regime". OPG's Western Used Fuel Dry Storage Facility (at the Western WMF) was reviewed as part of the IPPAS mission to Canada. The report included three recommendations, 30 suggestions and 21 good practices. The CNSC elected to address the recommendations and suggestions through its Harmonized Plan. A formal IPPAS management action plan was approved and findings were assigned to CNSC subject matter experts for action which has continued throughout this reporting period. Good practices were shared with various stakeholders but were not addressed in the management action plan. The IAEA IPPAS report is publicly available at http://nuclearsafety.gc.ca/eng/resources/emergency-management-and-safety/index.cfm.

The licensees that participated in the mission (Bruce Power, OPG, Nordion and McMaster University) and their industry peers from high-security nuclear facilities have been briefed on the findings from the IPPAS mission. CNSC staff provided guidance on how to address each area in which the licensed facilities may be impacted by the findings. The CNSC also encouraged the licensee participants in the mission to share with their peers for benchmarking purposes.

The CNSC intends to invite a follow-up IPPAS mission after the revised *Nuclear Security Regulations* are published.

K.6 Openness and transparency

Canada has a dedicated web page on the Joint Convention that gives the public access to all previous Canadian national reports: http://nuclearsafety.gc.ca/eng/resources/publications/reports/jointconvention/. Canada also publishes answers to questions presented to Canada about the report, as well as presentations given at the review meetings. In addition, Canada's web page offers information about the IAEA Joint Convention and includes a link to the Joint Convention web page.

Furthermore, in order to enhance openness and transparency, updates to Canada's Joint Convention web page are proactively shared with the public. When a new national report becomes available, Canada issues a news release and sends a notification of publication to a distribution list of approximately 4,000 members of the media and the public. Social media is also used to disseminate information to the public, with regular announcements about related publications appearing on the CNSC's Facebook and Twitter pages. Canada also communicates regularly with the public on social media to provide updated statuses of review meetings and information about upcoming activities related to the Joint Convention.

During the Sixth Review Meeting of the Joint Convention, Canada received a "good practice" mention for its commitment to openness and transparency by providing opportunities for public involvement in annual regulatory oversight reporting, independently of licensing processes.

The CNSC Commission makes its decisions fairly and transparently, guided by clear rules of procedure. The Commission takes into account the views, concerns and recommendations of CNSC staff, interested parties and interveners when establishing regulatory policy, making licensing decisions and implementing programs.

Public hearings – written only or with both oral and written submissions – are the public's primary opportunity to participate in the licensing process. CNSC staff participate in all public hearings to advise and make recommendations to the Commission.

In addition to public hearings, the Commission also holds public meetings. The Commission publishes a notice in advance of each meeting, inviting the public to attend. The opportunity for interventions on specific meeting items is determined by the Commission on a case-by-case basis. Meetings are webcast live and a written transcript and archived webcast are posted to the CNSC's external website afterward. Minutes of the meeting are approved by the Commission members and posted on the CNSC's external website. For more information, refer to section E.3.1.3.1.

Every three years, NRCan collects, compiles and analyzes data on the radioactive waste inventory in Canada. The updated data is published in the triennial *Inventory Summary Report* which provides an overview of the production, accumulation and future projections of radioactive waste in Canada based on Canada's four waste classes. Some information and excerpts from Canada's national reports were used to prepare this document. NRCan also contributes this data to the IAEA's radioactive waste management database, which tracks L&ILW worldwide.

K.6.1 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. In areas like security, emergency preparedness and mining, however, provincial departments or other federal departments have legislated parallel or complementary responsibilities.

In addition, to fulfill Canada's international obligations, the CNSC collaborates with various agencies, such as its counterparts in other countries and Global Affairs Canada, to ensure that nuclear cooperation is consistent with the terms of international agreements and the non-proliferation regime.

The CNSC's cooperation and involvement with international nuclear organizations extends to the IAEA and the OECD-NEA. The CNSC's role is to promote Canadian interests and evaluate international recommendations, standards and guides for adoption into the CNSC's regulatory framework.

K.6.2 Outreach at the CNSC

Disseminating technical, scientific and regulatory information related to nuclear activities is part of the CNSC's mandate. These outreach activities are meant to demystify nuclear science, describe the CNSC's role as Canada's nuclear regulator and bring a CNSC face into communities across the country. Outreach activities are also meant to bring openness, transparency and timely communication to the work and management of Canada's nuclear regulatory regime.

Because the CNSC has a reputation as an unbiased scientific expert in the nuclear field, it has been urged, now more than ever, to take part in outreach and engagement activities and events. The organization also strives to involve stakeholders, the public and Indigenous communities in the regulatory process through a variety of appropriate consultation opportunities.

Figure K.14: Students learn about radiation fundamentals from CNSC staff

K.6.2.1 Definition of outreach

Outreach is the delivery of awareness activities through targeted interactive forums to interested parties. These activities are designed to educate the public, licensees and other stakeholders about a particular issue or topic. Outreach is a way to deliver on the CNSC's mandate to disseminate objective scientific, technical and regulatory information to the public. It includes:

- meetings with municipal officials and community groups
- interactions with the public
- public hearings of the Commission, 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 or the Cost Recovery Advisory Group)
- presentations by the president, executives and staff at various seminars and stakeholder meetings
- participation in international and national conferences and events
- proactive media relations events
- consultations on impact assessments
- social media

Figure K.15: CNSC outreach with students

K.6.2.2 Definition of engagement

Engagement is a means of involving stakeholders in key issues. It involves providing information, understanding concerns and identifying solutions through collaboration between the CNSC and stakeholders. Engagement requires ongoing and sustained two-way dialogue.

K.6.2.3 Definition of consultation

Consultation is a means of involving stakeholders in the regulatory process. Through consultation, the CNSC receives feedback from individuals or groups on specific projects, policies or programs that may affect them directly or in which they have a significant interest.

K.6.2.4 Indigenous engagement

The CNSC seeks opportunities to work with Indigenous peoples to understand any concerns they may have about the nuclear sector and to ensure the safe and effective regulation of nuclear energy and materials.

As an agent of the Crown, the CNSC is responsible for fulfilling its legal duty to consult, and where appropriate, accommodate Indigenous peoples when its decisions may have an adverse impact on potential or established Indigenous and/or treaty rights pursuant to section 35 of the *Constitution Act, 1982*.

The CNSC's approach to Indigenous consultation includes commitments to uphold the honour of the Crown by sharing information, building relationships, promoting reconciliation and meeting its common-law duty to consult. The CNSC supports a coordinated, whole-of-government approach to improve the efficiency and effectiveness of the consultation process.

The CNSC cannot delegate its obligation, but it can assign procedural aspects of the consultation process to licensees and proponents, where appropriate. In many cases, licensees are best positioned to collect information and propose any appropriate additional measures. The information collected and measures proposed by licensees and proponents to avoid, mitigate or offset adverse impacts may be used by the CNSC in meeting its consultation obligations and in its reconciliation efforts.

Further information on the CNSC's approach to Indigenous consultation and engagement can be found in CNSC REGDOC-3.2.2, *Indigenous Engagement,* version 1.1.

Figure K.16: CNSC staff give a presentation to members of a community

K.6.3 CNSC requirement for public information programs

REGDOC-3.2.1, *Public Information and Disclosure* sets out the regulatory requirements of the CNSC for public information and disclosure, for licensees and applicants. A program for public information includes a public disclosure protocol regarding events and developments involving their facilities and/or activities. This document also provides guidance on how licensees and licence applicants can meet the regulatory requirements by providing explanatory information, process and procedural guidance, and examples of good practices currently in use in the nuclear sector. This document is also intended to assist CNSC staff in assessing the public information program and its disclosure protocol for a new CNSC licence, a licence renewal or continuing compliance verification.

This regulatory document applies to all uranium mines and mills and Class I nuclear facilities. It also applies to a Class II facility that is required to develop and implement a public information and disclosure program as a condition of its licence.

The primary goal of a public information program, as it relates to the licensed activities, is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of nuclear facilities are effectively communicated to the public. As a component, where the public has indicated an interest to know, the program must include a commitment to and protocol for the ongoing, timely communication of information about the licensed facility during the licence period.

The CNSC expects a licensee's public information program and disclosure protocol to be commensurate with the public's perception of risk and the level of public interest in the licensed activities, which may be influenced by the complexity of the nuclear facility's lifecycle and activities, and the risks to public health, safety and the environment perceived to be associated with the facility and activities.

References

[1] UNSCEAR, 2017. Sources, Effects and Risks of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation 2017 Report to the General Assembly, with Scientific Annexes. United Nations, New York.

[2] Ozasa K, Shimizu Y, Suyama A, et al. 2012. Studies of the mortality of atomic bomb survivors, Report 14, 1950–2003: an overview of cancer and non-cancer diseases. Radiat Res. 2012; 177(3):229–243. Published erratum appears in Radiat Res. 2013; 179: e40–e41.

[3] Eidemüller M, Jacob P, Lane RSD, Frost SE, Zablotska LB, 2012. Lung Cancer Mortality (1950–1999) among Eldorado Uranium Workers: A Comparison of Models of Carcinogenesis and Empirical Excess Risk Models. PLOS ONE 7(8): e41431.

[4] Lane RSD, Thompson P, Ilin M, Phaneuf M, Burtt J, Reinhardt P, 2011. Use of a Weight of Evidence Approach to Determine the Likelihood of Adverse Effects on Human Health from the Presence of Uranium Facilities in Port Hope, Ontario. Journal of Environmental Protection 2: 1149-1161.

[5] Lane, R.S.D., Tomášek, L., Zablotska, L.B. et al. Low radon exposures and lung cancer risk: joint analysis of the Czech, French, and Beaverlodge cohorts of uranium miners. Int Arch Occup Environ Health 92, 747–762 (2019).

[6] Lane RSD, Dagher E, Burtt J, Thompson PA. 2013. Radiation Exposure and Cancer Incidence (1990 to 2008) around Nuclear Power Plants in Ontario, Canada. Journal of Environmental Protection 4:888-913.

[7] Lane RS, Frost SE, Howe GR, Zablotska LB. 2010. Mortality (1950-1999) and cancer incidence (1969–1999) in the cohort of Eldorado uranium workers. Radiation Research 174(6):773-85.

[8] Navaranjan G, Berriault C, Do M, et al. Cancer incidence and mortality from exposure to radon progeny among Ontario uranium miners. Occupational and Environmental Medicine 2016; 73:838-845.

[9] Zablotska LB, Lane RSD, Frost SE, 2013. Mortality (1950–1999) and cancer incidence (1969–1999) of workers in the Port Hope cohort study exposed to a unique combination of radium, uranium and gamma-ray doses. British Medical Journal Open 3: e002159.

[10] Zablotska, L., Lane, R. & Thompson, P. A reanalysis of cancer mortality in Canadian nuclear workers (1956–1994) based on revised exposure and cohort data. Br J Cancer 110, 214–223 (2014a).

[11] Zablotska LB, Lane RSD, Frost SE, Thompson PA. 2014b. Leukemia, lymphoma and multiple myeloma mortality (1950–1999) and incidence (1969–1999) in the Eldorado uranium workers cohort. Environmental Research 130: 13-50.

[12] Zablotska LB, Fenske N, Schnelzer M, Zhivin S, Laurier D, Kreuzer M, 2018. Analysis of mortality in a pooled cohort of Canadian and German uranium processing workers with no mining experience. International Archives of Occupational and Environmental Health 91, 91–103.

[13] Chen J, Moir D, Lane R and Thompson P, 2013. An ecological study of cancer incidence in Port Hope, Ontario from 1992 to 2007. Journal of Radiological Protection 33: 227–242.

[14] Zielinski JM, Garner MJ, Band PR, et al. Health outcomes of low-dose ionizing radiation exposure among medical workers: a cohort study of the Canadian national dose registry of radiation workers. Int J Occup Med Environ Health. 2009; 22:149–56.

[15] UNSCEAR, 2008. Sources, Effects and Risks of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation 2008 Report to the General Assembly, with Scientific Annexes. United Nations, New York.

[16] Villeneuve, P.J., Lane, R.S.D. & Morrison, H.I. Coronary heart disease mortality and radon exposure in the Newfoundland fluorspar miners' cohort, 1950–2001. Radiat Environ Biophys 46, 291–296 (2007).

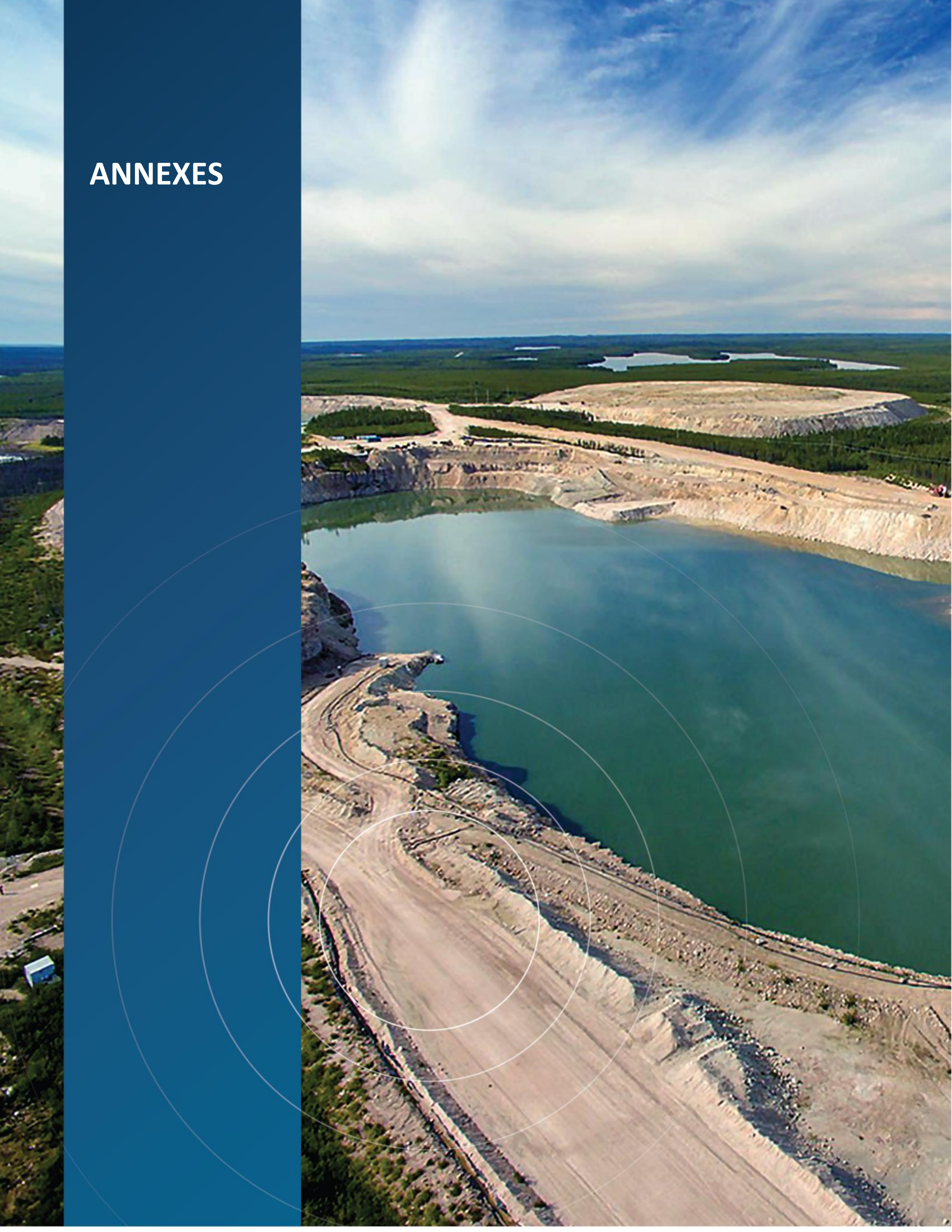
[17] Sutherland, J.K., 2003. Health Aspects of High-Level Radioactive Wastes. Nuclear Waste Management Organisation (NWMO), New Brunswick, Canada.

[18] OPG, 2011. OPG's Deep Geologic Repository Project for Low- and Intermediate-Level Waste. Environmental Impact Statement Summary. Ontario Power Generation, March 2013 https://www.nwmo.ca/~/media/Site/Files/PDFs/2015/11/09/12/54/551_32_NWMO_background_paper.ashx?la=en.

[19] Leiss W, 2013. Stigma and the Stigmatization of Place: A Paper commissioned by the Canadian Nuclear Safety Commission (available free online).

[20] International Atomic Energy Agency, IAEA Incident and Trafficking Database (ITDB) 2020 Fact Sheet, published January 20, 2020, https://www.iaea.org/sites/default/files/20/02/itdb-factsheet-2020.pdf.

ANNEXES



Annex 1 – Canadian Nuclear Safety Commission Regulatory Documents

A listing of CNSC regulatory documents published since the last review meeting can be found in table 1.1.

Table 1.1: Regulatory documents published by the CNSC since the Sixth Review Meeting

Document number	Document title	Publication date
REGDOC-1.1.1	*Site Evaluation and Site Preparation for New Reactor Facilities*	July 2018
REGDOC-1.1.2	*Licence Application Guide: Licence to Construct a Nuclear Power Plant*	August 2019
REGDOC-1.1.3	*Licence Application Guide: Licence to Operate a Nuclear Power Plant*	September 2017
REGDOC-1.1.5	*Supplemental Information for Small Modular Reactor Proponents*	August 2019
REGDOC-1.5.1	*Application Guide: Certification of Radiation Devices or Class II Prescribed Equipment*	April 2018
REGDOC-1.6.1	*Licence Application Guide: Nuclear Substances and Radiation Devices, Version 2*	May 2017
REGDOC-2.1.1	*Management System*	May 2019
REGDOC-2.1.2	*Safety Culture*	April 2018
REGDOC-2.2.1	*Human Factors*	March 2019
REGDOC-2.2.3	*Volume III: Certification of Persons Working at Nuclear Power Plants*	September 2019
REGDOC-2.2.4	*Fitness for Duty, Volume II: Managing Alcohol and Drug Use, Version 2*	December 2017
REGDOC-2.2.4	*Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical, and Psychological Fitness*	September 2018
REGDOC-2.2.5	*Minimum Staff Complement*	April 2019
REGDOC-2.4.3	*Nuclear Criticality Safety*	February 2019
REGDOC-2.5.1	*General Design Considerations: Human Factors*	March 2019
REGDOC-2.5.4	*Design of Uranium Mines and Mills: Ventilation Systems*	March 2018
REGDOC-2.5.5	*Design of Industrial Radiography Installations*	March 2018
REGDOC-2.5.7	*Design, Testing and Performance of Exposure Devices*	August 2017
REGDOC-2.6.1	*Reliability Programs for Nuclear Power Plants*	August 2017
REGDOC-2.6.2	*Maintenance Programs for Nuclear Power Plants*	August 2017
REGDOC-2.7.3	*Radiation Protection Guidelines for the Safe Handling of Decedents*	June 2018
REGDOC-2.8.1	*Conventional Health and Safety*	July 2019

Document number	Document title	Publication date
REGDOC-2.11	*Framework for Radioactive Waste Management and Decommissioning in Canada*	December 2018
REGDOC-2.11.1	*Waste Management, Volume II: Management of Uranium Mine Waste Rock and Mill Tailings*	November 2018
REGDOC-2.12.1	*High-Security Facilities, Volume I: Nuclear Response Force, Version 2*	September 2018
REGDOC-2.12.1	*High-Security Facilities, Volume II: Criteria for Nuclear Security Systems and Devices*	April 2018
REGDOC-2.12.3	*Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material, Version 2*	June 2019
REGDOC-2.13.1	*Safeguards and Nuclear Material Accountancy*	February 2018
REGDOC-2.13.2	*Import and Export, Version 2*	April 2018
REGDOC-2.14.1	*Volume II: Radiation Protection Program Design for the Transport of Nuclear Substances*	November 2018
REGDOC-3.1.2	*Reporting Requirements, Volume I: Non-Power Reactor Class I Facilities and Uranium Mines and Mills*	January 2018
REGDOC-3.1.3	*Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices*	March 2020
REGDOC-3.2.1	*Public Information and Disclosure*	May 2018
REGDOC-3.2.2	*Indigenous Engagement, Version 1.1*	August 2019
REGDOC-3.5.1	*Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills, Version 2*	May 2017
REGDOC-3.5.2	*Compliance and Enforcement, Volume II: Orders under the Nuclear Safety and Control Act*	December 2019
REGDOC-3.5.3	*Regulatory Fundamentals*	August 2018
REGDOC-3.5.4	*Pre-licensing Review of a Vendor's Reactor Design*	November 2018
REGDOC-3.6	*Glossary of CNSC Terminology*	December 2019

The draft regulatory documents available as of March 2020 are listed in table 1.2. Draft documents are either currently being developed by CNSC staff, issued for external stakeholder comment or revised to incorporate comments received during consultation. For a complete list of regulatory documents and the current status of the draft regulatory documents listed in table 1.2, visit the CNSC website at http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/index.cfm.

Table 1.2: Draft regulatory documents as of March 2020

Document number	Document title	Status
REGDOC-1.2.1	*Guidance on Deep Geological Repository Site Characterization*	Currently under development
REGDOC-1.4.1	*Licence Application Guide: Class II Nuclear Facilities and Prescribed Equipment*	Currently under development
REGDOC-1.6.2	*Developing and Implementing an Effective Radiation Protection Program for Nuclear Substances and Radiation Device Licences*	Currently under development
REGDOC-2.2.3	*Personnel Certification: Initial Certification Examinations*	Currently under development
REGDOC-2.7.1	*Radiation Protection*	Currently under development
REGDOC-2.7.2	*Dosimetry, Volume I: Ascertaining Occupational Dose*	Currently under development
REGDOC-2.7.2	*Dosimetry, Volume II: Technical and Quality Assurance Requirements for Dosimetry Services*	Currently under development
REGDOC-2.10.1	*Emergency Management and Fire Protection, Volume II: Framework for Recovery After a Nuclear Emergency*	Currently under development
REGDOC-2.10.2	*Fire Protection*	Currently under development
REGDOC-2.11.1	*Waste Management, Volume I: Management of Radioactive Waste*	Currently under development
REGDOC-2.11.1	*Waste Management, Volume III: Safety Case for Long-Term Radioactive Waste Management, Version 2*	Currently under development
REGDOC-2.11.2	*Decommissioning*	Currently under development
REGDOC-3.3.1	*Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*	Currently under development

Annex 2 – The Four Branches of the Canadian Nuclear Safety Commission

2.1 Regulatory Operations Branch

The Regulatory Operations Branch supports the CNSC mission and mandate by making final regulatory decisions or making recommendations to the Commission in the areas of licensing, certification and regulation of NPPs, uranium mines and mills, uranium fuel fabricators and processing facilities, WMFs, nuclear substance processing and transport, and industrial and medical applications. The Regulatory Operations Branch also coordinates the planning, monitoring and reporting of operational activities and leads the implementation of the CNSC Harmonized Plan and the CNSC Management System documentation.

This branch consists of the following directorates and respective divisions:

- Directorate of Nuclear Cycle and Facilities Regulation
    - Canadian Nuclear Laboratories Regulatory Program Division
    - Nuclear Processing Facilities Division
    - Uranium Mines and Mills Division
    - Wastes and Decommissioning Division
- Directorate of Nuclear Substance Regulation
    - Accelerators and Class II Facilities Division
    - Nuclear Substances and Radiation Devices Licensing Division
    - Operations Inspection Division
    - Transport Licensing and Strategic Support Division
- Directorate of Power Reactor Regulation
    - Bruce Regulatory Program Division
    - Darlington Regulatory Program Division
    - Gentilly-2/Point Lepreau Regulatory Program Division
    - Pickering Regulatory Program Division
    - Power Reactor Licensing and Compliance Integration Division
- Directorate of Regulatory Improvement and Major Projects Management
    - Internal Quality Management Division
    - New Major Facilities and Licensing Division
    - Regulatory Operations Coordination Division

2.2 Technical Support Branch

The Technical Support Branch supports the CNSC mission and mandate by providing leadership and specialized expertise in the areas of nuclear science and engineering, safety analysis, safety management, human factors, personnel training and certification, environmental and radiation protection, security, nuclear emergency management, safeguards, and nuclear non-proliferation.

This includes:

- participating in and supporting the licensing and compliance processes established for the CNSC's regulatory program
- developing and maintaining regulations and regulatory documents
- leading the activities associated with the CNSC's responsibilities under the IAA
- managing the CNSC's laboratory services and licensed dosimetry services
- certifying qualified licensee personnel
- overseeing implementation of the CNSC's Nuclear Emergency Management Program
- licensing the import and export of nuclear substances, materials and technology
- ensuring the effective implementation of IAEA safeguards agreements in Canada and administering Canada's bilateral nuclear cooperation agreements
- collaborating with stakeholders in Canada and other countries and sharing scientific and technical information

This branch consists of the following directorates and respective divisions:

- Directorate of Assessment and Analysis
  - Assessment Integration Division
  - Engineering Design Assessment Division
  - Operational Engineering Assessment Division
  - Physics and Fuel Division
  - Probabilistic Safety Assessment & Reliability Division
  - Reactor Behaviour Division
  - Reactor Thermalhydraulics Division
  - Systems Engineering Division
- Directorate of Environmental and Radiation Protection Assessment
  - Environmental Assessment Division
  - Environmental Risk Assessment Division
  - Health Sciences and Environmental Compliance Division
  - Laboratory Services Division
  - Radiation Protection Division
- Directorate of Safety Management
  - Human and Organizational Performance Division

  - Management Systems Division
  - Personnel Certification Division
  - Training Program Evaluation Division
- Directorate of Security and Safeguards
  - Emergency Management Programs Division
  - International Safeguards Division
  - Non-Proliferation and Export Controls Division
  - Nuclear Security Division

2.3 Regulatory Affairs Branch

The Regulatory Affairs Branch of the CNSC is responsible for providing strategic direction and for implementing the CNSC's regulatory policy, communications and stakeholder engagement, strategic planning, international relations and Executive Committee services.

This Branch consists of the following directorates, and respective divisions:

- Regulatory Policy Directorate
  - Regulatory Framework Division
  - Regulatory Policy Analysis Division
- Strategic Communications Directorate
  - Creative, Linguistic and Digital Communications Division
  - Corporate and Regulatory Communications Division
- Strategic Planning Directorate
  - Corporate Planning Division
  - Policy, Aboriginal and International Relations Division
  - Regulatory Research and Evaluation Division

2.4 Corporate Services Branch

The Corporate Services Branch is responsible for policies and programs related to the management of the CNSC's finances and administration, human resources, information technology and information management.

This branch consists of the following directorates and respective divisions:

- Finance and Administration Directorate
  - Contracting, Facilities and Administration Division
  - Corporate Security Division
  - Financial Management and Internal Controls Division

- Financial Reporting, Accounting, Policy and Systems Division

- Human Resources Directorate
    - Human Resources Planning and Talent Development Division
    - Workplace Wellness, Compensation and Resourcing Division

- Information Management and Technology Directorate
    - Enterprise Architecture and Solutions Delivery Division
    - IT Operations and Service Delivery Division
    - Policy, Planning and Project Management Division

Annex 3 – Canadian Nuclear Safety Commission Safety and Control Area Framework

Safety and control areas (SCAs) are the technical topics that CNSC staff use to assess, review, verify and report on regulatory requirements and performance across all regulated facilities and activities. By providing a common language and architecture, SCAs improve understanding and communication within the CNSC, as well as between the CNSC and licensees, the Commission and other stakeholders. The CNSC's 14 SCAs are organized in three functional areas: management, facility and equipment, and core control processes.

SCAs do not constrain the CNSC in its conduct of regulatory oversight activities. Additional topics may be added as needed to provide satisfactory assurance of compliance.

Table 3.1 outlines each functional area and their respective SCAs and specific areas.

Table 3.1: Safety and control areas

Functional area	Safety and control area	Specific area
Management	Management system	Management system
		Organization
		Performance assessment, improvement and management review
		Operating experience (OPEX)
		Change management
		Safety culture
		Configuration management
		Records management
		Management of contractors
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Initial certification examinations and requalification tests
		Work organization and job design
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Procedures
		Reporting and tending
		Outage management performance
		Safe operating envelope
		Severe accident management and recovery
		Accident management and recovery

Functional area	Safety and control area	Specific area
Facility and equipment	Safety analysis	Deterministic safety analysis
		Hazard analysis
		Probabilistic safety assessment
		Criticality safety
		Severe accident analysis
		Management of safety issues (including R&D programs)
	Physical design	Design governance
		Site characterization
		Facility design
		Structure design
		System design
		Component design
	Fitness for service	Equipment fitness for service/equipment performance
		Maintenance
		Structural integrity
		Aging management
		Chemistry control
		Periodic inspection and testing
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Radiation protection program performance
		Radiological hazard control
		Estimated dose to public
	Conventional health and safety	Performance
		Practices
		Awareness
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system
		Assessment and monitoring
		Protection of the public
		Environmental risk assessment
	Emergency management and fire protection	Conventional emergency preparedness and response

Functional area	Safety and control area	Specific area
		Nuclear emergency preparedness and response
		Fire emergency preparedness and response
	Waste management	Waste characterization
		Waste minimization
		Waste management practices
		Decommissioning plans
	Security	Facilities and equipment
		Response arrangements
		Security practices
		Drills and exercises
	Safeguards and non-proliferation	Nuclear material accountancy and control
		Access and assistance to the IAEA
		Operational and design information
		Safeguards equipment, containment and surveillance
		Import and export
	Packaging and transport	Package design and maintenance
		Packaging and transport
		Registration for use

Annex 4 – Spent Fuel Management Facilities

4.1 Bruce Nuclear Generating Station

The Municipality of Kincardine, Ontario, hosts the Bruce nuclear site, which contains two NPPs: the Bruce A NGS and the Bruce B NGS. Bruce A consists of four CANDU reactors (Units 1, 2, 3 and 4). Currently, all four units are in operation. Bruce B also consists of four CANDU reactors (Units 5, 6, 7 and 8). Units 5, 7 and 8 are currently in operation. In 2020, Unit 6 was safely removed from service in order to complete a major component replacement.

Bruce Power operates the Bruce A and Bruce B NGSs under a lease agreement with OPG. Spent fuel discharged from the reactor cores is wet-stored within the station's irradiated fuel bays. Bruce Power exercises the care and custody of the spent fuel on behalf of OPG which assumes title to spent fuel upon receiving it in the bays. After a minimum of 10 years in wet storage, Bruce Power loads used fuel into DSCs and OPG collects and transfers loaded DSCs to an on-site used fuel dry storage facility at OPG's Western WMF.

Figure 4.1: Bruce NGS Irradiated Fuel Bay

4.2 CRL National Research Universal

The NRU research reactor was 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. The NRU research reactor ceased operation on March 31, 2018. Approximately 30 related buildings and structures, along with the main reactor facility, will be turned over to decommissioning and waste management under SWS by 2021.

Spent fuel rods are initially stored in water-filled bays located within the research reactor. After an appropriate amount of time has passed to allow for radioactive decay and cooling, the spent fuel is transferred to tile holes in 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.

Figure 4.2: CRL National Research Universal

4.3 CRL Waste Management Area B

Spent fuel from the operation of research reactors at CRL is currently stored below ground in vertical cylindrical concrete structures called tile holes. These are situated in CRL 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. The fuel consists of about 700 prototype and research reactor fuel rods, with a total mass of approximately 22 tonnes. Although the fuel is safely stored, monitoring and inspection have shown that some of the fuel containers and fuel are corroding.

An above-ground dry storage facility has been constructed to repackage, dry and store this inventory of spent legacy research fuel. The last fuel package was transferred into this facility and dried in early 2020. The new dry storage system is located in the fuel packaging and storage building at Waste Management Area B. The fuel packaging and storage building contains a packaging and vacuum drying station and a monitored storage structure. The existing storage container was placed in a new stainless-steel container with the spent fuel remaining inside and dried before being placed in the monitored storage structure. The storage structure is engineered to last a minimum of 50 years and provides safe interim storage for the packaged fuel until a long-term management facility is available.

Fuels stored in tile holes at CRL since 1983 are more corrosion-resistant and continue to be stored in tile holes that are better designed to prevent water ingress.

Figure 4.3: CRL Waste Management Area B

4.4 CRL Waste Management Area G

CRL Waste Management Area G, which is operated by CNL, is a spent fuel dry storage area that contains concrete canisters, as described in section B.1.3.4.1. The NPD reactor was operated by Ontario Hydro (now OPG) from 1962 until 1987 when it was decommissioned. As part of its decommissioning program, the spent fuel was transferred to concrete canisters located at CRL Waste Management Area G. This site has stored 68 full and partial spent fuel bundles from Bruce, Pickering and Douglas Point, and 4,886 fuel bundles from the NPD reactor in 12 dry storage concrete canisters.

Note that as CNL proceeds with the decommissioning of AECL sites, and until a national repository is available, further consolidation for storage of spent fuel at CRL is planned, with transfers from WL to CRL expected to commence in late 2020. Two concrete canisters were constructed on the existing concrete support pad; the original intent was to store calcined waste from the processing of radioisotopes separated in the new processing facility at CRL which was never completed. These canisters will be combined with an additional 10 canisters, constructed in 2019, to accommodate the spent fuel currently stored at WL.

Figure 4.4: CRL Waste Management Area G

4.5 Darlington Nuclear Generating Station

The Darlington NGS, operated by OPG, consists of four CANDU reactors. The station began commercial operation in 1990 and continues to operate today. After years of detailed planning, OPG has started work to refurbish the four reactors at the Darlington site. The mid-life refurbishment of this facility will ensure continued power for 30 more years. The Darlington refurbishment is scheduled for completion by 2026.

The spent fuel generated at Darlington is stored in the spent fuel bays for a minimum of 10 years before being transferred to DSCs and moved to the Darlington WMF.

Figure 4.5: Darlington NGS

4.6 Darlington Waste Management Facility

The Darlington WMF (figure 4.6) is located at the Darlington site. It provides safe storage for the Darlington spent fuel until this fuel is transported to an alternative long-term spent fuel storage or disposal facility.

The Darlington WMF is currently made up of a processing building and two storage buildings, each designed to house up to 500 DSCs. However, the facility is designed to provide storage capacity for up to 676,000 fuel bundles (approximately 1,760 DSCs) once two additional storage buildings are constructed in the future.

The Darlington spent fuel dry storage system is designed to transfer spent fuel from wet storage in the Darlington NGS spent fuel bays into a steel clad concrete DSC designed by OPG. Before being transferred to the Darlington WMF, each loaded DSC is drained, its cavity is vacuum dried and the container surface is surveyed for loose contamination. Decontamination is carried out if necessary.

Once the DSC loaded with spent fuel is received at the Darlington WMF processing building, the transfer clamp is removed and the lid is seal-welded to the DSC body. The lid weld is subsequently inspected for defects. The DSC undergoes final vacuum drying and helium backfilling. Subsequently, the drain port is welded and inspected, and helium leak testing is performed.

Finally, touch-up paint is applied to scuffs or scrapes on the container's exterior. After processing, IAEA seals are applied to each container and placed in storage.

The Darlington WMF can process approximately 60 DSCs (or 23,040 spent fuel bundles) per year. In December 2019, a total of 664 DSCs were being stored at the Darlington WMF.

In 2019, OPG reported releases of 2,812 Bq particulate from the Darlington WMF into the air, and there were no reported releases into water. This release is orders of magnitude below the DRLs for the Darlington WMF which are derived from the public dose limit of 1 mSv/year.

Figure 4.6: Darlington WMF

4.7 Douglas Point Waste Management Facility

The Douglas Point WMF (figure 4.7) is located at the Bruce nuclear site. The prototype CANDU power reactor at Douglas Point became operational in 1968 and was shut down permanently after 17 years of operation. AECL is responsible for the decommissioning of Douglas Point, and that work is now being executed by CNL under a GoCo arrangement.

Decommissioning began in 1986. Approximately 22,256 spent fuel bundles were transported to on-site concrete canisters in late 1987. The dry fuel storage canister air sampling program demonstrates safe SWS with a continuing trend of close to zero releases. The maximum air sampling results for any one canister for 2019 was less than 0.563 Bq/filter gross gamma activity, less than 0.293 Bq/filter gross beta activity and less than 0.0291 Bq/filter gross alpha activity. This ongoing monitoring confirms that the facility continues to remain in a safe SWS state.

Figure 4.7: Fuel storage at Douglas Point

4.8 Gentilly-1 Waste Management Facility

The Gentilly-1 NGS 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. Responsibility for decommissioning Gentilly-1 belongs to AECL; this work is now being executed by CNL under a GoCo arrangement.

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 dry fuel storage canister air sampling program demonstrates safe SWS with a continuing trend of close to zero releases. Maximum air sampling results for any one canister for 2019 was less than 0.562 Bq/filter gross gamma activity, less than 0.323 Bq/filter gross beta activity and less than 2 Bq/filter gross alpha activity. This ongoing monitoring confirms that the facility continues to remain in a safe SWS state.

Figure 4.8: Internal view of the fuel storage at Gentilly-1

4.9 Gentilly-2 Nuclear Generating Station

Operated by H-Q, Gentilly-2 (figure 4.9) houses one CANDU reactor. The station went into service in 1982 and began commercial operation in 1983. At the end of 2012, H-Q ended operations at Gentilly-2 to proceed with decommissioning

Because the station has ended operations, the total number of spent fuel bundles on-site will not increase. There are 129,925 spent fuel bundles in safe storage at the station. Spent fuel is first stored in a pool; after an appropriate cooling period of at least seven years (or six years under specific conditions), it is transferred to the dry storage facility. The transfer of spent fuel in baskets is performed directly at the pool. The loaded baskets are then transferred to a shielded workstation where the contents are dried and the basket lids are welded on. Once the work on the baskets is complete, the baskets are transported to a H-Q on-site spent fuel dry storage facility.

Figure 4.9: Gentilly-2 NGS

4.10 Gentilly-2 Waste Management Facility

In operation since 1995, the Gentilly-2 WMF (figure 4.10) stores fuel used during the station's operation. H-Q was authorized to build all of the MACSTOR modules required for the storage of its spent fuel. At the end of 2019, eleven MACSTOR modules were in service. Each MACSTOR module can store 12,000 spent fuel bundles.

The storage baskets are transferred on an as-needed basis, in accordance with decommissioning planning requirements. Transfers are normally done between April and October each year until 2020. H-Q must ensure that dose rates at the fence line of these facilities stay within the authorized limit of 2.5 µSv/hour at all times.

Figure 4.10: Gentilly-2 Spent Fuel Dry Storage Facility

4.11 McMaster Nuclear Research Reactor

The McMaster Nuclear Reactor is a pool-type reactor with a core of LEU fuel moderated and cooled by light water. The reactor operates at powers of up to 5 megawatts. It was converted from HEU fuel to LEU fuel in 2006–07. The original HEU fuel was returned to a licensed spent fuel management facility in the U.S.

The McMaster Nuclear Reactor is the only Canadian medium-flux reactor operated in a university environment. The reactor's neutrons are used in nuclear physics, biology, chemistry, earth sciences, medicine and nuclear medicine. Spent fuel at the McMaster Nuclear Reactor is stored in the pool until it can be shipped to a licensed spent fuel management facility in the U.S.

Figure 4.11: McMaster Nuclear Research Reactor pool

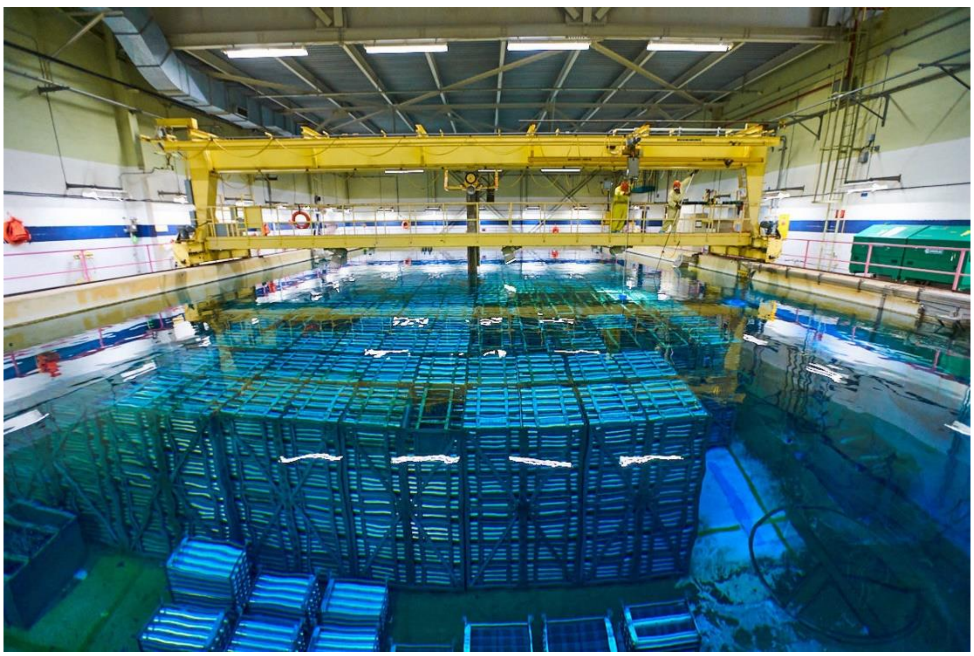
4.12 Pickering Nuclear Generating Station

Pickering hosts two NPPs, each consisting of four CANDU reactors. The first station (Units 1–4, formerly known as Pickering A) commenced operation in 1971 and Units 1 and 4 continue to operate. Units 2 and 3 were shut down in 1997 and placed in safe storage by September 2010.

The second station (Units 5–8, formerly known as Pickering B) commenced commercial operation in 1983 and continues to operate today. OPG plans to continue operating the Pickering NGS through 2024.

The spent fuel generated at both Pickering stations is stored in the spent fuel bays for a minimum of 10 years before it is transferred to the Pickering WMF. There is a primary fuel bay and an auxiliary fuel storage bay for each side of the station (014 and 058). Each bay is filled with demineralized water, with associated heat exchangers, filters and ion exchange columns to maintain water temperature and clarity. Fuel bays are connected to the station's active ventilation system to monitor for any airborne emissions.

Figure 4.12: Spent fuel bays at the Pickering NGS



4.13 Pickering Waste Management Facility

OPG's Pickering WMF processing building and first two storage buildings are located within the protected area at the Pickering site; storage buildings 3 and 4 are located within their own security protected area on the Pickering site. In operation since 1996, the facility's primary purpose is to store spent fuel from the Pickering reactors. It is expected that the Pickering WMF will be in operation (receiving spent fuel) until at least 10 years after the shutdown of the last Pickering reactor unit. The fuel will continue to be stored at the site until it is transferred to the NWMO long-term disposal facility.

The spent fuel dry storage area of the Pickering WMF comprises a dry storage container processing building and four storage buildings. The nominal design capacity of the Pickering WMF is approximately 650 DSCs, or 249,600 fuel bundles, in the two existing storage buildings in the Pickering WMF Phase I area. The Pickering WMF Phase II area has been constructed in the Pickering East complex, as shown in figure 4.13. The Pickering WMF Phase II complex currently contains two spent fuel dry storage buildings (storage buildings 3 and 4) with a nominal capacity of 500 DSCs each and has space for additional storage buildings. The storage buildings in the Pickering WMF Phase I and Phase II areas will eventually have a combined capacity of up to 3,000 DSCs, sufficient to store all of the fuel consumed during the operating lifetime of the Pickering site. The Pickering WMF Phase II area operates within its own established protected area.

Spent fuel is stored in dual-purpose (i.e., storage container plus transportation package) concrete DSCs that are identical to those currently in use at the Darlington and Western WMFs. The processing of DSCs is also identical to the operations at the Darlington and Western WMFs.

The Pickering WMF can process approximately 50 DSCs, or 19,200 spent fuel bundles, per year. As of December 2019, a total of 1,000 DSCs were being stored at the Pickering WMF.

In 2019, OPG reported releases of <1.76×10^{5} Bq particulate to air from the Pickering WMF used fuel dry storage container processing building. Total waterborne emissions for 2019 were 7.36×10^{7} Bq tritium and <2.98×10^{5} Bq gross beta/gamma. Note that the lab results for gross beta/gamma were below the detection limit. These releases are orders of magnitude below the DRLs for the Pickering WMF which are derived from the public dose limit of 1 mSv/year. It is important to note, however, that releases from the Pickering WMF are included in the total releases reported for the Pickering site (which includes 6 operating CANDU units).

Figure 4.13: Pickering WMF

4.14 Point Lepreau Nuclear Generating Station

The Point Lepreau NGS, operated by NB Power, consists of one CANDU reactor. The station commenced operation in 1982. It is currently in full-power operation following a major refurbishment outage in the fall of 2012 that will enable the station to operate for another 25 to 35 years.

Figure 4.14: Point Lepreau NGS

4.15 Point Lepreau Waste Management Facility

The spent fuel generated at Point Lepreau is initially stored in the spent fuel bay for a minimum of seven years, then transferred to the spent fuel dry storage facility (figure 4.15), also known as the Phase II area of the solid radioactive WMF. In operation since 1990, the facility provides storage capacity for Point Lepreau in 300 above-ground concrete canisters which can house a total of 180,000 spent fuel bundles. In order to handle the spent fuel from the station's extended operational life following the refurbishment outage, land was prepared to permit the construction of up to 300 additional canisters; the exact number depends on future needs.

During the reporting period (from April 01, 2017, to March 31, 2020), 28 canisters were filled and sealed; by the end of the reporting period, 225 of the 300 canisters constructed had been filled and sealed. Approximately 5,000 spent fuel bundles are transferred to dry storage for each year the station operates, depending on the power output of the Point Lepreau NGS.

Samples of surface runoff from the Phase II area, collected and analyzed over the reporting period, had an average tritium concentration of 96.4 Bq/L. The average dose rate for the reporting period at the spent fuel storage facility perimeter fence, as read from TLDs, was 0.11 µSv/hour. The regulatory limit for dose to the public is 1 mSv/year.

Figure 4.15: Point Lepreau WMF

4.16 Western Waste Management Facility

OPG's Western Used Fuel Dry Storage Facility, which is part of the Western WMF, began operations in February 2003. The facility was designed to provide safe storage for spent fuel from Bruce A and B until an alternative long-term spent fuel storage or disposal facility becomes available.

The Western WMF can currently provide dry storage for 2,000 DSCs, or 768,000 fuel bundles, generated at the Bruce NGSs in four storage buildings. The construction of the next storage buildings (storage buildings 5 and 6) is underway; completion is expected in 2021. Spent fuel is stored in dual-purpose concrete DSCs, identical to those currently in use at the Darlington and Pickering WMFs. DSCs are processed in a manner similar to that followed at the Darlington and Pickering WMFs.

The Western WMF can process approximately 130 DSCs, or 49,920 spent fuel bundles, per year. As of December 2019, a total of 1,576 DSCs were being stored at the Western WMF.

Annex 5.13 describes the combined releases to air and water of the Western WMFs spent fuel dry storage area and the L&ILW storage area.

Figure 4.16: Western Used Fuel Dry Storage Facility

4.17 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 WR-1 organic cooled reactor, which began operation in 1965. WR-1 continued to operate until 1985.

The Concrete Canister Storage Facility Program was developed at Whiteshell in the early 1970s to demonstrate that dry storage was a feasible alternative to water pool storage for spent reactor fuel.

Due to the success of the demonstration program, the Concrete Canister Storage Facility (see figure 4.17) was built to store all remaining WR-1 spent fuel. In addition, a number of spent fuel bundles from CANDU stations are stored in the facility after undergoing post-irradiation examinations in Whiteshell's shielded facilities. The facility provides storage for 2,268 spent fuel bundles originating from both the WR-1 operation and CANDU reactors. Some spent fuel from operations prior to 1975 is stored in standpipes in the waste management area. Further details on the Whiteshell decommissioning program can be found in annex 8.8.

The transfer of used fuel currently in storage at WL for consolidation at CRL until a national repository is available is expected to commence in late 2020.

Figure 4.17: Whiteshell Laboratories Concrete Canister Storage Facility

Annex 5 – Radioactive Waste Management

5.1 AECL nuclear research and test establishment facilities

AECL currently has one research facility in Canada: Chalk River Laboratories (CRL) in Chalk River, Ontario. AECL previously had another active research facility, WL in Manitoba, which is currently undergoing decommissioning (annex 8 provides more information about decommissioning activities). After transitioning to a GoCo model in 2015, these sites are operated by CNL under agreement with AECL. The radioactive wastes produced at these two sites are stored in WMFs at each site.

5.1.1 Chalk River Laboratories

The CRL site is located in Renfrew County, Ontario, on the shore of the Ottawa River, 160 kilometres northwest of Ottawa. The site, which comprises 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 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 on the CRL property, along the southwest to northeast corridor. The CRL waste management areas 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 waste management areas manage eight types of waste:

- nuclear reactor operation wastes (from AECL-owned prototype and research reactors), 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
- fuel fabrication facility wastes, which include zirconium dioxide and graphite crucibles used to cast billets, filters and other trash like gloves, coveralls and wipes
- isotope production wastes, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- isotope usage wastes, which include general radioactive wastes contaminated primarily with cobalt-60 and molybdenum-99
- hot cell operations wastes, which include cleaning materials, contaminated air filters, contaminated equipment and discarded irradiated samples
- decontamination and decommissioning wastes, which include a variety of contaminated wastes with variable physical, chemical and radiological properties
- remediation wastes, which include solidified waste resulting from the treatment of contaminated soil and groundwater
- CRL and off-site miscellaneous wastes, which include radioactive wastes that do not readily fall within the other types of wastes described above (e.g., wastes from radioisotope laboratories and workshops)

Liquid wastes, such as scintillation cocktails, radiological-contaminated lubricating oils, wastes contaminated by polychlorinated biphenyl and isotope production wastes are also handled by the CRL waste management operations. Approximately 15 to 20 m^3 of these types of waste are received into the waste management areas each year, including wastes received from off-site 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. After processing through a liquid waste evaporator, the treated effluent is monitored and released to the process sewer, which eventually discharges to the Ottawa River.

Figure 5.1: Arial photo of CRL site

5.1.1.1 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 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 reactor's calandria) that had to be managed quickly and safely. At that time, approximately 4,500 m^3 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. Waste is no longer accepted for emplacement in Waste Management Area A.

The two active liquid waste tanks in this area 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 to have received an estimated 3.7×10^{13} Bq of strontium-90 and about 100 g of plutonium. The radioactive liquids inside the tanks were recovered in 2013 and sent to an off-site service provider for processing. Retrieving the liquids from these tanks minimizes the potential for and consequences of contaminant release from the tanks.

Waste Management Area A is on the western flank of a sand ridge. Three aquifers have been identified in its vicinity: lower sand, middle sand and upper sand (see figure 5.2). 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 Waste Management Area A, but infiltration has transported contaminants into the groundwater, which creates a contaminated plume with an area extent of 38,000 m^2. Groundwater monitoring data collected to date have encountered total beta (10 Bq/L to 7,740 Bq/L), gross alpha (0.13 Bq/L to 2.5 Bq/L) and strontium-90 (5 Bq/L to 3,800 Bq/L) in some of the sample wells. The groundwater plume is subject to periodic investigations to monitor its migration and to identify any deviations from expected conditions. Routine groundwater monitoring around the perimeter of Waste Management Area A (i.e., near the source of the plume) indicates that the conditions are stable or improving, because the contamination levels in the groundwater around the perimeter are generally either remaining at similar concentrations or gradually declining with time.

The construction of a permeable reactive barrier, known as the South Swamp Groundwater Treatment System, was completed in 2013. The treatment system is intended to intercept the strontium-90 plume emanating from Waste Management Area A via the upper sand aquifer that flows into South Swamp, located in its vicinity. Sampling results confirm that the groundwater from Waste Management Area A is being treated and that the permeable reactive barrier is reducing the amount of strontium-90 reaching the South Swamp wetland from concentrations of up to 2465 Bq/L in up-gradient samples down to 0.6 to 2.4 Bq/L in the down-gradient wells.

Figure 5.2: Waste Management Area A at CRL

5.1.1.2 Waste Management Area B

Waste Management Area B was established in 1953 to succeed Waste Management Area A as the site for solid waste management at CRL. The site is located on a sand-covered upland, approximately 750 m west of Waste Management Area A. Early waste storage practices for LLW were the same as in Waste Management Area A, namely, emplacement in unlined trenches, 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 Waste Management Area B for LLW was discontinued in 1963 in favour of concrete bunkers and Waste Management Area C.

Concrete structures were used to store solid waste packages that did not meet sand trench acceptance criteria, but also did not require a significant amount of shielding. Early concrete bunkers were rectangular. These were superseded in 1979 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 m^3, but typical volumes of stored waste average about 60 m^3.

Wastes that present a higher level of hazard are also stored in Waste Management Area 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 Waste Management Area B was constructed in 2010 and made available for use in 2011.

Several groundwater contaminant plumes extend from Waste Management Area 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. This solvent 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 Waste Management Area B (near the source of the plume) indicates stable conditions, given 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 Waste Management Area 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 Waste Management Area B (near the source of the plume) indicates improving conditions; 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 2019, the Spring B Treatment Plant treated 2,201 m^3 of groundwater, removing 3.7 GBq of strontium-90 and reducing input concentrations from 1,704 Bq/L (average) to 5.0 Bq/L (average). Since the Spring B Treatment Plant is close to the end of its design life, a conceptual design for a new treatment system was finalized in 2013. Construction of the new facility has been completed and the plan is to operate the new treatment plant in parallel with the original for one year before taking the original plant out of service later in 2020.

Tritium is another contaminant observed in the groundwater at Waste Management Area B. Routine groundwater monitoring indicates that the tritium contamination levels remain stable over time. A number of different types of waste storage structures within Waste Management Area B are considered the source of this contamination.

Figure 5.3: Waste Management Area B at CRL

5.1.1.3 Waste Management Area C

CRL's Waste Management Area C was established in 1963 to receive LLW with hazardous half-lives of 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 were covered with an impermeable membrane of high-density polyethylene.

An extension was constructed adjacent to the south end of Waste Management Area 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 the surface of Waste Management Area 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 wastes 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 waste inventory, including sewage sludge, has been restricted to interim above-ground storage of sealed containers. The new bulk materials landfill was completed in 2010 and the sewage sludge in containers on the surface of Waste Management Area C was transferred to Waste Management Area J in late 2010. Groundwater monitoring data at Waste Management Area C indicates that a plume has been emanating from this area. The primary contaminant is tritium, although organic compounds are also observed at elevated concentrations in some boreholes. In 2012 and 2013, materials stored on the surface of Waste Management Area C, namely the NRX stack pieces, were removed in preparation for the installation of an engineered cover over Waste Management Area C. The NRX stack pieces were re-packed in specially designed PacTec bags and transferred to Waste Management Area H for surface storage. In 2013, the engineered cover with geotextile and geomembrane layers was installed over Waste Management Area C to minimize infiltration of atmospheric water in the stored waste.

Routine groundwater monitoring indicates that the tritium contamination levels have decreased and the plume has been receding since the engineered cover was installed in 2013. In early 2020, a nuclear safety note was prepared to consider modifications to Waste Management Area C making it possible to mobilize the area as a temporary storage location for contaminated soils in marine containers or engineered waste bags. The nuclear safety note was approved, and the prerequisite for entering the detailed design phase for the necessary modifications has been satisfied. This change will require the CNSC's consent prior to implementation.

Figure 5.4: Waste Management Area C at CRL

5.1.1.4 Waste Management Area D

Waste Management Area D was established in 1976 to store obsolete or surplus equipment and components, such as pipes, vessels and heat exchangers, that are known or suspected to be contaminated, but do not require enclosure. Much of this legacy material has been removed and either returned to owners or disposed of through off-site metal recycling in the last three years.

The mixed waste storage facility is composed of three interconnected, engineered structures designed for the safe short-term storage and handling of mixed liquid waste (i.e., waste that is both chemically and radiologically hazardous). The structures have two storage rooms with proper leak containment and ventilation, as well as a sampling or bulking area with fume hoods, exhaust and leak containment capabilities.

The site consists of a fenced compound that encloses a gravel-surfaced area in which the components are placed. Components that have surface contamination must be packaged appropriately to make them free of surface contamination.

In an aggressive cleanup campaign that started in 2014, the outside compound was cleared of all but neatly stored marine containers. In 2016, material that had been stored in the buildings from prior LLRWMO remediation activities was consolidated in modern standard storage containers to be disposed of in the proposed near-surface disposal facility, when it becomes available. All storage in Waste Management Area D is above ground. No burials are authorized in this area. Since the Sixth Review Meeting, this waste management area has been modified in conjunction with neighbouring Waste Management Area H (see annex 5.1.1.8), and boundary fences that previously prevented free movement between these two areas have been modified. To support accelerated decommissioning and waste management activities, both of these areas have been modified to be able to accommodate the development of new waste treatment capabilities (facility to support maintenance and characterization under construction in spring 2020, anticipated to become operational later in 2020), the expansion of the fenced compound area and improvement of the hard-standing surfaces to permit maximum capacity for interim storage of packaged LLW waiting for operations to begin at the proposed NSDF. Currently, the area can accommodate up to 10,000 m^3 of LLW in soft-sided packages. When the proposed modifications to store waste in Waste Management Area C are implemented (see annex 5.1.1.3), this area would be able to accommodate much more LLW for storage in marine containers.

Figure 5.5: Waste Management Area D at CRL

5.1.1.5 Waste Management Area E

Waste Management Area E is an area that received suspect and slightly contaminated soils and building materials, as well as other bulk soils and building debris, from approximately 1977 to 1984. The waste materials were used to construct a roadway in the area which was meant to become a site for suspect contaminated materials, to be used in place of Waste Management Area C, but it was never put into operation.

Figure 5.6: Waste Management Area E at CRL

5.1.1.6 Waste Management Area F

Waste Management Area 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 the possible migration of radioactive and chemical contaminants. Waste stored in this location is being considered to be used as the base waste layer of the proposed NSDF currently being proposed at CRL.

Figure 5.7: Waste Management Area F at CRL

5.1.1.7 Waste Management Area G

Waste Management Area G was established in 1988 to store the entire inventory of spent fuel from the NPD prototype reactor in above-ground concrete canisters. It originally consisted of 12 NPD fuel canisters and two calcine waste canisters. A total of 11 NPD canisters are full and one canister is empty, as a spare. The calcine waste canisters were constructed for the anticipated waste that would be created by the processing of radioisotopes separated in the new dedicated isotope facility at CRL. However, both of the calcine waste canisters are currently empty. These two canisters, plus an additional ten identical canisters that were constructed in 2019, will store all fuel from Whiteshell. Transfers from Whiteshell to CRL are expected to commence in late 2020.

Figure 5.8: Waste Management Area G at CRL

5.1.1.8 Waste Management Area H

Waste Management Area H began operating in 2002. It is the location for the MAGS and SMAGS structures. Dry LLW is packaged, and in some instances, compacted in steel containers prior to storage in MAGS (see figure 5.9) and SMAGS. In March 2014, the CNSC granted approval for the construction of six SMAGS structures at CRL. The first three structures have been completed and are operational. The remaining three have been deferred pending the availability of the proposed NSDF. Once the NSDF is operational, pending regulatory approvals, wastes that meet the proposed NSDF waste acceptance criteria will be routed directly to it and suitable wastes currently in storage will be sent to the facility for disposal. SMAGS will then be focused on storage of wastes not suitable for disposal in the proposed NSDF.

The footprint in Waste Management Area H that SMAGS 4 through 6 would have occupied has been prepared as a compacted gravel hard-standing surface to accept containerized wastes for interim storage while construction of the proposed NSDF is being planned. Since the Sixth Review Meeting, this waste management area has been further modified in conjunction with neighbouring Waste Management Area D (see annex 5.1.1.4). Waste Management Area H can now accommodate up to 138,000 m^3 of LLW in marine containers.

All waste that used to be stored in the two MAGS structures has been recovered, characterized, sorted and segregated, and repackaged in NSDF packages that are compliant with waste acceptance criteria while awaiting disposal once the proposed NSDF is available. This work has informed the development of plans for improved processing of legacy waste in storage that will need to be recovered and reworked in order to be compliant for disposal. One of the MAGS structures has now been removed to free up the footprint for the construction of the new sort and segregation facility currently under construction. The other MAGS structure is available to trial further development of improved sort and segregation techniques and procedures to be implemented in the new facility.

Figure 5.9: Waste Management Area H at CRL

5.1.1.9 Waste Management Area J

Construction of Phase 1 of the bulk material landfill located in CRL's Waste Management Area J was completed in 2010. The landfill is designed for the long-term management of the dewatered sewage sludge produced at the sewage treatment plant at CRL. Dewatered sewage sludge had been stored in roll-off containers in Waste Management Area C since 2004; the contents of these containers were safely emplaced in the bulk material landfill in late 2010.

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.

Construction of phase 2 was completed in 2017. Once all phases (a total of four) are complete, the bulk material landfill 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.

Figure 5.10: Waste Management Area J at CRL

5.1.1.10 Liquid dispersal area

The 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 Waste Management Area 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 g 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 Waste Management Area 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.

A 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.

A laundry pit, installed in 1956, is the last facility in the liquid dispersal area. As its name implies, the laundry pit was used for waste water from the active area laundry and the decontamination centre, but it was only employed for that purpose for a year. The recorded inventory is 100 GBq of mixed fission products.

The liquid dispersal area has not been used since 2000 and there are no plans for the 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; 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 facility removes a significant fraction of strontium-90 from the groundwater collected from four collection wells that are spaced across the width of the plume near the pit. In 2013, the chemical pit treatment plant treated 2,550 m^3 of groundwater, removing 2.1 GBq of strontium-90 and reducing input concentrations from 743 Bq/L (average) to 3.5 Bq/L (average).

The current groundwater treatment facility has been operating for nearly 20 years and is approaching the end of its design life. Given many recent developments, the strategy for this particular area is being revisited. With the proposed NSDF expected to be available in 2020, and with continued work on proposed land uses and interim soil cleanup levels, the future for this area could involve either early source removal or continued pump and treat. The current treatment methods will continue to be used while the options are further evaluated.

5.1.1.11 Acid, chemical and solvent pits

Three small pits are located north of Waste Management Area C and are collectively known as the acid, chemical and solvent pits. Constructed in 1982 and in operation until 1987, the pits were individually used for inactive acid, chemical and solvent wastes. The acid pit received about 11,000 L 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 L of mixed solvents, oils, paint thinner and acetone, while the chemical pit received smaller volumes of wastes. Although the intent was to exclude active materials, investigations later showed that radioactive materials were inadvertently placed in the pits due to poor segregation practices, and lightly contaminated sands were used to backfill the holes in 1987.

5.1.1.12 Waste tank farm

The waste tank farm contains seven underground stainless steel tanks that store liquid ILW. The first series of three tanks contains 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.

In 2012, the tank 40D leak avoidance project was launched to reduce the environmental risk of a leak in an aging storage structure. Tank 40D is a single-walled direct buried tank. The objective of the project was to protect the environment by removing the tank contents before any leakage occurs. By 2014, more than 80 percent of the liquid contents of this tank was retrieved and processed, leaving only a fine silty sludge. This volume was further reduced with improved filtration in 2017.

More hazard reduction activities are underway. It is expected that by 2026, the stored liquid wastes from this tank farm will have been removed and will be undergoing processing. The resulting waste product is expected to be transferred to interim storage if it is not suitable for immediate disposal in the proposed NSDF. The tank farm facilities will then be turned over for decommissioning.

5.1.1.13 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, given 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 – that operates passively using a clinoptilolite zone installed in the ground next to an impermeable barrier that extends across the plume flow path. This passive treatment system removes a significant portion of the strontium-90 activity in the influent. In 2013, the system prevented the discharge of 53.1 GBq of strontium-90 and reduced input concentrations from 2,590 Bq/L (average) to less than 1 Bq/L (average). In 2019, the estimated average concentration of strontium-90 in the groundwater entering the system was 234 Bq/L. The concentration measured in 2018 was 156 Bq/L. In 2019, the average effluent concentration was 0.283 Bq/L and the total volume of water treated was 1.57 x 107 L. The treatment system captured an estimated 3.68×10^9 Bq of strontium-90 in 2019.

5.1.1.14 Thorium nitrate pit

In 1955, about 20 m^3 of liquid waste from a uranium-233 extraction plant on the CRL site was discharged into a pit. The solution contained 200 kg of thorium nitrate, 4,600 kg of ammonium nitrate, 10 g of uranium-233 and 1.85×10^{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, then covered with soil.

5.1.1.15 Glass block experiments

In 1958, a set of 25 hemispheres of glass (weighing 2 kg each) of mixed fission products was buried below the water table as part of a program to investigate methods for converting high-level liquid radioactive 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.

5.1.1.16 Bulk storage area

The bulk storage area was used prior to 1973 to store large pieces of equipment from the control area. Significant cleanup of this area was completed, resulting in reduction of future liability. The cleanup of the area was completed in November 2013.

5.1.1.17 Emissions

The operation of the CRL waste management areas results in the release of radioactive and non-radioactive contaminants into the environment. Most of the existing releases are historic. They resulted from discontinued practices, such as the dispersal of intermediate-level liquid waste and sand trench disposal of intermediate solid and liquid wastes. The releases contaminated on-site land, groundwater and surface water, and also resulted in off-site releases of contaminants to the Ottawa River.

The contaminant concentrations in off-site 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. In addition, CRL has developed administrative levels set at a fraction of the DRL and close to the normal operating levels. These levels are used to provide timely warning that a higher than expected release has occurred and the situation will be investigated promptly.

5.1.1.18 CRL Waste Treatment Centre

The CRL Waste Treatment Centre treats wet solid wastes and liquid wastes from CRL facilities that are contaminated or suspected of being contaminated by radioactivity. It also treats small volumes of liquid radioactive waste received by CRL from off-site waste generators.

The wet solid wastes are baled (after compacting, if possible) and transferred for storage in concrete bunkers in Waste Management Area B. Between 50 and 150 bales measuring 0.4 m^3 are produced per year. In addition to those quantities, the Waste Treatment Centre generates solid waste internally. This waste includes disposable clothing, paper and cleaning materials, and is compacted (where possible), baled and stored in Waste Management Area B. Liquid waste is treated in variable amounts per year, ranging from 1,500 m^3 to 4,000 m^3/year. It consists primarily of liquid wastes from the decontamination centre, chemical active drain system and reactor active drain system. Smaller amounts of concentrated legacy-stored liquid wastes originating from historical operations are pre-treated locally with ion exchange media to reduce radioactive content prior to final treatment in the Waste Treatment Centre. Treatment facilities include a liquid waste evaporator, which concentrates the waste, and a liquid waste immobilization system, which immobilizes the concentrated liquid in a bitumen matrix in drums that are then stored in Waste Management Area B.

Since the permanent shutdown of the NRU reactor in March 2018, annual quantities of radioactive liquids sent for treatment have reduced considerably. Progress has been achieved in retrieving legacy liquid wastes as part of the stored liquid waste project. As such, operations have shifted from running both the liquid waste evaporator and liquid waste immobilization system roughly the same amount time, to operating the liquid waste immobilization system as the primary support for the stored liquid waste project and operating the liquid waste evaporator only periodically, as required. This mode of operations will continue until the Waste Treatment Centre reaches its end of life, coinciding with the completion of the stored liquid waste project, which is expected between 2026 and 2030. Future needs for liquid waste treatment capability at CRL beyond the Waste Treatment Centre are currently being determined.

Atmospheric releases of radionuclides from the Waste Treatment Centre occur via roof vents. Roof vents are monitored for particulate gross alpha activity, particulate gross beta activity, tritium oxide and iodine-131. Treated liquid effluent from the Waste Treatment Centre 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, power of hydrogen, conductivity, organic carbon, chemical oxygen demand, solvent extractables, metals, volatile organics and semi-volatiles.

5.1.2 Whiteshell Laboratories

WL is a nuclear research and test establishment currently undergoing decommissioning in Manitoba, located on the east bank of the Winnipeg River, about 100 km northeast of Winnipeg. Comprising a number of nuclear and non-nuclear facilities and activities, the major facilities on-site include the WR-1, shielded facilities, research laboratories, and liquid and solid radioactive waste management areas and facilities, which include the concrete canister storage facility complex for the dry storage of spent research reactor fuel. Annex 8.8 provides further information on these decommissioning activities.

One waste management area is located approximately 1.5 km northeast of the main WL site (2.7 km by road). The area measures approximately 148 m by 312 m, representing 4.6 hectares. The waste management area, which has been in operation since 1963, provides storage for L&ILW and includes the following facilities:

- 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 annex 5.1.1.2)
- liquid waste storage tanks

The concrete canister storage facility, described in annex 4.17, is located next to the waste management area.

Hydrologically, the waste management area 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 excavations is limited to ensure the impermeable clay layers are not penetrated.

From 1963 to 1985, LLW was buried in unlined trenches approximately 6 m wide by 4 m deep, and up to 60 m long. Trenches were covered with at least 1.5 m of excavated material after they were filled. There are 25 filled trenches located in the waste management area. Trench storage of LLW was discontinued in 1985 in favour of engineered above-ground LLW storage bunkers. The LLW bunkers are constructed of concrete; overall dimensions are 26.4 m long by 6.6 m wide by 5.2 m high, with a wall thickness of 0.3 m, for a total of 805 m^3 of storage space each. A SMAGS structure has been constructed (discussed in annex 5.1.1.8) for the storage of future LLW from decommissioning.

In-ground or partially in-ground bunkers are used to store ILW. Possessing a variety of dimensions, these bunkers are constructed of reinforced concrete, with a wall thickness of 0.25 m. In-ground, concrete standpipes (similar to the CRL tile holes described in annex 5.1.1.2) 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 m thick, with a 0.3 m integral base lined with galvanized steel pipes. A removable concrete shielding plug, about 0.9 m thick, provides access.

As part of the decommissioning plan for WL, all radioactive waste currently stored in bunkers, standpipes and above-ground storage buildings is to be sent to CRL for disposal at the NSDF, or consolidated for storage with CRL ILW until disposal is available. A safety case must be developed for the *in situ* disposal of the trenches. Wastes for which such safety case cannot be made will be retrieved and sent to CRL for disposal or storage, as appropriate.

Figure 5.11: Whiteshell Laboratories

5.2 Best Theratronics Manufacturing Facility Kanata

Best Theratronics Ltd. is a medical device manufacturing company, located in Kanata, Ontario, that manufactures medical equipment used throughout the world. The main products that require the possession of a Class 1B licence include cobalt-60-based external beam radiation therapy units, cesium-137-based self-contained irradiators for blood or research irradiation, and cyclotrons with beam energies ranging from 15 to 70 MeV.

Currently, Best Theratronics Ltd. stores disused cobalt-60 sealed sources (<1 m^3) and depleted uranium (<1 m^3) in dry storage.

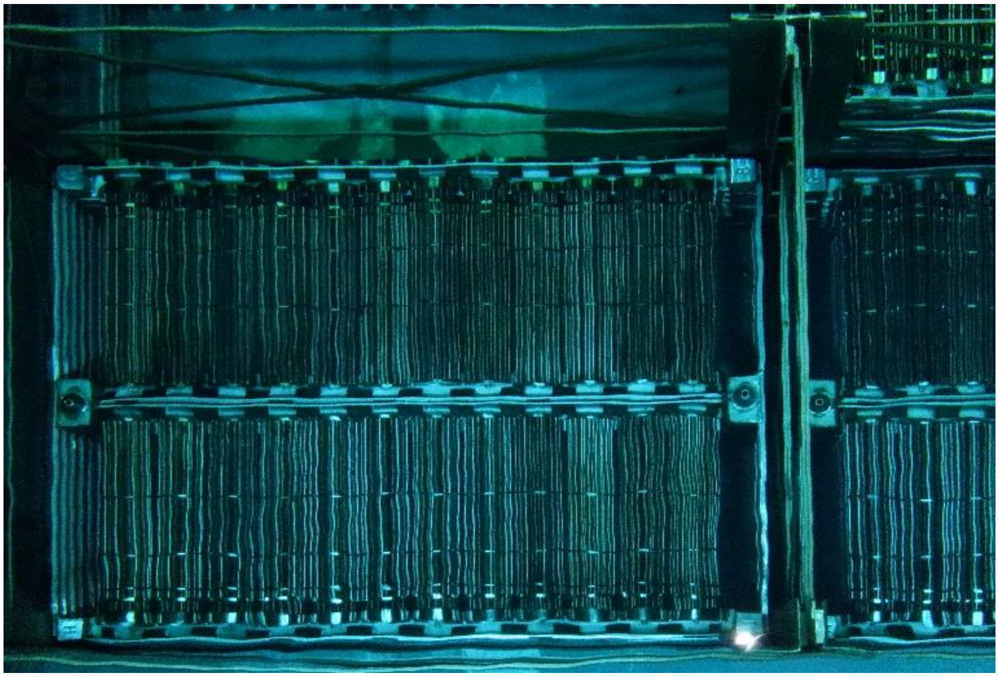
Figure 5.12: Best Theratronics Manufacturing Facility Kanata

5.3 Bruce Nuclear Generating Station

For more than 30 years, the four reactors at BP's Bruce B NGS have been a reliable cobalt-60 supply for Nordion, an Ottawa-based company. BP's cobalt-60 helps to sterilize 40 percent of the world's single-use medical devices, including sutures, syringes, masks and gloves. Bruce Power also produces medical-grade cobalt-60 that is used in radiation-based cancer treatments, as well as other diseases in Canada and around the world.

The cobalt-60 rods are stored in BP's secondary fuel bay. The harvested rods are suspended on the wall of the fuel bay, about 4.3 m below the surface; the water provides employees with shielding from the radioactivity. From the reactivity mechanism deck over the fuel bay, BP's specialized fuel handlers extract the individual irradiated rods and place them in a shielded flask to be shipped to Nordion's facility.

Figure 5.13: Non-fuel HLW at the Bruce NGS



5.4 BWXT Fuel Manufacturing, Peterborough and Toronto

BWXT NEC implements programs to conserve natural resources, prevent pollution and minimize waste. All articles removed from radiation controlled areas are included in radioactive waste, unless they meet the limits for unconditional release. BWXT NEC has an effective and well-established radioactive waste program that ensures all radioactive waste disposals are compliant with regulations and the conditions of the facility's operating licence. The production of radiological waste is minimized by limiting that articles that enter radiological areas and reusing items like shop coats and shoe covers that are laundered. Scrap materials like pellets, powder and sludge are returned to the supplier for recycling.

Radioactive solid wastes generated from fuel manufacturing which consist of or are contaminated by uranium are accumulated in controlled and classified areas in drums, in waste boxes or on skids. A low volume of radioactive waste from Peterborough is transported to and consolidated with the Toronto facility's wastes. These are combined, compacted for volume reduction where possible and shipped routinely to a licensed radioactive waste facility.

Figure 5.14: BWXT Fuel Manufacturing Peterborough

Figure 5.15: BWXT Fuel Manufacturing Toronto

5.5 Cameco Blind River Refinery, Port Hope Conversion Facility and Cameco Fuel Manufacturing Facility

For both environmental and economic reasons, conserving resources and recycling materials is an important part of operations. At Cameco's Blind River Refinery (see figure 5.16), nitrogen oxide off-gases are absorbed and converted to nitric acid for reuse.

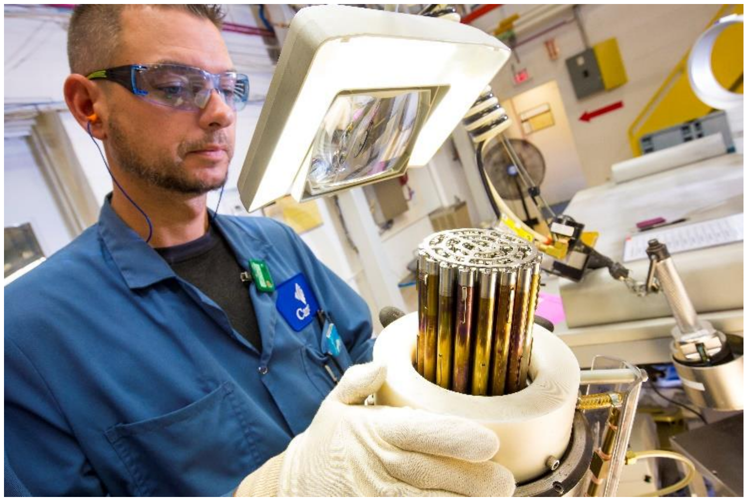
Figure 5.16: Cameco Blind River Refinery

At Cameco’s Port Hope Conversion Facility (see figure 5.17), ongoing recycling programs include in-plant recovery of hydrofluoric acid from air emissions for reuse, as well as the creation and sale of an ammonium nitrate by-product for use as commercial fertilizer.

Figure 5.17: Port Hope Conversion Facility

Several process streams in the uranium refining, conversion and fuel manufacturing processes result in materials that contain economically viable quantities of natural uranium. The Blind River Refinery receives and processes small quantities of natural uranium-bearing scrap materials, such as uranium dioxide from the Cameco Fuel Manufacturing Facility and the Port Hope Conversion Facility in various forms (e.g., fuel pellets, sludge and powder). The uranium refining process produces two recyclable products: the regeneration product produced in the solvent treatment circuit, and the calcined product produced in the raffinate circuit. Both of these products contain recoverable uranium and are recycled via re-milling for uranium recovery at a licensed facility. These products are either reprocessed at a Cameco facility or sent to a uranium mill for recovery. Scrap fuel pellets from the Cameco Fuel Manufacturing Facility (see figure 5.18) are reprocessed at the Blind River Refinery.

Figure 5.18: Cameco Fuel Manufacturing Facility



The waste management programs at Cameco's Blind River Refinery, Port Hope Conversion Facility and Cameco Fuel Manufacturing outline the implemented process to collect, clean and monitor all materials for free release to commercial recycling organizations. Material that is contaminated with uranium and cannot be recycled or does not meet the strict release criteria can be incinerated and reduced to ash or packaged for disposal at a licenced WMF. The packaged non-recyclable material that cannot be cleaned consists of materials like insulation, sand, soil and some scrap metal.

The Government of Canada has agreed to accommodate 150,000 m^3 of waste from the Port Hope Conversion Facility that arises from the early operations of that site and pre-date Cameco's formation. These wastes include drummed radioactive wastes, contaminated soils and wastes arising from decommissioning that are part of the PHAI (see annex 7.2.1 for more details). The transfer of these materials began in 2018 and is expected to continue until approximately 2023.

5.6 Darlington Waste Management Facility

The operating lives of the Darlington NGS reactors are limited by the condition of the major reactor fuel channel components. As a result, refurbishment is required in order to extend the lives of these reactors. Reactor refurbishment consists of a large-scale overhaul wherein the fuel channel components and channel feeder tubes are replaced.

The Retube Waste Storage Building was constructed as part of the Darlington Refurbishment Project, and was placed in service in 2017. As part of the refurbishment of each reactor, after the calandria tubes and feeders are removed, the materials are sent to a processing building where they are prepared for safe disposal or storage, as applicable. The refurbishment retube waste is classified as ILW.

The reactor retube waste is placed in a primary shielded container known as the Darlington retube waste container, which is stored within a secondary shielding overpack, referred to as the Darlington storage overpack. Darlington storage overpacks are loaded in the processing building before transport to storage at the Darlington WMFs Retube Waste Storage Building. Interim storage of the processed Darlington storage overpacks is required for approximately 25 years to allow the waste to radiologically decay and reduce dose rates to acceptable levels so it can be transported off-site to a permanent long-term storage facility.

The Retube Waste Storage Building has the capacity to accommodate the waste from all four Darlington reactor refurbishments.

Figure 5.19: Darlington storage overpacks stored at the Darlington WMF

5.7 Gentilly-2 Waste Management Facility

H-Q's solid radioactive waste management facilities consist of two separate facilities that provide safe storage for radioactive materials produced at the Gentilly-2 NGS (see figure 5.20). Both facilities comprise several types of reinforced concrete bunkers.

Figure 5.20: Compacted LLW stored at Gentilly-2

The new solid radioactive waste management facilities were commissioned in 2008; the commissioning of Phase II was authorized in 2013. They were originally built for the storage of refurbishment waste. The new facilities store the spent resins, ILW and LLW from operations and decommissioning activities.

The volume of LLW produced at Gentilly-2 is now less than 10 m^3/year. Samples of surface water runoff from both solid radioactive waste management facilities collected and analyzed in 2019 have shown that average tritium concentrations were 240 and 427 Bq/L. The average dose rates for 2019 at each of these facilities' perimeter fences were 0.055 and 0.074 µSv/hour. The regulatory limit for dose to the public is 1 mSv/year.

Figure 5.21: Gentilly-2 Waste Management Facility

5.8 Nordion manufacturing facility, Kanata

Nordion has designated space and processes to store and segregate radioactive waste that is generated in its operations. The primary area where radioactive materials are processed and stored consists of processing hot cells (see figure 5.22) and storage pools. Cobalt-60 encapsulated radioactive sources are stored underwater in storage pools; the water in the pools serves as a cooling and shielding medium. The storage pools are used for unloading incoming encapsulated radioactive sources and measuring, storing and transferring the materials into hot cells for further processing. Spent cobalt-60 sealed sources may be returned by customers to Nordion, where they are reprocessed or transferred to licensed facilities for long-term management. Returned cobalt sources may be recycled into new-source manufacturing, re-encapsulated into new sources or added to Nordion's source inventory.

Figure 5.22: Hot cells at the Nordion manufacturing facility, Kanata

5.9 Pickering Waste Management Facility

The Pickering WMF (see figure 5.23) consists of the spent fuel dry storage area (see annex 4.13) and the retube components storage area, which stores reactor core component waste from retube activities at the Pickering NGS (Units 1–4) conducted in the 1990s. The retube components storage area is located in the protected area of Pickering NGS and is operating in SWS mode; as such, it is closed to new waste, unless it receives prior written approval from the CNSC.

The retube components storage area uses dry storage modules – cylindrical casks made of reinforced heavy concrete – to store the retube components. The storage area was designed to accommodate 38 dry storage modules. The design of the modules provides adequate shielding to meet dose rate requirements outside the facility and to keep worker dose rates ALARA. At present, the retube components storage area consists of 34 loaded dry storage modules, two empty modules and space for two additional modules.

The ground surface of the retube components storage area is covered with an impermeable membrane which provides a low-maintenance surface. A drainage system directs the runoff water from the storage area to the Pickering NGS Units 5–8 outfall. Catch basins permit the periodic sampling of the water.

Figure 5.23: Pickering WMF with retube components storage area (left) and spent fuel dry storage area (right)

5.10 Point Lepreau Waste Management Facility

The Point Lepreau Solid Radioactive WMF is composed of Phase I (for the storage of operational solid radioactive waste), Phase II (for the storage of spent fuel, as described in annex 4.15) and Phase III (for the storage of solid radioactive waste from the refurbishment outage).

Figure 5.24: Point Lepreau Waste Management Facility

The Phase I area contains the following storage structures:

- **Vaults** – The Phase I vaults are concrete structures (see figure 5.25) used to store operational LLW and ILW. There are six vaults, five of which contain four equal compartments and one of which contains two such compartments, and two compartments that were modified to be filter storage structures (described below). The activity of the majority of the waste stored in the Phase I vaults is expected to decay to an insignificant level by the end of the design life of these structures. Of the approximately 3,071 m^3 of storage space in the six vault structures, a total of approximately 915 m^3 was occupied with solid radioactive waste at the end of the reporting period.

- **Quadricells** – The Phase I quadricells are designed to house high-dose rate ILW, such as spent ion exchange resins and contaminated system components. Approximately 144 m^3 of storage space is available in a total of nine quadricells. These structures were empty at the end of the reporting period; they have not been used to date.

- **Filter storage structures** – The two filter storage structures in Phase I are used for storing operational ILW filters, specifically, spent purification filters from the heat transport purification, moderator purification, active drainage, gland seal supply, spent fuel bay and fuelling machine systems. These structures are contained within one of the vault structures, mentioned above. There is approximately 43 m^3 of storage space in two structures. A total of approximately 13 m^3 of spent filter waste was stored in these storage structures at the end of the reporting period.

A total of approximately 266 m^3 of radioactive waste was transferred to Phase I over the reporting period. A volume reduction strategy was implemented in December 2010; under this strategy, processable radioactive waste is sent to EnergySolutions' Bear Creek Processing Facility in Oak Ridge, Tennessee. An approximate volume reduction of 80:1 is realized via this process in terms of shipped incinerable waste, while an approximate volume reduction of 5:1 is realized in terms of compactable waste. Recyclable radioactive metal waste is used for shielding purposes in the nuclear industry in the United States, therefore it is not returned to NB Power. A total of approximately 1,045 m^3 of radioactive waste was transferred from Phase I to EnergySolutions during the reporting period.

The samples of surface runoff from Phase I, collected and analyzed over the reporting period, had an average tritium concentration of approximately 205 Bq/L. The average dose rate for the reporting period at the Phase I perimeter fence, as read from TLDs, was approximately 0.12 µSv/hour. The regulatory limit for dose to the public is 1 mSv/year.

Figure 5.25: Point Lepreau vault storage structure

The Phase III area contains the following storage structures:

- **Vaults** – The Phase III vaults are concrete structures identical to those in Phase I. They are used to store LLW and ILW from the refurbishment outage. There is approximately 890 m^3 of storage space in the two vault structures. As of March 31, 2020, approximately 871 m^3 of vault storage space was being occupied.

- **Retube canisters** – The Phase III retube canisters (see figure 5.26) are concrete structures used to store high dose rate ILW from the refurbishment of the Point Lepreau reactor, which consists primarily of reactor components. There is approximately 165 m^3 of storage space in the five structures. Approximately 140 m^3 of retube canister storage space was occupied at the end of the reporting period.

No solid radioactive waste was transferred to or from this facility during the reporting period.

Samples of surface runoff from the Phase III area, collected and analyzed over the reporting period, had an average tritium concentration of approximately 114 Bq/L. The average dose rate for the reporting period at the Phase III perimeter fence, as read from TLDs, was approximately 0.11 µSv/hour. The regulatory limit for dose to the public is 1 mSv/year.

Figure 5.26: Point Lepreau retube waste canisters

5.11 Radioactive waste management at decommissioned reactor sites

The Douglas Point, Gentilly-1 and NPD reactors are currently shut down, partially decommissioned and in SWS. Because these facilities contain radioactive materials, including radioactive wastes from preliminary decommissioning activities, they are presently licensed as WMFs. Annex 8 provides more information about the decommissioning activities at each of these sites.

5.11.1 Douglas Point Waste Management Facility

The Douglas Point WMF 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 was transferred to concrete canisters in late 1987. The responsibility for decommissioning Douglas Point belongs to AECL, and this work is now being executed by CNL under a GoCo arrangement.

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
- ILW stored in the fuel transfer tunnel leading from the reactor building to the receiving bay

Routine discharge and environmental monitoring measurements confirm that the facility continues to operate safely.

Figure 5.27: Douglas Point

5.11.2 Gentilly-1 Waste Management Facility

The Gentilly-1 WMF is situated within H-Q's Gentilly-2 NGS boundary. The responsibility for decommissioning Gentilly-1 belongs to AECL, and work is now being conducted by CNL. For more information, refer to annex 4.8.

The Gentilly-1 WMF 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 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 facility. Routine waste water discharge and environmental monitoring measurements confirm that the facility continues to operate safely.

Figure 5.28: Gentilly-1

5.11.3 Nuclear Power Demonstration Waste Management Facility

Located in Rolphton, Ontario, the NPD WMF contains the decommissioned NPD station. The station operated from 1962 until 1987, when Ontario Hydro (now OPG), with assistance from AECL, decommissioned it, placing it in a static-state interim storage condition. After the static state was achieved, Ontario Hydro turned over control of the NPD WMF to AECL in September 1988. Since then, various non-nuclear ancillary facilities – the administration wing, training centre, pump house and two large warehouses – were demolished and the refuse was removed from the site for reuse, recycling or waste. The spent fuel was transferred to the CRL waste management area for storage.

The NPD WMF is divided into nuclear and non-nuclear areas. Stored waste consists of induced radioactive products, activated corrosion products and some fission products. The confined residual radioactivity in NPD after removal of the spent 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

Routine discharge and environmental monitoring measurements confirm that the facility continues to operate safely.

After the transition to a GoCo model in 2015, AECL is seeking to close the NPD site through the work of CNL. While AECL continues to own the site, CNL is responsible for the facility; the facility is presently in the SWS phase of decommissioning under a waste facility decommissioning licence issued by the CNSC. The NPD site currently comprises a limited number of structures, including the main reactor building, a diesel generator, a guardhouse and a ventilation stack. Several temporary structures are being added to support the decommissioning project.

Figure 5.29: Nuclear Power Demonstration

5.12 Radioactive Waste Operations Site-1

Radioactive Waste Operations Site-1 is owned and maintained by OPG at the Bruce nuclear site. The facility is used for the storage of L&ILW produced at the Douglas Point reactor and from the early operating life at Pickering Units 1–4. The majority of the original wastes from this facility were retrieved and relocated to the Western WMF in the late 1990s and early 2000s. A small volume of waste remains stored in reinforced concrete trenches with concrete covers inside in-ground monoliths and lined tile holes.

The facility currently operates in caretaking mode and no longer receives new wastes. OPG monitors and maintains the site and structures; new waste can only be added with the prior written approval of the CNSC.

The spent solvent treatment facility was demolished in October 2019, after a rigorous process of radiological surveying with results submitted to and approved by the CNSC. As an older facility adjacent to the Western WMF, it was used from the 1990s until 2008 to process solvents used at the Bruce NGSs. On October 31, 2019, the Radioactive Waste Operations Site-1 waste nuclear substance licence was amended to remove the spent solvent treatment facility, following its demolition.

Figure 5.30: Radioactive Waste Operations Site-1

5.13 Western Waste Management Facility

The Western WMF is owned and operated by OPG at the Bruce nuclear site near Kincardine, Ontario. The Western WMF consists of two distinct areas (see figure 5.31):

- L&ILW storage area
- spent fuel dry storage area (see annex 4.16)

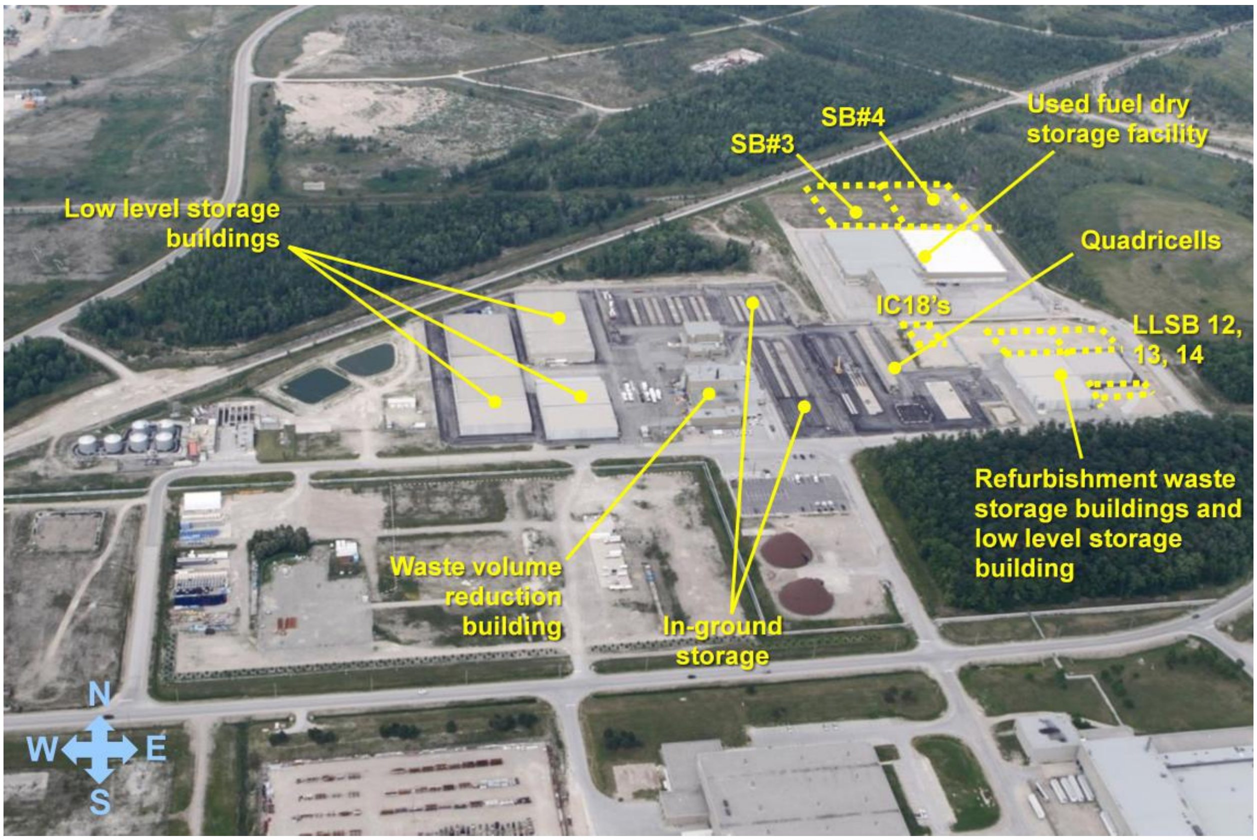
The L&ILW storage area provides safe handling, processing and storage of radioactive materials produced at Ontario's nuclear stations (Pickering, Darlington and Bruce) as well as other facilities currently or previously operated by OPG or its predecessor, Ontario Hydro. The L&ILW storage area consists of various buildings, such as the waste volume reduction building and the transportation package maintenance building. The storage structures used in this facility consist of above-ground LLW storage buildings, refurbishment waste storage buildings, quadricells, in-ground containers, in-ground trenches and tile holes.

The waste volume reduction building can receive LLW and sort it into processable and non-processable streams. Staff can further process some of the waste by compacting or incinerating it prior to storage. The building consists of the following main areas:

- the radioactive waste incinerator area, which contains the radioactive waste incinerator, auxiliary systems and equipment, as well as an active drainage sump
- the compaction area, which contains a box compactor and a civil maintenance shop. Control and mechanical maintenance shops are located in the transportation package maintenance building to carry out repairs and equipment maintenance
- the material handling, storage and sorting area, which provides for material movement, sorting and temporary storage of incoming and processed wastes. This area has close access to the incinerator and compaction areas

- the control room which houses the main work control centre. All L&ILW storage area systems and services alarms are monitored in this room
- truck bays, which establish a weather-protected area for receiving and unloading LLW
- ventilation equipment areas, which 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, which provide housing for electrical switch gear and motor control centres, as well as storage for non-waste products

Figure 5.31: Western WMF



OPG has developed DRLs for airborne radioactive releases from the radioactive incinerator and active ventilation in the waste volume reduction and transportation package maintenance buildings, as well as for releases to surface and subsurface drainage at the site. The non-radioactive effluents must conform to the environmental compliance approval for the Western WMF site issued by the Ontario Ministry of the Environment and Climate Change. Radioactive and non-radioactive effluents are all now below regulatory requirements and have historically been so.

The safe handling, processing and storage of radioactive waste at the Western WMF 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.

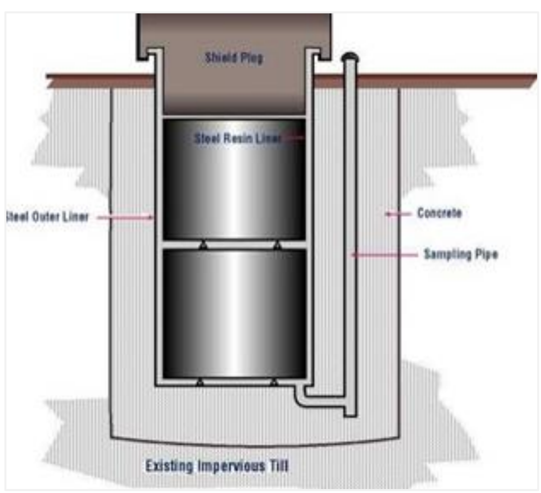
The L&ILW storage area of the Western WMF received approximately 1,000 m^3 of radioactive waste in 2019. The annual amount can vary widely, depending on maintenance activities at the various NPPs. The waste is subsequently processed, when possible, and placed into the appropriate storage structure. Currently, an estimated 11,000 m^3 of ILW and 105,000 m^3 of LLW is stored on-site on an interim basis.

There are two refurbishment waste storage buildings located within the L&ILW storage area. These buildings store the waste from the refurbishment of Bruce A NGS Units 1 and 2. One of these buildings contains the reactor tube ("retube") components in specially designed concrete and steel boxes, while 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 NPPs by the power reactor licensee.

In 2019, the Western WMF (the spent fuel dry storage area and L&ILW storage area combined) released 1.03×10^{13} Bq of tritium, $6.52\text{x}10^{2}$ Bq of particulate, 0 Bq of iodine-131 and 2.69×10^{9} Bq of carbon-14 to air. Releases to water were 1.6×10^{11} Bq of tritium and $7.08\text{x}10^{7}$ Bq of gross beta. These releases are orders of magnitude below the DRLs and action levels for the Western WMF.

Figure 5.32: In-ground storage structures at Western WMF for ILW

Figure 5.33: Schematic of in-ground storage structures at Western WMF (note: only 2 of 6 resin liners are shown)



Annex 6 – Uranium Mine and Mill Facilities

6.1 Key Lake

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

6.1.1 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 achieve 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 that covered an area 600 m by 600 m (36 hectares) and 15 m deep. The TMF was constructed five metres above the groundwater table using engineered dikes for perimeter containment and a modified bentonite liner to seal the bottom and isolate the tailings from the surrounding soil infrastructure.

Since 1996, the mined-out Deilmann open pit has been used as the 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 the solids consolidation of overlying tailings.

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

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

After decommissioning, groundwater will follow the path of least resistance (i.e., around the tailings rather than through them), which minimizes environmental impacts. At the end of 2019, the Deilmann TMF (see figure 6.1) contained 6.18 million tonnes of tailings.

Figure 6.1: Deilmann TMF at Key Lake

6.1.2 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. While operating, material from the special waste areas is reclaimed for blending with high-grade McArthur River ore for the Key Lake mill feed. All other waste rock areas are inactive.

To reduce the decommissioning liability associated with the Deilmann north waste rock pile, approximately 1.3 million m^3 of nickel-rich waste rock were excavated and disposed of in the Gaertner pit in 1998. In addition, an additional 300,000 m^3 was processed and used in the Deilmann TMF west wall stabilization project in 2013. Similarly, in 2017, a total of 57,320 m^3 of nickel-rich waste rock was removed from the Gaertner waste rock pile and placed on the south bench of the Deilmann TMF.

6.1.3 Contaminated industrial wastes

Contaminated industrial wastes are either recycled or landfilled in the above-ground TMF. Leachates from these materials are collected by the above-ground TMF's seepage collection system and returned to the mill for use as process make-up water or treated and released to the environment. An estimated 11,300 tonnes of uncompacted contaminated waste were placed at this site from 2015 to the end of 2019.

6.2 Rabbit Lake

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

6.2.1 Tailings management

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

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

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

Figure 6.2: Rabbit Lake in-pit TMF

Figure 6.3: Rabbit Lake in-pit TMF

6.2.2 Waste rock management

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

Current projections are that no waste rock will remain on the surface at Eagle Point after the mining and backfilling of mined-out stopes is complete. The A-zone (28,307 m^3 of clean waste) and D-zone (200,000 m^3 of primarily lake-bottom sediments) waste rock piles have been flattened, contoured and vegetated. The B-zone waste pile contains an estimated 5.6 million m^3 of waste material stored on a pile covering an area of 25 hectares. The B-zone pile was contoured and reclaimed through the installation of an engineered cover followed by a one-metre till cover, complete with vegetation and drainage channels to promote controlled runoff. All the special waste from the A-zone (69,749 m^3), B-zone (100,000 m^3) and D-zone (131,000 m^3) open-pit mines was returned to the pits and covered with layers of waste rock and/or clean till before the mined-out pits were allowed to flood.

There are approximately 6.89 million m^3 of predominantly sandstone waste rock with some basement rock and overburden tills stored on the West 5 waste rock pile adjacent to the Rabbit Lake in-pit TMF. Mineralized waste is stored on four piles (630,000 m^3) adjacent to the Rabbit Lake mill. Runoff and seepage from these areas are collected in the Rabbit Lake in-pit TMF.

6.2.3 Contaminated industrial wastes

Radioactive and other contaminated materials from the Eagle Point mine, Rabbit Lake mill and Cigar Lake mine are disposed of in the contaminated landfill site located on the west side of the Rabbit Lake above-ground TMF. An estimated 587 m^3 of uncompacted waste were placed at this site in 2019.

6.3 McClean Lake

Uranium mills and operational TMFs exist at McClean Lake.

6.3.1 Tailings management

McClean Lake is the only uranium mill constructed in North America in the last 20 years. The mill and TMF feature state-of-the-art efforts for worker and environmental protection when processing high-grade uranium ore. Open-pit mining of the initial ore body (the John Everett Bates or JEB pit) began in 1995. After the ore was removed and stockpiled, the pit was developed as a TMF (see figures 6.4 and 6.5). 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 the 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 subaqueous tailings placement within the mined-out JEB pit for long-term, secure containment in a below-ground facility
- use of natural surround as the optimum approach for long-term groundwater diversion around the consolidated tailings plug

- subaqueous tremie placement (from a floating barge) of the thickened tailings below a water cover in the pit; this method minimizes the segregation of fine and coarse material, prevents the freezing of the tailings and enhances radiation protection by using the water cover to attenuate radon emissions
- a bottom filter drain feeding a dewatering drift and raise wells to allow collection and treatment of discharged pore water during tailings consolidation
- recycling of pit water by floating barge and a pipe-in-pipe handling system
- complete backfilling of the pit upon decommissioning with clean waste rock and a till cap

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

Figure 6.4: McClean Lake operation with JEB TMF located to the left of the mill

Figure 6.5: JEB TMF at McClean Lake

6.3.2 Waste rock management

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

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

Figure 6.6: Sue mining area at McClean Lake

Figure 6.7: Sue E pit at McClean Lake

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

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

6.3.3 Contaminated industrial wastes

Chemically or radiologically contaminated waste materials originate from the mining, milling and water treatment areas of the McClean Lake operation. Contaminated material is collected in yellow dumpsters that are distributed around the site, then deposited in the landfill for chemically and radiologically contaminated materials contained in the Sue C pit (formerly located at the perimeter of the JEB TMF). In summer 2017, the temporary contaminated landfill located at the perimeter of the JEB TMF was decommissioned and permanent contaminated landfill was developed on a platform within the Sue C pit (the Sue C contaminated landfill). Approximately 17,000 m^3 of waste was relocated from the temporary contaminated landfill into the Sue C contaminated landfill, where it and newly generated waste is routinely covered and compacted. The Sue C contaminated landfill has a design capacity of between 57,000 and 65,000 m^3; it is estimated that the McClean Lake Operation generates a maximum of 1,500 m^3 of contaminated waste annually. The waste will remain in place permanently and be capped with the decommissioning of the Sue C pit at the end of operations. During the reporting period (April 1, 2017 to March 31, 2020) approximately 3,716 m^3 of contaminated waste was generated and placed in to the contaminated landfill(s).

6.4 Cigar Lake

6.4.1 Tailings management

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

6.4.2 Waste rock management

There are four mine rock waste stockpiles (stockpile A clean rock, and A1 concrete and benign rock; B low-grade contaminated waste including wood, metal and rock, and C potentially reactive-acid waste rock) in operation at Cigar Lake. The current inventories are the result of mine development and operation at the site. The waste rock is classified as either clean or benign waste rock, potentially acid-generating waste rock or mineralized waste rock. Potentially acid-generating and mineralized waste rock (stockpiles B and C) are temporarily stored on engineered lined containment storage areas. Leachate from these areas is contained and collected for treatment in the mine water treatment plant. When possible, clean or benign waste rock is used as fill or construction material on-site. While some potentially acid-reactive waste rock may be used as backfill in the mine, the majority of this material is expected to be eventually transported to the McClean Lake mine site for disposal in a mined-out pit. At the end of 2019, stockpile B contained 2,373 m^3 and stockpile C contained 378,541 m^3. All potentially acid-generating mine rock (remaining stockpile C) is to be transported and disposed of at McClean Lake in a purpose-engineered in-pit repository. No mineralized mine rock, potentially acid generating rock or other contaminated or mineralized waste materials will remain on the surface after decommissioning is complete.

6.4.3 Contaminated industrial wastes

Contaminated industrial wastes are stored on stockpile B, which is one of the stockpiles used to store mineralized waste rock (described in annex 6.4.2) at Cigar Lake and other approved storage areas. These materials will ultimately be disposed of underground during the backfilling of exhausted mine chambers and drifts, or at other approved locations. In 2019 all contaminated industrial wastes were transported to the Rabbit Lake above-ground TMF for disposal.

Figure 6.8: Arial view of Cigar Lake operation with waste rock stockpile C in the right foreground

6.5 McArthur River

6.5.1 Tailings management

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

6.5.2 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. 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.

6.5.3 Contaminated industrial wastes

A transfer area adjacent to the mine headframe is used to sort and temporarily store contaminated material. The contaminated material is then shipped to the Key Lake operation, where it is disposed of in the above-ground TMF.

Figure 6.9: Arial view of McArthur River operation with waste rock pads 1–4 in the middle foreground

Annex 7 – Inactive Uranium Mines and Mills Tailings Management Areas and Contaminated Sites

7.1 Introduction

A total of 20 tailings management sites have resulted from operating uranium mines in Canada: four in Saskatchewan, two in the Northwest Territories and 14 in Ontario. See figure D.4 for a map of their locations.

7.1.1 Saskatchewan

There are four inactive uranium tailings sites in Saskatchewan: Beaverlodge, Gunnar, Lorado and Cluff Lake. In September 2013, Orano's Cluff Lake project completed decommissioning activities, and site occupancy ceased. In 2020, Orano applied to begin the process of transitioning the Cluff Lake site to the Province of Saskatchewan's institutional control program.

7.1.1.1 Beaverlodge

Cameco holds a waste facility operating licence for the decommissioned Beaverlodge uranium mine and mill properties near Uranium City in the northwest corner of Saskatchewan. Mining and milling of ore at this site began in 1952 and milling in 1953; both activities continued until its closure in 1982 when decommissioning began and was completed in 1985. The site has since been in a monitoring and maintenance phase. All mine structures have been removed from the site, the open pits have been completely backfilled and the mine shafts have been capped and decommissioned.

All of the control structures associated with this site are passive, and there are no effluent treatment plants. Some roads, waste rock piles and tailings management areas are subject to inspection programs and local and area-wide environmental monitoring programs.

The decommissioned Beaverlodge tailings management areas contain approximately 5.6 million tonnes of tailings. In addition, 4.3 million tonnes of tailings were disposed of underground – for a total of 9.9 million tonnes of lower-grade uranium mine tailings. In addition, there are approximately 4.8 million tonnes of waste rock on the site.

At the time of decommissioning in 1982, the site consisted of 70 separate properties that covered approximately 744 hectares. There were 10 different mining areas; 10.161 million tonnes of ore recovered 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 (IC) framework for the long-term provincial management of post-decommission properties. As a result, five of the 70 decommissioned Beaverlodge properties were exempted from CNSC licensing and entered into this framework in 2009. These five properties were not part of the overall radiological waste inventory considered in this report. In 2019, an additional 20 decommissioned properties were released from CNSC licensing, and 19 of them were transferred into the IC framework in 2020; one property was free released due to a lack of disturbance. A total of 45 properties remained under CNSC licence at the end of 2019.

Figure 7.1: Beaverlodge former mill area

7.1.1.2 Gunnar

The Gunnar mine site is located on the southern tip of the Crackingstone Peninsula along the north shore of Lake Athabasca, approximately 25 km southwest of Uranium City, Saskatchewan (see figure 7.2). The Gunnar mine site has been abandoned since 1964 and was not adequately decommissioned. The Gunnar site consists of open and underground mine pits, mining infrastructure, three mine tailings deposits and waste rock piles. The total volume of mine tailings at the site is 4.4 million tonnes and the total volume of waste rock is approximately 2.2 to 2.7 million tonnes. The Province of Saskatchewan now has ownership of the site, under the Saskatchewan Ministry of the Economy. The ministry subsequently appointed the Saskatchewan Research Council (SRC) as project manager to oversee the ongoing management and remediation of the Gunnar mine site.

On April 2, 2007, the governments of Canada and Saskatchewan announced the first phase of the cleanup of the Gunnar legacy uranium mine site in northern Saskatchewan. Private sector companies that no longer exist operated this facility from the 1950s until the early 1960s. When the site was closed, the regulatory framework in place was not sufficient to ensure the appropriate containment and treatment of the waste, and this had environmental impacts on local soils and lakes.

Since the CNSC issued the licence to the SRC in 2015, it has completed Phase 1 of its project which involved characterizing and monitoring the on-site waste and developing remediation plans. The SRC is currently in Phase 2 of the project and has implemented the following remediation work:

- development of borrow areas and haul road construction
- grading, excavation and placement of waste rock at both Gunnar main and central tailings surfaces
- submission, review and approval of detailed remediation design for other cleanup aspects

Additional remediation work is scheduled to continue until the end of 2024. The current licence is valid until November 30, 2024, but will need to be renewed once remediation work is complete, and the site transitions to Phase 3.

Figure 7.2: Aerial view of Gunnar mine site (taken by the SRC in 2017)

7.1.1.3 Lorado

The Lorado legacy mill site is located north of Lake Athabasca in the northwest corner of Saskatchewan, approximately 8 km southwest of Uranium City. The Lorado mill was closed in 1961 and minimal decommissioning work was completed. The Lorado mine site is several kilometres away from the Lorado mill and is not included in the Lorado mill site remediation project.

At the end of operations at Lorado, uranium mine tailings covered an area of about 14 hectares, including tailings submerged in the adjacent Nero Lake. EnCana West Limited 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, EnCana West Limited negotiated an agreement with the Government of Saskatchewan. The company paid a significant amount of money for the Saskatchewan government to assume current and future control of and responsibility for the site.

The Province of Saskatchewan now has ownership of the site which is administered by its Ministry of the Economy. The ministry subsequently appointed the SRC as the project manager to oversee the ongoing management and remediation of the Lorado site. The SRC's current CNSC licence for Lorado is valid until April 30, 2023.

The SRC completed the remediation of the Lorado site at the end of 2015 (see figure 7.3). In 2016, the SRC completed the placement of till in the remaining areas of the cover, installed riprap on the shore of Nero Lake and initiated the revegetation of the cover, which concludes the active remediation activities planned for Lorado. In 2017, the SRC continued to monitor the local environment and the progress of the cover revegetation. The SCR submitted an application in 2019 to amend its licence to transition to the long-term monitoring phase. CNSC staff have reviewed the application and will have the designated officer decision licence amendment finalized in mid-2020.

Figure 7.3: Remediated Lorado tailings site, June 2019

7.1.1.4 Cluff Lake

The Cluff Lake Project (see figure 7.6), owned and operated by Orano Canada Inc., began in 1980 and ended in late 2002 when ore reserves were depleted. More than 6 million pounds of triuranium octoxide was produced over the 22-year life of the project. Site facilities included the mill and tailings management area, four open-pit and two underground mines, the camp for workers and site infrastructure.

Following a comprehensive environmental assessment and licensing process, including extensive public engagement, regulatory approval for decommissioning was granted in 2004 with agreed end-state decommissioning objectives. Physical decommissioning work to achieve long-term objectives was completed by 2006. Over the last Cluff Lake CNSC licence term from 2009 to 2019, the remaining minor physical decommissioning work was completed and the achievement of decommissioning objectives was demonstrated.

Continuous site occupancy ended in 2013 accompanied by a program to decommission infrastructure that had remained in support of on-site monitoring and maintenance crews, and minor remedial work to prepare the site for open public access. In the summers of 2017 and 2018, final earthwork was conducted to ready the site for eventual transfer to the Province of Saskatchewan's Institutional Control Program (ICP).

The CNSC Comprehensive Study Report in 2003 described the effects of decommissioning as largely positive. Decommissioning involved removing or stabilizing built structures and reclaiming disturbed areas. Orano's key objective was to remove, minimize or control potential contaminant sources and thereby minimize the potential for adverse environmental effects associated with the decommissioned property. Decommissioning was designed to minimize the need for care and maintenance activities and long-term institutional controls, taking socio-economic factors into consideration. The objectives for decommissioning have been achieved.

In 2019, the CNSC granted a renewal of the Cluff Lake licence for five years. While retaining CNSC regulatory oversight, the requested amendments administratively prepare for the transfer of the Cluff Lake site to the provincial ICP. In January 2020, Orano applied to commence this process. The following subsections briefly describe the main decommissioning activities at the site.

7.1.1.4.1 Mill area

The mill was decommissioned in two phases which were completed in 2004 and 2005 (see figures 7.4 and 7.5). The mill demolition work was broadly similar to the 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. Two warehouses were retained for storage and equipment repair up until 2013, when they were demolished during site cleanup activities. Waste materials were disposed of in one of the open pits at the site, along with much larger volumes of waste rock. After the mill was demolished, 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.

Figure 7.4: Cluff Lake mill areas during operation

Figure 7.5: Cluff Lake mill area following decommissioning, but before vegetation became re-established

Figure 7.6: Cluff Lake mill area in 2017 with established vegetation

7.1.1.4.2 Tailings management area

The TMA at Cluff Lake is a surface impoundment constructed using a series of engineered dams and dikes that extends over about 70 hectares. It formerly consisted of a solids containment area, a water decantation area and water treatment facilities (see figure 7.7). Thickened tailings were pumped to the solids containment area, where consolidation and liquid decantation occurred. The decant water, along with waste water from other sources, was piped to a two-stage water treatment facility for radium-226 precipitation.

Decommissioning of the tailings management area was initiated by covering the tailings with till in stages to promote consolidation. When consolidation was complete, the cover of the tailings management area was contoured to provide positive drainage, using locally available till with a minimum one-metre thick cover, then revegetated (see figure 7.8). The surface contour and vegetated cover promote the runoff of rainfall and snowmelt as well as the 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.

More than a decade of post-decommissioning monitoring (2006 to 2018) has provided the environmental data for comparison to water quality, radiological objectives or key model inputs used to forecast long-term surface water quality (e.g., infiltration rates through soil covers and source terms). The decommissioning groundwater and ecological risk models are validated and long-term predictions remain within decommissioning objectives. During the licence renewal hearing in 2019, CNSC staff and the Commission concluded that Orano met the objectives of the Cluff Lake Project detailed decommissioning plan. A new detailed post-decommissioning plan was accepted, along with a revised financial guarantee which reflects the decommissioned state of the site.

Figure 7.7: Cliff Lake tailings management area during operation

Figure 7.8: Cluff Lake tailings management area after decommissioning, but before vegetation became re-established

7.1.1.4.3 Mining area

Mining involved four open pits and two underground mines (see figure 7.9). 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. 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 the two also used to accept industrial waste during operations and decommissioning, including 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 the waste rock, re-contouring it within another open pit (Dominique-Janine North), then allowing this pit and the contiguous Dominique-Janine extension pit to flood to the natural level to eventually form a small lake that meets surface water quality criteria (see figure 7.10)
- 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, geologic formations in the area and site hydrogeology has been performed to acquire reliable data for assessing 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 and seven more were installed in 2012 to collect additional hydrogeological data for comparison with the key assumptions. The groundwater and contaminant transport modelling, and the ecological and human health risk assessment were updated for the Cluff Lake Project in 2019 (and are currently undergoing technical review by regulators). This update incorporated the new monitoring data along with data collected through other components of the follow-up program.

Figure 7.9: Cluff Lake mining areas during operations

Figure 7.10: Decommissioned Cluff Lake mining areas

Figure 7.11: Cluff Lake mining areas 6 years post-decommissioning

7.1.2 Northwest Territories

There are two licensed legacy uranium mine, mill and tailings sites in the Northwest Territories: the Port Radium and Rayrock mines.

7.1.2.1 Port Radium

The Port Radium site, shown in figure 7.12, is located in the Northwest Territories at Echo Bay on the eastern shores of Great Bear Lake, about 265 km east of the Dene community of Deline, at the edge of the Arctic Circle. Mining at the Port Radium site took place from 1932 to 1940, from 1942 to 1960, and from 1964 to 1982 (in the last instance, to recover silver). The licensed area covers approximately 12 hectares and is estimated to contain 1.7 million tonnes of uranium and silver tailings (see figure 7.13). 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. In 2016, the CNSC renewed the licence for the Port Radium closed uranium mine site for 10 years to continue long-term monitoring and maintenance at the site. Under the renewed licence, Indigenous and Northern Affairs Canada (INAC) will continue performance and environmental monitoring and reporting under the licence.

INAC sampled surface water in 2016. For the sampling period, the radionuclide concentrations were below detection limits and below Health Canada's drinking water criteria. INAC is currently in the process of revising their long-term monitoring program for the Port Radium site, as the program expired in late 2016.

Figure 7.12: Google satellite view of Port Radium

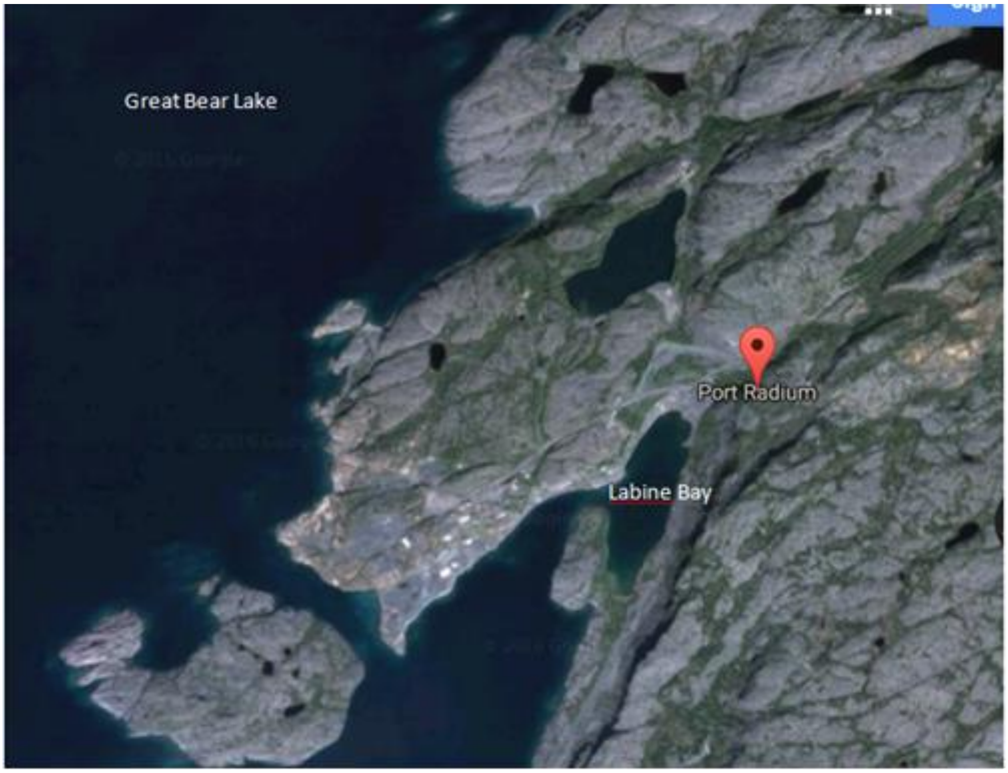


Figure 7.13: Aerial view of Port Radium mine in 2002

7.1.2.2 Rayrock

The Rayrock site is located in the Northwest Territories, approximately 145 km northwest of Yellowknife. Uranium mining and milling occurred at the Rayrock site from 1957 until 1959 when it was abandoned (see figure 7.14). The licensed site area is 206 hectares and contains an estimated 80,000 tonnes of tailings. Under a licence issued by the Atomic Energy Control Board (reissued as a CNSC licence in 2001), INAC decommissioned and rehabilitated the Rayrock site (which includes capping the tailings) in 1996. Performance monitoring and reporting of the results have been ongoing since 1996. INAC sampled surface water in 2014.

For the sampling period, most of the radionuclide concentrations were below detection limits and in all cases were below Health Canada's drinking water criteria.

In 2017, INAC undertook a field program to collect additional data to support the updated human health and ecological risk assessment (HHERA). In 2018, INAC submitted an updated HHERA which was reviewed by the CNSC and other government agencies. The final results will be used to support additional remediation activities and a revised post-remediation monitoring plan.

Figure 7.14: Aerial view of Rayrock mine

7.1.3 Ontario

7.1.3.1 Elliot Lake area

There are 12 inactive uranium mine sites and 10 uranium tailings management areas 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 remaining Elliot Lake uranium mines – the Stanleigh, Quirke, Panel, Stanrock and Denison mine sites – was essentially complete by the end of 1999. All of the sites have been substantively decommissioned; all mine features have been 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 triuranium octoxide). 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. With most of the Elliot Lake tailings management areas, therefore, some degree of effluent treatment system is associated with each site.

All of the tailings management areas 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, Pronto and Milliken mine sites and their associated tailings management areas. Rio Algom Ltd. is also responsible for the Buckles mine site; however, the tailings from Buckles were disposed of at the Nordic tailings management area. Denison Mines Inc. is responsible for the Denison, Stanrock and Can-Met mine sites and their tailings management areas. Two of the former mine sites – Denison and Stanrock – currently have CNSC licences.

In 2004, Rio Algom Ltd. consolidated all of its Elliot Lake mine sites under one CNSC licence governed by the CINFR under the NSCA.

7.1.3.1.1 Effluent treatment and environmental monitoring

In Elliot Lake, the TMAs use a mixture of both dry and wet covers. Four of the areas (Lacnor, Nordic, Pronto and Stanrock) are engineered with dry covers; 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 at these sites for many more years, 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 Tailings Management Area Operational Monitoring Program and the Source Area Monitoring Program. The first collects data to track tailings management area performance and supports decisions regarding their management and discharge compliance. 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: the Serpent River Watershed Monitoring Program and the In-Basin Monitoring Program. The Serpent River Watershed Monitoring Program 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 km^2 and drain into Lake Huron via the Serpent River. Its companion program, the In-Basin Monitoring Program, focuses on the risks to biota feeding at the tailings management areas by monitoring their physical, chemical and ecological conditions, and ecological changes.

Both programs run in five-year cycles and began in 1999. The fourth cycle of the report was completed in 2016, and the CNSC completed its review in 2017.

The CNSC reviewed the results of the various monitoring programs that Rio Algom Ltd. and Denison Mines Inc. implemented and found that overall, environmental conditions are improving at the Elliot Lake sites. More specifically, water quality is improving and environmental impacts, such as lower taxonomic richness and abundance in the benthic communities, are now only evident immediately downstream of the Quirke, Denison and Stanleigh tailings management areas. Although lakes further afield are in good environmental health, sediment contaminant levels continue to be slightly elevated, which is to be expected.

These sites will continue to require monitoring and active management until effluents meet discharge criteria without treatment, then will require some form of ongoing (permanent) care and maintenance.

7.1.3.2 Agnew Lake

The Agnew Lake mine, located about 25 km northwest of Nairn Centre, Ontario, ceased operation in 1983. The former underground uranium mine site was decommissioned and monitored by Kerr-Addison Mines Ltd. 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 (MNDM) holds a CNSC licence for the Agnew Lake TMA. The TMA is estimated to hold 1.35 million m^3 of material deposited and covers approximately 13 hectares, surrounded by the West Dam and East Barrier dyke.

Repair to the cover of the TMA is planned, and the MNDM has proposed adding niobium ore and tailings classified as NORM from the former Beaucage Mine near North Bay, Ontario, to cover these tailings. The MNDM proposes that the placement of the niobium waste will provide shielding for the existing tailings, and the soil cover over the niobium waste will prevent contact with the niobium waste and reduce gamma doses to background levels.

Figure 7.15: Agnew Lake tailings management area

7.1.3.3 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.

7.1.3.3.1 Dyno

The Dyno idle mine property is located at Farrel Lake, about 30 km southwest of Bancroft, Ontario. The mill circuit at Dyno operated between April 1958 and April 1960. The property consists of an abandoned and sealed underground uranium mine, a mill that has been largely demolished, a tailings area, a dam (see figure 7.16) and various roadways. The site licence was renewed in 2018 for a period of 15 years.

The site is currently being safely managed by EnCana West Ltd.

Figure 7.16: Main tailings dam, Dyno mine site

7.1.3.3.2 Madawaska

The Madawaska mine property is located 6 km southwest 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. Approximately 4 million tonnes of waste, covering an area of about 13 hectares at a depth ranging from 6 to 15 m, containing about 9 x 10^{13} Bq of nuclear material, remain at the location. The site is currently being safely managed by EnCana West Ltd.

In 2018 and 2019, EnCana West Ltd. relocated 80,600 m^3 of tailings from the TMAs to underground stopes as paste backfill to enhance crown pillar stability in the decommissioned mine workings. During the period from 2017 to 2020, EnCana West Ltd. removed the existing cover from the two tailings areas, contoured the surfaces to improve surface drainage and recapped the tailings with new covers which meet modern standards.

7.1.3.3.3 Bicroft

The uranium tailings stored at the Bicroft tailings storage site resulted from processing low-grade uranium ore at the Bicroft mine from 1956 to 1962 (see figure 7.17). Remediation work done includes the vegetation of exposed tailings in 1980 and dam upgrades in 1990 and 1997. In 2005, the Barrick Gold Corporation was issued a CNSC licence for the Bicroft tailings management site. The effluents discharge results generally meet the Ontario

Provincial Water Quality Objectives, with a few exceptions. Therefore, as part of its licence application, Barrick conducted a screening-level human health and ecological risk assessment to demonstrate that there is no unreasonable risk to health, safety and the environment, and to support a five-year surface water sampling program.

Figure 7.17: South tailings basin spillway at Bicroft tailings storage facility

7.2 Historic contaminated lands

Sites contaminated with very low-level uranium- and radium-contaminated soil resulting from early industrial practices (1930s to 1950s) were identified in the 1970s and have been subject to Government of Canada oversight through the LLRWMO since 1982. Under a GoCo model, AECL is responsible for the LLRWMO, but CNL delivers this work on behalf of AECL.

Progress continues to be achieved in discharging Canada's historic LLW liabilities. A key objective is that by 2026, CNL will significantly reduce or eliminate liabilities through detailed classification and characterization and the safe execution of remediation projects. CNL is facilitating the cost-effective long-term management of historic LLW, in keeping with the policy direction provided by AECL.

Since the Sixth Review Meeting, the following progress has been achieved:

- The means of disposal for wastes from the cleanup of contaminated sites along the NTR has been identified and secured.
- Additional characterization has confirmed that the majority of the contamination still to be remediated at sites along the NTR is below the threshold to be categorized as LLW and is NORM.

- Preparations for the remediation of contaminated sites along the NTR have begun; the plan is to have all identified remediation substantially completed by 2026.
- Selective remediations have been undertaken in the GTA in response to requests of support from property owners.

7.2.1 Port Hope Area Initiative

On March 29, 2001, an agreement was signed between the Government of Canada (represented by the Minister of Natural Resources) and the Ontario communities of Port Hope, Hope Township and Clarington for the construction of long-term WMFs for historic LLW and for the cleanup of contaminated sites in the Port Hope area. The wastes consist of about 2 million m^3 of LLW and contaminated soils, in which radium-226, uranium and arsenic are the primary contaminants.

With this agreement, the Government of Canada began the PHAI to evaluate and implement a long-term solution to manage the wastes from the Port Hope area sites. This initiative was divided into two projects that align 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 implementing a long-term management approach for radioactive wastes at the previous Port Granby WMF in the Municipality of Clarington (see figure 7.18).

Both projects come under the responsibility of AECL, but are being delivered by CNL under a GoCo model.

Large, near-surface, long-term management facilities have been or are being constructed to manage the wastes from each cleanup project: the Port Hope long-term WMF and the Port Granby long-term WMF. The Port Hope long-term WMF, with an estimated design capacity of 1.8 million m^3, is expected to accept a variety of wastes from the area. These include wastes from the major unlicensed sites in the municipality of Port Hope, including the former municipal landfill and the harbour. Other wastes, such as contaminated roadways and soils from private properties, will also be included, along with wastes from the previous Welcome WMF and eligible historic wastes from the Cameco Port Hope Conversion Facility. Wastes from consolidation sites and temporary storage sites within the community that are being temporarily managed under the LLRWMO scope of work will also be included, along with non-radiologically contaminated industrial wastes, as requested by the municipality and provided for in the agreement.

The Port Hope long-term WMF is being constructed as an expanded site at the existing Welcome WMF in the Municipality of Port Hope, which currently contains an estimated 550,000 m^3 of LLW and contaminated soils. An environmental assessment process has been completed for this project, and on November 15, 2012, the CNSC issued a 10-year licence to AECL for the Port Hope Project. This project, as well as the Port Granby long-term WMF, is moving forward through a phased approach.

The Port Hope Project is currently in its implementation phase (Phase 2), which includes the construction of the new long-term WMF and associated water treatment plant, remediation of the existing facility and contaminated sites in the area of Port Hope, followed by the closure of the long-term WMF. The waste water treatment plant for the proposed long-term WMF was completed in 2016 and is now operational. Construction of the containment mound commenced in the summer of 2016. The first cell was completed in late 2017. On-site waste placement from the Welcome WMF began in 2017 and was followed by the placement of wastes from sites within the community in 2018. The remediation of the Port Hope sites is slated for completion in 2025–26.

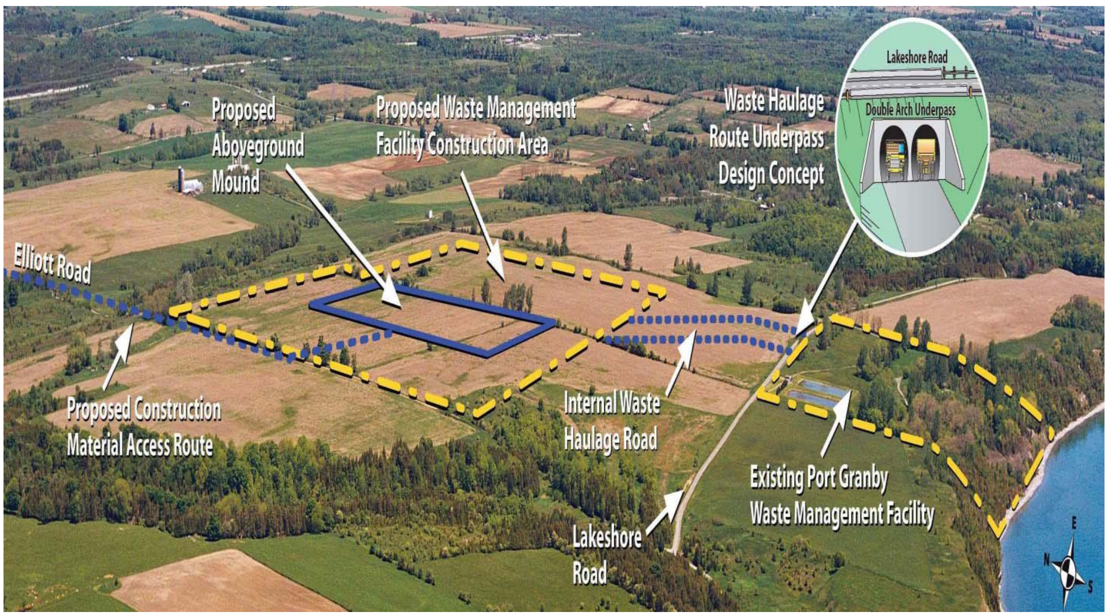
The Port Granby long-term WMF, with a revised design capacity of around 900,000 m^3, accepts wastes only from the existing Port Granby WMF located in the Municipality of Clarington. The site selected for these wastes is immediately northwest of the existing facility and away from the Lake Ontario shoreline. An environmental assessment process was completed for this project on November 29, 2011, and the CNSC issued a 10-year licence to AECL for the Port Granby Project.

The implementation phase (Phase 2) of the project is currently nearing completion; this includes the construction of the new long-term WMF and associated state-of-the-art water treatment plant, as well as the decommissioning and remediation of the existing facility, followed by the closure of the long-term WMF.

Construction of the containment mound commenced in the spring of 2016. On November 1, 2016, the first truckloads of LLW were transported away from the Lake Ontario shoreline to the newly built Port Granby Project long-term WMF, signaling the start of this significant environmental cleanup. The legacy waste removal was completed in February 2020. The final waste placement of lightly contaminated infrastructure materials (from haul roads, drainage ditch liners, etc.) will be completed in 2020, after which the cover system will be installed in late 2021.

After completing the Port Hope and the Port Granby projects and capping both long-term WMFs, the projects will move to a long-term monitoring and surveillance phase (Phase 3).

Figure 7.18: Port Granby concept diagram



7.2.2 Port Hope contaminated sites

The PHAI is a Government of Canada funded project to clean up historical LLW in the Municipality of Port Hope and Clarington. Over 1,000 contaminated sites have been identified in Port Hope. The sites include residential and commercial properties that are not licensed and four licensed sites that were used as temporary storage sites until the construction of the long-term WMF. Due to the low levels of radioactive material found at the unlicensed sites, there is minimal risk to the health and safety of the public and environment. However, there are restrictions on disturbing the soil on these properties which require administrative permitting controls before digging. Once remediation activities are completed, there are to be no land restrictions on residential properties.

The licensed sites are well known by the community and municipality and will not be further developed until the LLW is remediated and placed in the long-term WMF. Some LLW also exists in some roadway beds and underground infrastructure that will be remediated over several years, as upgrades and repairs to roads and underground infrastructure are required.

The initially estimated volume of contaminated soil in Port Hope was 1.2 million m^3; however, the number of residential properties identified with LLW more than doubled the original estimate. The Government of Canada remains confident that the long-term WMF will be able to accommodate the additional contaminated soil.

7.2.3 Deloro mine site

The Deloro mine site began operation as an underground gold mine in the 1860s, and the historical mining, refining and manufacturing operation closed in 1961. The mining and industrial operations resulted in large volumes of by-products that were deposited on the Deloro site as waste. This waste legacy includes soil, sediment, groundwater and surface water that are contaminated with arsenic, cobalt, copper, nickel and small quantities of LLW. Arsenic is the main contaminant of concern at the Deloro site. LLW materials containing uranium and its decay products from historic refining operations in Port Hope constitute up to 6 percent of the waste and coexist with the non-radioactive hazardous wastes.

The site is under the care and control of the Province of Ontario for the long-term management of contaminated sediments, soils and waste. The province implemented a comprehensive environmental monitoring program and a comprehensive environmental remediation program. In August 2019, the CNSC released the Deloro mine site from CNSC regulatory control. Due to the elevated levels of arsenic, the site will continue to be under the Ontario provincial regulatory regime, which requires the continuation of post-closure monitoring and maintenance activities indefinitely.

Figure 7.19: Aerial view of Young's Creek area

Annex 8 – Decommissioning Activities

8.1 Chalk River Laboratories

The CRL site is located in Renfrew County, Ontario, on the shore of the Ottawa River, 160 km 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 CRL site was established in the mid-1940s and has a history of hosting 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.

To date, the pace of decommissioning at CRL has been constrained by the availability of waste disposal routes. Priority has been given to hazard reduction and the mitigation of risk at facilities that represent a high hazard and risk, and to demolish low-hazard structures for which waste routes are available. Major activities completed since the Sixth Review Meeting include:

- abatement of asbestos in many facilities, including the NRX annex and reactor hall, B250 (Chemistry and Tritium Lab) and B440 (Emergency Process Cooling Water NRU)
- reduction of fire risk in several facilities after completion of actions from fire hazard analysis, including installation of fire/smoke detection and fire suppression systems, where appropriate
- decommissioning of the active area carpenter shop (B554)
- decommissioning of the library (B432)
- decommissioning of the waste water evaporator building (B228)
- decommissioning of the NRX delay tanks (B103/104)
- draining and decommissioning of the j-rod bay of the NRX
- decommissioning of active area buildings 102, 102x, 100x, B202, B174
- decommissioning of supervised area buildings B498A, 404D, B542, B549, Perch Lake buildings, B458, B447, B592, B599, B580

The implementation of a GoCo model at CRL provides an opportunity for AECL to significantly accelerate the decommissioning activities at the site. Until 2026, CNL will continue to focus on the early reduction of liabilities in the supervised area footprint, building a skilled workforce, removing redundant buildings, and clearing space for science and technology and supporting facilities. In the controlled area, the schedule for reducing risk in high-hazard facilities will rely on the construction of the proposed NSDF to provide a final waste disposal path. Planned goals and milestones include continuing to deliver against the commitments made in 2015 for the first 10 years of the GoCo arrangement:

- sustaining improved performance in environmental and safety standards
- decommissioning the NRX reactor to an end-state agreed with the CNSC
- placing the NRU reactor in a storage-with-surveillance state
- reducing the footprint of the controlled area in keeping with the decommissioning plan

- decommissioning and demolishing the remaining 28 of more than 120 buildings committed in the supervised and controlled areas
- site remediation activities will progress and be coordinated with the proposed NSDF availability and need for cover material during the facility's operations

CNL is self-performing the majority of decommissioning activities to gain efficiencies and reduce risks associated with redundant, high-hazard facilities. In the supervised area, integrated teams are developing decommissioning skills on low-hazard buildings, which will prepare them for higher hazard work in the controlled area. With this progressive approach, decommissioning teams continue to learn and build on relatively low-risk experience, before moving on to more difficult areas, as they become more proficient in the treatment and management of industrial and radiological hazards. This approach also supports the acceptance and adaptation of site-wide program controls to enable an accelerated decommissioning schedule.

International decommissioning experience gained on multiple sites has demonstrated that the development of a trained and experienced workforce with flexibility to move between buildings as conditions require is a key step to safely accelerating decommissioning scopes of this magnitude. Additionally, the development of a core team and capabilities will reduce incidents and costs, particularly those associated with multiple subcontractors performing multiple scopes of work on a congested site amid other ongoing missions. Decommissioning is coordinated with capital project timelines to provide the space required for both permanent new facilities and temporary enabling facilities.

Until the proposed NSDF is operational in 2024, decommissioning in the controlled area will focus on minimizing radiological waste and removing areas and facilities of high concern. This will be based on health, safety and environmental risk evaluations. Early emphasis will be on removing facilities in the controlled area to support temporary infrastructure and access requirements, which will enable future decommissioning and demolition work. During this period, all non-releasable waste from the controlled area will be placed in interim storage.

Additional interim waste storage capacity has been developed as required to address any gaps. Any adjustment required to the planned sequence of work will be evaluated during the development of CNL's annual plans, taking new information into consideration as capital projects progress, mission requirements change and the potential for risk reduction increases or decreases.

CNL plans to commence large-scale demolition work in the controlled area with the availability of the proposed NSDF which is anticipated in 2024. Work will be closely coordinated with the start of larger scale environmental restoration efforts, which will need to supply soil to the proposed NSDF concurrently with building debris. With the establishment of environmental remediation and cleanup criteria, CNL will move seamlessly between building demolition and any soil remediation required. CNL will further advance schedules and reduce costs by using the same personnel and equipment already mobilized for demolition.

8.2 Douglas Point Waste Management Facility

The Douglas Point WMF is located at the site of the former Douglas Point NGS on the Bruce nuclear site. The station, which consists of a 200-MW CANDU reactor, was put into service in 1968. It was owned by AECL and operated by Ontario Hydro (now OPG) until 1984. During this operational period, the station generated 17 x 10^9 kW hours of electricity and attained a capacity of 87.3 percent.

The main components of Douglas Point 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.

Douglas Point was permanently shut down on May 5, 1984, and placed in SWS state, an interim safe and sustainable shutdown state. The Douglas Point NGS then became the Douglas Point WMF.

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 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 were 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 brought the facility to a safe, sustainable shutdown state. Phase 2 is a period of SWS. Final decommissioning occurs in Phase 3. The Douglas Point WMF is currently in Phase 2, the SWS phase of a deferred decommissioning program.

CNL has applied to the CNSC for a licence amendment to commence Phase 3 of decommissioning with a hearing scheduled in 2020.

8.3 Gentilly-1 Waste Management Facility

The Gentilly-1 WMF consists of a permanently shut down, partially decommissioned prototype reactor and associated structures and ancillaries. This facility is presently in the long-term SWS phase of a deferred decommissioning program. Located on the south bank of the St. Lawrence River, about 15 km east of Trois-Rivières, Quebec, the Gentilly complex accommodates both the Gentilly-1 WMF and the Gentilly-2 NGS, a CANDU 600-MW unit, which shut down in 2012 (for more information on Gentilly-2, see annex 8.4).

The Gentilly-1 NGS consists of a CANDU BLW-250 reactor that 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 to not rehabilitate the station was made in 1982.

The main components of Gentilly-1 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, 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 shutdown the reactor was made in 1984. A two-year decommissioning program began in April of that year to bring Gentilly-1 to an interim safe and sustainable shutdown state that is equivalent to SWS. 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 upon the completion of each decommissioning activity.

A three-phase approach has been established for reactor decommissioning. Phase 1 brought the facility to a safe, sustainable shutdown state. Phase 2 is a period greater than 30 years of SWS. Final decommissioning, approximately 10 years, occurs in Phase 3. The Gentilly-1 WMF is currently in Phase 2. During the reporting period, CNL continued a campaign to remove the dry active waste which was stored in the Gentilly-1 reactor building during Phase 1 of decommissioning. The active resins stored in underground tanks at the Gentilly-1 site have now been removed, reduced and stored at CRL. CNL continued to remove industrial hazards from the Gentilly-1 facility, such as asbestos and polychlorinated biphenyls (PCB).

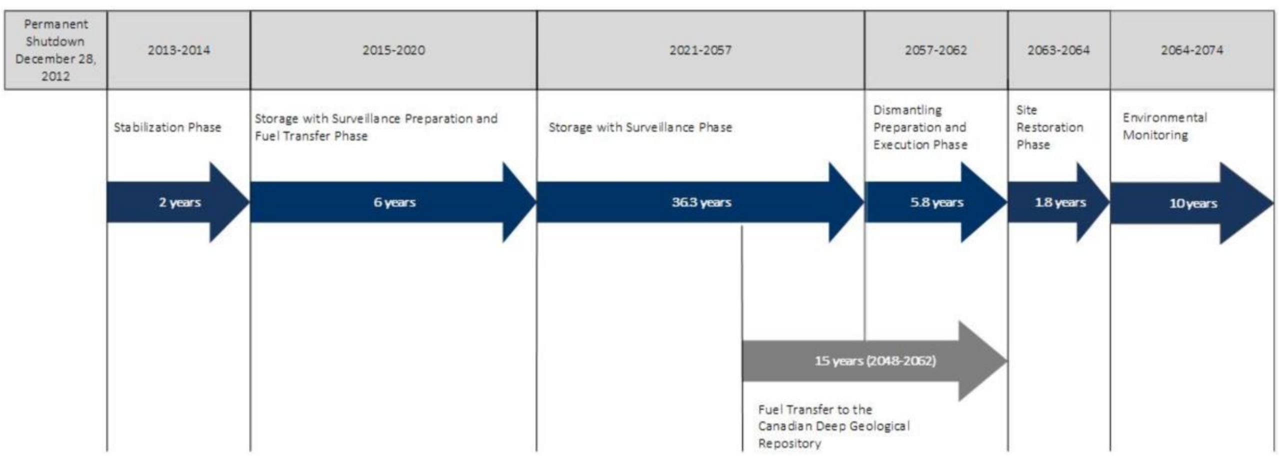
8.4 Gentilly-2 Nuclear Generating Station

Following the decision by the Government of Quebec and upon H-Q's recommendation, Gentilly-2's commercial operation ended on December 28, 2012. The station was placed in a guaranteed shutdown state and decommissioning activities are being undertaken. H-Q has adopted a deferred decommissioning strategy approach. The activities under this strategy are divided into several phases, the first three of which are:

1. stabilization phase (2013–14)
2. SWS preparation phase (2015–20)
3. SWS phase (2021–57)

Figure 8.1 shows the schedule of major decommissioning activities for Gentilly-2, and the following subsections outline these activities.

Figure 8.1: Schedule for major decommissioning activities at Gentilly-2 NGS



8.4.1 Stabilization phase

During this phase, which took place in 2013–14, station reconfiguration was planned and preparations were made to reach the SWS and fuel transfer phase.

The main activities were as follows:

- removal of spent fuel from the reactor and its storage in a pool
- drainage of heavy water circuits (coolant and moderator) and their storage
- drainage of large volumes (light water, oil)
- shutdown of systems that are no longer required
- introduction of monitoring programs for the next phase (environment, radioprotection, safety)

8.4.2 Storage with surveillance preparation phase

This current phase, planned from 2015–20, consists of completing the transfer of spent fuel stored in the pool to the dry storage facility at the Gentilly-2 NGS's secure site. Two additional storage units were built to store all the spent fuel currently in the pool. Other activities planned for this phase involve mainly the establishment of a program for preventive maintenance, the aging management of systems, structures and components, and environmental monitoring.

At the start of 2015, an organization dedicated to completing this phase became operational with the human and budgetary resources required to fulfill its mandate.

8.4.3 Storage-with-surveillance phase

The former NGS will be in SWS for approximately 36 years, from 2021 to 2057, before preparation and execution of dismantling activities are undertaken. The transfer of spent fuel to the planned national long-term storage site is scheduled to begin in 2048. Final site restoration will be completed in 2064.

8.5 Gunnar Mine Site

The Gunnar Remediation Project is located on the southern tip of the Crackingstone Peninsula along the north shore of Lake Athabasca, approximately 25 km southwest of Uranium City, Saskatchewan. The Gunnar mine site has been abandoned since 1964, and it was not adequately decommissioned. The Gunnar site consists of open and underground mine pits, mining infrastructure, three mine tailings deposits and waste rock piles. The total volume of mine tailings at the site is 4.4 million tonnes, and the total volume of waste rock is approximately 2.2 to 2.7 million tonnes. The Province of Saskatchewan's Ministry of Energy and Resources owns the site; it subsequently appointed the SRC as project manager to oversee the ongoing management and remediation of the Gunnar mine site.

In January 2015, the Commission issued a licence to the SRC for the Gunnar Remediation Project following a public hearing. The SRC's licence is valid until November 30, 2024. The remediation work is divided into three phases. Phase 1, which is now complete, involved characterizing and monitoring the on-site waste and developing remediation plans. Phase 2 consists of implementing the remediation plans. Phase 3 will be the long-term monitoring and maintenance to ensure the site remains stable and safe.

The SRC is currently in Phase 2 of the project and has implemented the following remediation work:

- development of borrow areas and haul road construction
- grading, excavation and placement of waste rock at both Gunnar main and central tailings surfaces
- submission, review and approval of detailed remediation design for other cleanup aspects

Additional remediation work scheduled to continue until the end of 2024 will include:

- the construction of two landfill areas to contain both radioactive and hazardous waste
- legacy waste sweeps and the consolidation of all waste on site
- grading, excavating and constructing the tailings cover area at Langley Bay
- the remediation of all mine openings on site (e.g., vent raises)

The current licence is valid until November 30, 2024, but it will need to be renewed, because once the remediation work is complete, the site will transition to Phase 3 which includes long-term monitoring and maintenance to ensure the site remains stable and safe.

8.6 Nuclear Power Demonstration

The NPD site is located in Renfrew Country in Ontario, adjacent to the west bank of the Ottawa River, approximately 3 km downstream of the Des Joachims Dam and Generating Station, 25 km upstream from CRL and 15 km from the town of Deep River. The NGS 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. The NGS was placed into an interim safe and sustainable shutdown phase. This interim storage period is referred to as the SWS phase under the deferred decommissioning strategy. After the reactor shutdown, the heavy water from the primary heat transport and moderator systems was drained and shipped off-site. The reactor was defueled and the fuel bundles were transferred to CRL for storage. 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, and 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.

The NPD site consists of a limited number of structures, including:

- the main building (reactor building/powerhouse) which stores the partially decommissioned 20-MW electrical prototype CANDU reactor and its associated underground services and structures
- the ventilation stack
- the diesel generator enclosure
- two sea containers
- the pressure relief duct
- foundations from previously removed pump houses, emergency vehicle garage, training centre, construction camps, warehouses, dousing tank, transformer and administration wing
- two on-site landfills, which are currently closed

The site is currently licensed as a waste facility and is still owned by AECL, but it is operated by CNL. Since the transition to GoCo model in 2015, CNL is pursuing an accelerated decommissioning approach for the NPD site.

CNL is now proposing *in situ* decommissioning for the NPD site. Although not used widely, this approach has been used at other sites internationally. The technique is intended to minimize radiological exposure to workers, reduce the need for handling and transportation, and minimize risk to workers and the environment.

The proposed *in situ* decommissioning activities include:

- assembling and operating the grout batch mixing plant
- removing the above-ground structure and placing contaminated materials in the below-grade structure
- using grout to seal the below-grade structure, reactor vessel and all of the systems, components and contaminated materials
- installing a concrete cap and engineering barrier over the grouted area
- conducting final restoration of the rest of the site
- preparing for long-term care and maintenance activities

Starting in 2016, as part of an environmental assessment process under the CEAA, 2012, CNL started preparing an environmental impact statement for submission to the CNSC for consideration. In conjunction with the required environmental assessment process, CNL will also be requesting a licence amendment from the CNSC to perform the proposed decommissioning activities.

Once the CNSC authorizes the project, it will take approximately two years to decommission the NPD site. After site restoration activities have been completed, the site will enter a period of long-term surveillance under a monitoring program for a period of time established through a safety analysis process.

CNL has not yet submitted its licensing application or safety case in support of *in situ* decommissioning for regulatory review. A licensing hearing to consider this proposal is expected later in 2021.

8.7 Saskatchewan Research Council SLOWPOKE-2

SRC operated a SLOWPOKE-2 nuclear research reactor for 37 years between 1981 and 2018. SRC applied to the CNSC for a licence to decommission the nuclear facility in 2019 and it was granted later that year.

The facility is located in the city of Saskatoon, Saskatchewan. The reactor provided a source of neutrons for neutron activation analysis and isotope production, and it was used for teaching purposes in conjunction with the University of Saskatchewan.

The SLOWPOKE-2 reactor was a 20 kW-thermal sealed-container-in-pool type research reactor, cooled and moderated with light water, and operated on HEU. The core was cooled by natural convection and was surrounded by a beryllium reflector. The facility consisted of the reactor room, two rooms for support equipment and a sample storage room. The reactor itself was located in a concrete well underneath the floor of the reactor room.

During decommissioning, the building and remaining structures were surveyed for contamination. The waste from the decommissioning project was segregated, and non-radioactive items were reused and recycled to the extent possible. Decommissioning the facility produced an estimated 8 m^3 of solid radioactive waste which was transported to a licensed radioactive WMF. Water from the reactor pool was purified through ion-exchange columns and released to the city sewers after it was determined to be free of contaminants. The fuel was repatriated to the United States under the Canada-United States agreement to return spent HEU fuel to its country of origin.

The small inventory of non-radioactive, hazardous materials was disposed of in accordance with applicable regulations.

The project will be completed in 2020, at which point the SRC is expected to apply to the CNSC for a licence to abandon a nuclear facility. SRC plans to return the facility to a condition that allows for unrestricted use.

8.8 Whiteshell Laboratories

8.8.1 Background

WL is a nuclear research and test establishment developed in the early 1960s by AECL to investigate higher temperature versions of its CANDU reactor design. In the late 1990s, AECL decided to discontinue research programs and operations at the facility, and the planning for its closure and decommissioning began. The site is still owned by AECL, but is now operated by CNL under a GoCo arrangement.

WL is located in Manitoba on the east bank of the Winnipeg River, about 100 km northeast of Winnipeg, 10 km west of Pinawa and 9 km upstream from Lac du Bonnet. The major structures located on the site include WR-1, the main research building (building B300), other research and supporting buildings, and a radioactive waste management area that contains the concrete canister storage facility for the dry storage of spent fuel.

WL is currently licensed under a nuclear research and test establishment licence to decommission that was issued in 2002, renewed in 2008 and amended in 2016. In 2014, the licence was transferred to CNL which became the licensee. The licence was renewed in 2018 and 2019 and is currently valid until December 31, 2024.

During the initial six-year period of the licence to decommission (2002–08), 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.

CNL continues to decommission the WL. The current licence to decommission expires in December 2024. Major activities completed since the Sixth Review Meeting include the demolition and site remediation of the following facilities:

- Research & Development Building B300 stages 4 and 7, a total footprint of 2,435 m^2
- seven storage buildings (B306, B532, B409, B416, B427, B428, B418) totalling 814 m^2 in size
- Decontamination Centre B411, which had a footprint of 535 m^2
- south side Material Warehouse B415, which had a footprint of 1,922 m^2
- south side Material Handling B408, which had a footprint of 1,622 m^2
- Organic Incinerator Feed Building and the organic incinerator located at the waste management area, footprint of 25 m^2
- Large-Scale Vented Combustion Test Facility including 4 structures (B308, B311, B309, B310) with a total footprint of 360 m^2
- Research & Development Building B300 Stage 6, which was also known as the RD-14M Thermohydraulic Test Loop, which had a footprint of 448 m^2
- Combustion Test Facility B303 and the Gas Dynamics Research Lab B304, with a total footprint of 1,329 m^2

For the next licence period, CNL is proposing to extend site closure activities to 2027 and decommission the WR-1 using *in situ* decommissioning, which is a different approach to what is currently authorized under the licence and subject to regulatory approval.

For the wastes that are currently on-site, CNL is planning to:

- transport certain LLW and other suitable wastes from Whiteshell to CRL for disposal in the proposed NSDF
- transport ILW to CRL for storage
- transport HLW (spent fuel) to CRL for interim storage until disposal facilities become available
- dispose of most of the LLW that resides in unlined soil trenches in the waste management area *in situ*

In situ decommissioning is being proposed by CNL for WR-1. This entails removing the above-grade structure and grouting the below-grade components using a concrete based grout. The structure would then be capped with concrete and covered with an engineered barrier. *In situ* decommissioning is intended to isolate the reactor vault and contaminated systems and components inside the below-grade structure. Although not used widely, this approach has been used at other sites internationally. The technique is intended to minimize radiological exposure to workers, reduce the need for handling and transportation and minimize risk to workers and the environment. This proposal has yet to be approved by the CNSC.

8.8.2 Underground Research Laboratory

The URL, located approximately 15 km northeast of WL in Manitoba, was an underground experimental facility used for research on 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 HLW were ever placed in the URL.

Two underground radioisotope laboratories (using low levels of tracer isotopes) were licensed by the CNSC under its NSRDR. These laboratories were closed and decontaminated several years ago. CNSC staff confirmed this during an inspection conducted prior to the revocation of the site's licence to operate in 2003. The URL site was closed in 2015 after selected boreholes, ventilation raises and the main shaft were sealed, and an environmental and post-closure borehole hydraulic and geochemical monitoring program was conducted over a three-year period.

This also included the removal of the 22 post-closure boreholes, contaminated soil and the URL's surface facilities. AECL returned the leased lands to the Province of Manitoba on March 31, 2016.

Annex 9 – Matrix for Canada's Seventh National Report

Type of Liability	Long-term Management (LTM) Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Spent fuel	National approach for the LTM of spent fuel NWFA, 2002 outlines process and implementation	Long term: • licensees are required to contribute to segregated funds to finance LTM activities under the NFWA Short term: • licensees are financially responsible and required to provide a financial guarantee for the decommissioning of interim WMFs for spent fuel under the NSCA	Spent fuel from power reactors held in interim storage in wet or dry storage facilities located at the waste producers' site Spent fuel from research reactors returned to the fuel supplier or transferred to CRL for storage	Long term: • NWMO implementation of the APM approach – a DGR for the LTM of spent fuel in Canada Short term: • interim dry storage facilities constructed as needed
Nuclear fuel cycle waste	Licensees are responsible for the funding, organization, management and operation of their WMFs (*Radioactive Waste Policy Framework*) Government of Canada accepted responsibility for LTM of historic wastes and funds the management of legacy waste	Licensees are financially responsible and required to provide a financial guarantee for the decommissioning and LTM of the waste they produce	• managed by licensee (on-site or at a dedicated WMF) • managed *in situ*/ above-ground mounds • managed in near-surface facilities adjacent to the mines and mills • waste from small generators transferred to licensed WMFs for management • material decontaminated and recycled/disposed of through conventional means • recovery of uranium from recoverable process streams	• OPG assessing options for LTM of its LLW and ILW • CNL assessing CRL site for hosting LTM facilities for L&ILW • LTM of the bulk of Canada's historic waste implemented under the PHAI • LTM of uranium mines and mills in near-surface facilities adjacent to the mines and mills • CNL assessing options at CRL site for hosting LTM facilities for radioactive wastes
Application wastes	Licensees are responsible for the funding, organization, management and operation of their WMFs	Licensees are financially responsible and required to provide a financial guarantee for the decommissioning and the LTM of the waste that they produce	• delay and decay • returned to manufacturer • transferred to licensed WMFs for management	CNL assessing options at CRL site for hosting LTM facilities for radioactive wastes

Type of Liability	Long-term Management (LTM) Policy	Funding of Liabilities	Current Practice / Facilities	Planned Facilities
Decommissioning liabilities	• Licensees are responsible for the funding, organization, management and implementation of decommissioning activities • Licensees to give due consideration to the immediate dismantling approach when proposing a decommissioning strategy (G-219)	Licensees are financially responsible and required to provide a financial guarantee for the decommissioning and LTM of the waste that they produce	Major facilities required to keep decommissioning plans and financial guarantee up to date throughout the lifecycle of a licensed activity (G-219 and G-206). These are reviewed on a five-year cycle by the licensee and regulator	CNL assessing CRL site for hosting LTM facilities for L&ILW OPG assessing options for LTM of its L&ILW arising from decommissioning
Disused sealed sources	Licensees are responsible for the funding, organization, management and operation of their WMFs Sources tracked through NSSR and SSTS	Licensees are financially responsible and required to provide a financial guarantee for the decommissioning and the LTM of the waste that they produce	• delay and decay • returned to manufacturer • transferred to licensed WMF for LTM • recycling by reusing, re-encapsulating or reprocessing	CNL assessing options at CRL site for hosting LTM facilities for radioactive wastes

List of Acronyms and Abbreviations

AECL	Atomic Energy of Canada Limited
ALARA	as low as reasonably achievable
AMPR	*Administrative Monetary Penalties Regulations*
APM	Adaptive Phased Management
ASDR	l'aire de stockage des déchets radioactifs (radioactive waste storage area)
BP	Bruce Power
BWXT	BWX Technologies Inc.
CANDU	Canada deuterium-uranium
CANUTEC	Canadian Transport Emergency Centre
CARP	Coordinated Assessment and Research Program
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CEA Agency	Canadian Environmental Assessment Agency
CEPA	*Canadian Environmental Protection Act*
CINFR	*Class I Nuclear Facilities Regulations*
CIINFPER	*Class II Nuclear Facilities and Prescribed Equipment Regulations*
CLC	community liaison committee
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CRL	Chalk River Laboratories
CRMN	Canadian Radioactivity Monitoring Network
CSA	Canadian Standards Association
DDP	detailed decommissioning plan
DECOVALEX	Development of Coupled models and their Validation against Experiments
DGR	deep geological repository
DGRRF	Deep Geological Repository Regulators Forum

DGR-SRA	Strategic Research Agenda for Deep Geological Repositories
DRL	derived release limit
DSC	dry storage container
EBS	engineered-barrier system
ECCC	Environment and Climate Change Canada
ECM	engineered containment mound
EIS	environmental impact statement
EMA	*Emergency Management Act*
EMS	environmental management system
EPREV	Emergency Preparedness Review
ERA	environmental risk assessment
EWL	EnCana West Limited
FEP	features, events and processes
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
FPS	fixed point surveillance
GEOSAF	International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste
GNSCR	*General Nuclear Safety and Control Regulations*
GoCo	government-owned, contractor-operated
GSR	General Safety Requirements (IAEA)
GTA	Greater Toronto Area
H-Q	Hydro-Québec
HEU	highly enriched uranium
HHERA	human health and ecological risk assessment
HLW	high-level radioactive waste
IAA	*Impact Assessment Act*

IAAC	Impact Assessment Agency of Canada
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEMP	Independent Environmental Monitoring Program
IGSC	Integration Group for the Safety Case
ILW	intermediate-level radioactive waste
INAC	Indigenous and Northern Affairs Canada
IPPAS	International Physical Protection Advisory Service
IRRS	Integrated Regulatory Review Service
IRSN	Institut de radioprotection et de sûreté nucléaire
ITDB	Incident and Trafficking Database
JEB	John Everett Bates
JRP	Joint Review Panel
L&ILW	low- and intermediate-level radioactive waste
LCH	licence conditions handbook
LEU	low-enriched uranium
LLRWMO	Low-Level Radioactive Waste Management Office
LLW	low-level radioactive waste
LSS	life span studies
LTM	long-term management
MACSTOR	modular air-cooled storage
MAGS	modular above-ground storage
MAPLE	Multipurpose Applied Physics Lattice Experiment
MNDM	Ministry of Northern Development and Mines (Ontario)
MoE	Ministry of the Environment
MPMO	Major Projects Management Office
N/A	not available

NB Power	New Brunswick Power Corporation
NCA	nuclear cooperation agreement
NEA	*Nuclear Energy Act*
BWXT NEC	BWXT Nuclear Energy Canada Inc.
NFWA	*Nuclear Fuel Waste Act*
NGS	nuclear generating station
NLCA	*Nuclear Liability and Compensation Act*
NNIECR	*Nuclear Non-proliferation Import and Export Control Regulations*
NORM	naturally occurring radioactive material
NPD	nuclear power demonstration
NPP	nuclear power plant
NPRI	National Pollutant Release Inventory
NPT	non-proliferation of nuclear weapons
NRCan	Natural Resources Canada
NRU	National Research Universal
NRX	National Research Experimental
NSCA	*Nuclear Safety and Control Act*
NSDF	near surface disposal facility
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
OAE	Office of Audit and Ethics
OECD	Organisation for Economic Cooperation and Development
OPG	Ontario Power Generation Inc.
PCB	polychlorinated biphenyls

PDP	preliminary decommissioning plan
PFP	Participant Funding Program
PHAC	Public Health Agency of Canada
PHAI	Port Hope Area Initiative
PTNSR, 2015	*Packaging and Transport of Nuclear Substances Regulations, 2015*
R&D	research and development
RMC	Royal Military College
ROR	Regulatory Oversight Report
RPR	*Radiation Protection Regulations*
RWLF	Radioactive Waste Leadership Forum
SCA	safety and control area
SITEX II	Sustainable Network for Independent Technical Expertise on Radioactive Waste Management
SLOWPOKE	Safe Low-Power Kritical Experiment
SMAGS	shielded modular above-ground storage
SMART	specific, measurable, attainable, realistic and timely
SRC	Saskatchewan Research Council
SSR	Specific Safety Requirements (IAEA)
SSTS	Sealed Source Tracking System
STEM	science, technology, engineering and mathematics
SWS	storage with surveillance
TDGR	*Transportation of Dangerous Goods Regulations*
THMC	thermal-hydraulic-mechanical-chemical
TLD	thermoluminescent dosimeter
TMA	tailings management area
TMF	tailings management facility
UFC	used fuel container
UFTP	used fuel transportation package

UMMR	*Uranium Mines and Mills Regulations*
UNENE	University Network of Excellence in Nuclear Engineering
URL	underground research laboratory
U.S.	United States of America
VLLW	very-low-level radioactive waste
VSLLW	very-short-lived low-level radioactive waste
WISTEM	Women in STEM
WL	Whiteshell Laboratories
WMF	waste management facility
WR-1	Whiteshell Reactor-1
WTP	waste water treatment plant
ZED-2	zero energy deuterium-2