The science behind safe nuclear waste disposal: decades of research

Used Nuclear Fuel Project

1978 — Nuclear Fuel Waste Management Program begins

- The governments of Canada and Ontario announce the **Nuclear Fuel Waste Management Program**.
- **Atomic Energy of Canada Limited (AECL) is directed to develop the concept of deep geological disposal of used nuclear fuel** and to demonstrate the feasibility of placing waste at depths of hundreds of metres in a granitic rock formation in the Canadian Shield.
- To review AECL's research, the Canadian nuclear regulator (called the **Atomic Energy Control Board (AECB)** at the time) creates an **independent regulatory research program** focused on granitic rock.

1989 — Seaborn Panel is established to independently review results

- **The Seaborn Panel**, a federal environmental assessment review panel, is established to independently review AECL's deep geological disposal concept.
- **AECL continues to develop the deep geological disposal** concept performed by research performed at the underground research laboratory in Whiteshell, Manitoba.
- **The AECB continues its independent assessment and regulatory program**, which consists of in-house research, collaboration with external experts, as well as participation in international research and in the review of disposal. The AECB also participates in workshops organized by AECL and reviews their interim reports.

1994 — AECL submits its environmental impact statement (EIS)

- **AECL submits its environmental impact statement (EIS)** for the concept to the Seaborn Panel. No specific site is identified.
- **The AECB publishes its findings in reports, presentations, and conference proceedings.**
- The overall conclusion is that the concept proposed by AECL is technically feasible on the basis of evidence. **AECB staff advise the Seaborn Panel that Canada should proceed with site selection.**

1996 — Seaborn Panel conducts public hearings

- From 1996 to 1997, **the Seaborn Panel conducts public hearings in five provinces** – Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick.
- The **AECB reviews the EIS submitted by AECL and participates in the public hearings** as one of the primary intervenors.

1998 — Seaborn Panel submits its report to the Government of Canada

- **The Seaborn Panel submits its report, which includes recommendations to the federal Ministers of the Environment and Natural Resources.**
- The panel's key conclusions are the following:

  From a technical perspective, safety of the AECL concept has been balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it has not.

  As it stands, the AECL concept for deep geological disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be the basis for a national approach for managing used nuclear fuel.

1999 — Government reviews the Seaborn Panel report

- **The Government of Canada reviews the Seaborn Panel report.**
- **The AECB continues independent research on geological disposal in preparation for a future licensing decision on the Seaborn Panel report.**

  Research on the long-term performance of granitic rock formations has been conducted at underground research laboratories in Canada, Japan and Switzerland, among others. AECB staff develop mathematical models to interpret data generated from these experiments.

2002 — Nuclear Waste Management Organization (NWMO) is established

- The Government of Canada brings into force the **Nuclear Fuel Waste Act** and **establishes a new agency called the Nuclear Waste Management Organization (NWMO).**
- The NWMO is tasked with **exploring options for the long-term management of used nuclear fuel.**

  They will recommend the preferred option and, if accepted by the government, implement the chosen option. **The NWMO is to work collaboratively with Canadians at all stages** and be funded by nuclear energy corporations.
- **The AECB becomes the Canadian Nuclear Safety Commission (CNSC)** in 2000. The CNSC continues with independent regulatory research on deep geological disposal.

2005 — NWMO recommends an adaptive phased management approach

- **The NWMO recommends an adaptive phased management (APM) approach** to manage used nuclear fuel for the long term.

  The APM approach provides a high degree of flexibility and adaptability with explicit decision points along each phase.

  Under the APM approach, an informed and informed decision to site a deep geological repository.

  Both sedimentary and crystalline rock formations in the Canadian Shield will be considered.
- The CNSC continues its independent regulatory research on geological disposal.

2006 — CNSC publishes regulatory document G-320

- **CNSC publishes regulatory document G-320**, which provides guidance on how to demonstrate the long-term safety of a deep geological repository with explicit decision points along each phase.

  G-320 defines the concept of the safety case: *an integrated and documented set of arguments to demonstrate the long-term safety of radioactive waste disposal.*

  Central to the safety case is the safety assessment: *a systematic and quantitative analysis of the level of safety associated with a radioactive waste management facility. The safety assessment must be supported by additional arguments and evidence.*

  Regulatory document G-320 will be used by the NWMO to demonstrate the long-term safety of its project.

2007 — The adaptive phased management (APM) approach is accepted

- **The Government of Canada accepts NWMO's APM approach** for the long-term management of used nuclear fuel.
- **The NWMO starts to develop a site selection process** among volunteer communities.
- The CNSC begins the **Coordinated Assessment and Research Program (CARP)** to review the Canadian nuclear waste for the disposal of used nuclear fuel.

2010 — The NWMO invites Canadian communities to learn about APM

- **The NWMO commences site selection process**, inviting Canadian communities to learn more about the APM approach to long-term used nuclear fuel disposal.

2011 — Research on sedimentary rock show favourable properties

- **Results from the CARP** show that sedimentary rocks of the Michigan Basin in Southern Ontario have **many favourable properties for the potential disposal of used nuclear fuel:**

  The Cobourg limestone (the host formation) has **good mechanical strength and very low permeability.**

  The many layers of shale that overlay the Cobourg limestone have **very low permeability and high sorption capacity** *(to retain radionuclides).*

  The formations have been **resilient to nine cycles of glaciation during the last million years.**

  Southern Ontario is a low seismic region. **No evidence of major fracturing was found.**

2012 — Research starts on clay seals

- In 2012, CNSC extended the **CARP to include experimental and theoretical research on the long term** performance of clay seals and their interaction with sedimentary rocks and brine groundwater. The research included natural analogues, and the development of computer models to perform a long-term safety assessment.

2014 — CNSC establishes the Independent Advisory Group

- **The CNSC establishes the Independent Advisory Group (IAG)** to provide CNSC with an independent review of both the CNSC's and NWMO's research programs.

  IAG's members are Canadian geoscientists who are internationally recognized for their scientific contributions to geology, hydrogeology, geomechanics and geochemistry.

2015 — CNSC research continues in preparation for the review of the NWMO's APM

- The NWMO continues site selection among nine volunteer communities, as located in Ontario.
- **The Coordinated Assessment and Research Program (CARP) continues.** Its results will help with the independent review of the NWMO's APM plan.

2005 — Ontario Power Generation (OPG) submits a project description for DGR

- **Ontario Power Generation (OPG) submits a project description** for the disposal of their low - and intermediate - level waste in a **Deep Geologic Repository (DGR)** within a sedimentary rock formation beneath the Bruce site in Kincardine (Ontario).
- The Canadian Nuclear Safety Commission **(CNSC) reviews the Deep Geologic Repository (DGR) project description** submitted by OPG.

OPG's Deep Geologic Repository Project

2006 — The Commission recommends the DGR project be referred to a review panel

- CNSC posts a notice of environmental assessment (EA) for the DGR project.

  Following a public hearing in Kincardine, ON, the **CNSC recommends that the Minister of the Environment refer the DGR project to a review panel.**

  The CNSC publishes regulatory document G-320, which provides guidance on how to demonstrate the long-term safety of radioactive waste.

  Regulatory document G-320 will be used by OPG to demonstrate the long-term safety of its project.

2007 — Research starts on sedimentary rock

- The federal Minister of the Environment **refers OPG's DGR project to an environmental assessment by a Joint Review Panel (JRP).**
- The CNSC begins the **Coordinated Assessment and Research Program (CARP)** on sedimentary rock at the Bruce site.

2009 — CNSC and CEAA publish the JRP Agreement and the EIS Guidelines

- **The CNSC and the Canadian Environmental Assessment Agency (CEAA) publish the final Environmental Impact Statement (EIS) Guidelines and the JRP Agreement.**

  The EIS Guidelines identify the information needed for OPG to prepare the EIS, which will provide a detailed analysis of the potential environmental effects of the proposed DGR project. It also lists the information that OPG must prepare the site and construct the DGR.

  The JRP Agreement establishes how the panel will function and the terms of reference for conducting an environmental assessment, and for considering the licence application to prepare a site and construct OPG's proposed DGR project.

  The draft EIS Guidelines and JRP Agreement were drafted in consultation with the Saugeen Ojibway Nation (SON) and subject to public consultation. They were amended following consideration of the comments received.

2011 — OPG submits the environmental impact statement for DGR

- **OPG submits the EIS** for the proposed DGR on the Bruce site.

  OPG also applies to the CNSC for a licence to prepare the site and construct a DGR, and submits the EIS and a preliminary safety report in support of the application.
- **The CARP concludes that the many layers of sedimentary rock at the Bruce site would constitute robust barriers for the long-term containment** of low- and intermediate-level waste, based on the following findings:

  Groundwater *at depths of more than 500 m* **has remained isolated from the near-surface waters for hundreds of millions of years.**

  The rock at depths of more than a few hundred metres was **unaffected by nine glacial cycles over the last million years.**

  Damage of the rock due to the construction of the repository, **and future perturbations** *such as glaciation and gas generation* **would be limited.**

2012 — Joint Review Panel (JRP) is established

- **The Minister of the Environment and the CNSC President announce the establishment of a JRP** for OPG's proposed DGR project.

  The members of the JRP are also announced.
- **CNSC staff conduct a detailed technical and scientific review of OPG's EIS that results in more than 50 requests to OPG for additional information.**

2013 — JRP holds 25 days of hearings

- **The Joint Review Panel holds 25 days of public hearings** in Kincardine and Port Elgin, ON.
- **The results of CARP provide major inputs** to the JRP's staff interventions at the JRP public hearing.

  CNSC staff conclude that the DGR project will not cause significant adverse environmental effects nor impact aboriginal treaty rights, and recommend to the JRP the issuance of a licence to prepare site and construct the DGR.

2014 — JRP holds additional hearings for the DGR

- The JRP holds an additional 8 days of public hearings in Kincardine, ON. Overall, there were **33 days of hearings and 219 participants,** including representation from Aboriginal groups and the United States. More than **20,000 pages of information** were reviewed.

2015 — JRP submits its report and recommendations

- The JRP for OPG's proposed DGR **submits its report to the Minister of the Environment with a positive recommendation for the project.**

  The report includes 97 recommendations on proposed environmental and health and safety protection measures over the lifetime of the project.

  The report is consistent with the CNSC's conclusions.

- Decisions
- Research
- Reports
- Review
- Public/Panel Hearings

- Government Agencies
- Activities related to Used Nuclear Fuel Project
- Activities related to OPG's DGR project
- Activities by Canada's Nuclear Regulator

AECB: Atomic Energy Control Board
AECL: Atomic Energy of Canada Limited
APM: Adaptive phased management
CARP: Coordinated Assessment and Research Program
CEAA: Canadian Environmental Assessment Agency
CNSC: Canadian Nuclear Safety Commission
DGR: Deep Geologic Repository
EIS: Environmental impact statement
IAG: Independent Advisory Group
JRP: Joint Review Panel
NWMO: Nuclear Waste Management Organization
OPG: Ontario Power Generation