APM DGR Preliminary Description

Prepared to Support Ontario Power Generation Cumulative Effects Response to Minister of Environment and Climate Change Canada (2016)

APM-REP-06415-0201 **December 2016**

Nuclear Waste Management Organization

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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ABSTRACT

Title: **APM DGR Preliminary Description, Prepared to Support Ontario Power Generation Cumulative Effects Response to Minister of Environment and Climate Change Canada (2016)**

Report No.: **APM-REP-06415-0201**
Company: Nuclear Waste Management Organization
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Abstract

The NWMO is implementing Adaptive Phased Management (APM), selected by the Government of Canada as Canada's plan for the safe long-term management of Canada's used nuclear fuel. NWMO is presently in the site selection phase for this project, with several areas across Ontario under consideration but no site identified.

This document presents a preliminary description of an APM Deep Geological Repository for used nuclear fuel (APM DGR). In this description, this facility is assumed to be located within the boundaries of the Township of Huron-Kinloss, the Municipality of South Bruce, or the Municipality of Central Huron, and within Saugeen Ojibway Nation (SON) traditional territory. This description is provided in order to assist Ontario Power Generation (OPG) in preparing its response to the federal Minister of Environment and Climate Change Canada request for an updated analysis of the cumulative environmental effects of the OPG DGR project, assuming an APM DGR were to be built in one of these communities.

This document presents a description at a conceptual level for a deep geological repository facility for used nuclear fuel. The description is based on what is known or reasonably expected at the present time, assuming that a suitable location for a used fuel repository has been identified in one of these three communities involved in the APM siting process. A definitive description would be completed in the future if a site were actually to be selected, and the site, design, community input and environmental assessments had been completed, consistent with NWMO's siting process. NWMO would not proceed without the involvement of the interested community, First Nation and Métis communities, and surrounding communities working to implement the project.

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1. INTRODUCTION

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), which was selected by the Government of Canada as the approach for the safe long-term management of Canada's used nuclear fuel. NWMO is presently in the site selection phase for this project, with several areas across Ontario under consideration but no site yet identified. Phase 1 Preliminary Assessments were undertaken by the NWMO as the first phase to assess the potential suitability of several communities to host an APM deep geological repository (APM DGR).

In a separate activity, Ontario Power Generation (OPG) is currently seeking a licence to prepare the site and construct a Deep Geologic Repository for its low and intermediate level radioactive waste (L&ILW) at the Bruce nuclear site in the Municipality of Kincardine (the OPG DGR Project).

In 2015 a Joint Review Panel issued the Environmental Assessment Report on the OPG DGR Project, which concluded "*that the project is not likely to cause significant adverse environmental effects*" and identified terms and conditions that should be imposed. In February 2016 the Federal Minister of Environment and Climate Change requested OPG provide additional information, prior to making a decision on the Environmental Assessment (EA). In particular, the Minister requested

> *"An updated analysis of the cumulative environmental effects of the Project in light of the results from the Phase 1 Preliminary Assessments undertaken by the Nuclear Waste Management Organization, which identified three potential host communities that fall within the traditional territory of the Saugeen Ojibway Nation."*

The purpose of this document is to provide a summary description of the NWMO proposed deep geological repository project for Canada's used nuclear fuel , in order to assist OPG in responding to the request from the Minister.For purposes of this description, the facility is assumed to be located at a a site within the boundaries of the Township of Huron-Kinloss, the Municipality of South Bruce, or the Municipality of Central Huron, and within Saugeen Ojibway Nation (SON) traditional territory.

The description presents an estimate based on what is known or reasonably expected at the present time. A definitive description would be completed in the future if a site were actually to be selected in one of these three communities, and the site, design, community input and environmental assessments had been completed, consistent with NWMO's siting process.

2. APM APPROACH

2.1 PROJECT CONTEXT

Canada has used nuclear power to provide electricity for the past 50 years. The wastes generated from nuclear power, including used nuclear fuel , are currently stored safely in interim structures at or near the nuclear reactor sites. While safely managed at present, long term management is needed due to the nature of the hazard of the material.

Along with other countries, and in alignment with best practices identified by international organizations such as the International Atomic Energy Agency and the Nuclear Energy Agency, Canada has been developing the deep geological repository concept for the long-term management of used nuclear fuel.

In 2002, the Federal government passed the *Nuclear Fuel Waste Act (NFWA)* to address the requirement for long-term management of used nuclear fuel. The NWMO was created by the nuclear energy corporations in Canada in response to the requirements of the *NFWA* and was mandated to explore options with Canadians for long-term management of used nuclear fuel.

In 2007, after a three year study involving a broad cross-section of Canadians and based on the NWMO's recommendation, the federal cabinet selected APM as the plan for long-term management of Canada's used nuclear fuel (OIC 2007). This plan best met the values and expectations expressed by Canadians.

APM is both a technical method and a management system. The end point of the technical method is the safe, centralized containment and isolation of Canada's used fuel in a deep geological repository in an area with suitable geology and an informed and willing host. APM also involves the development of a transportation system to move the used fuel from the facilities where it is currently stored to the repository. The management system involves realistic, manageable phases, each marked by explicit decision points. It allows for flexibility in the pace and manner of implementation, and fosters the sustained engagement of people and communities throughout its implementation.

Since 2007, NWMO has been charged with implementing this project. NWMO submits annual and triennial reports on progress to the Minister of Natural Resources, which are tabled in Parliament. The federal government also required that funding for implementation of the repository be set aside, and it maintains oversight on these funds.

2.2 PROGRAM OBJECTIVES

The APM program includes the site selection, preparation, construction, operation, decommissioning and long-term performance of an above- and below-ground facility for the long-term management of Canada's used nuclear fuel . These facilities, including the containment system, will be specific to the requirements for safe long-term management of used nuclear fuel. In this document, this facility is referred to as the APM DGR.

Following the operational phase of the APM DGR, the facility would be maintained accessible and monitored for some period. At the end of this phase, based on discussions with communities and approval of the regulator, the above ground facilities would be removed, the underground facility would be closed and sealed, and long-term monitoring established.

2.3 AMOUNT OF NUCLEAR WASTE

The *Nuclear Fuel Waste Act (NFWA)* requires the NWMO to manage all used nuclear fuel produced in Canada. Based on input from Canadians, the NWMO has committed that no used fuel from other countries will be placed in the APM DGR. Consistent with the *NFWA*, the APM DGR does not include low and intermediate level radioactive waste.

The *NFWA* identifies irradiated fuel bundles from commercial and research reactors as the nuclear fuel waste to be managed by NWMO. Most of these wastes are used CANDU fuel from the operation of the Pickering, Bruce and Darlington reactors. As of June 2016, there are about 2.7 million used CANDU fuel bundles in interim storage in Canada. Canadian reactors produce about 90,000 used CANDU fuel bundles per year.

The current reference APM DGR design concept is based on an inventory of 4.6 million used fuel bundles. This is the basis for the reference design presented in this preliminary description. The repository capacity will be decided in the future as part of the siting process.

2.4 APM DGR PROJECT STATUS

Since 2007, the NWMO has been proceeding with its federal mandate to implement APM. This plan includes a deep geological repository (the APM DGR). NWMO is currently undertaking a multi-year site selection process, which is designed to identify a safe site with a willing and informed host.

NWMO is currently in discussion with three communities in southern Ontario, and with six communities and areas in northern Ontario, regarding the potential to host the APM DGR.

At present, no community or area has indicated its intent to host an APM DGR, nor has there has been an NWMO decision on siting a repository. Consequently there is no site specific repository design or site specific assessment of environmental effects in any of these communities. This information would only be produced through a multi-year phased technical assessment process and community engagement effort. communities.

2.5 COLLABORATIVELY IMPLEMENTING THE SITE SELECTION PROCESS

For purposes of this document, it has been assumed that a site has been selected. However it is important to be clear that the selection of a site, the characterization of that site, the development of a detailed design for that site, and the development of the safety and environmental understanding of that site, has yet to be done.

In order to select the preferred location for siting the APM repository, the NWMO would need to have a sufficient degree of confidence that:

- A deep geological repository can be developed with a strong technical safety case at that location;

- A safe, secure and socially acceptable transportation plan can be developed to transport used nuclear fuel to that location; and

- A strong partnership can be developed with the interested community, First Nation and Métis communities in the area, and surrounding communities.

Finally, any proposed site and facility would be subject to a rigorous regulatory approvals process before a licence could be provided to allow site preparation and construction to begin.

3. DESIGN DESCRIPTION

The design of the APM DGR is currently under development. Following is a summary of the conceptual design description, more details are provided in (NWMO 2016b). This would be revised in future, in part based on site-specific characteristics.

3.1 PHYSICAL DESCRIPTION

The main physical works related to the project are the surface facilities at the APM DGR site, the underground repository, and the waste rock management area.

3.1.1 Site Surface Facilities

The site surface facilities provide processes and equipment for receiving, inspecting, repackaging and moving used fuel to the main shaft for transfer underground and placement in the repository. These would include the used fuel packaging plant, the shaft complexes, and the sealing material compaction plant. It would also include support facilities such as the administrative buildings, security, water management facilities and power and water supply. Figure 1 provides an illustrative layout of the surface facilities. According to this layout, the surface facilities would require a dedicated area of about 650 metres by 550 metres for the main buildings and about 100 metres by 100 metres for the ventilation exhaust shaft, which may be located on-site, or alternatively may be located away from the main buildings. This is a combined area of about 40 hectares.

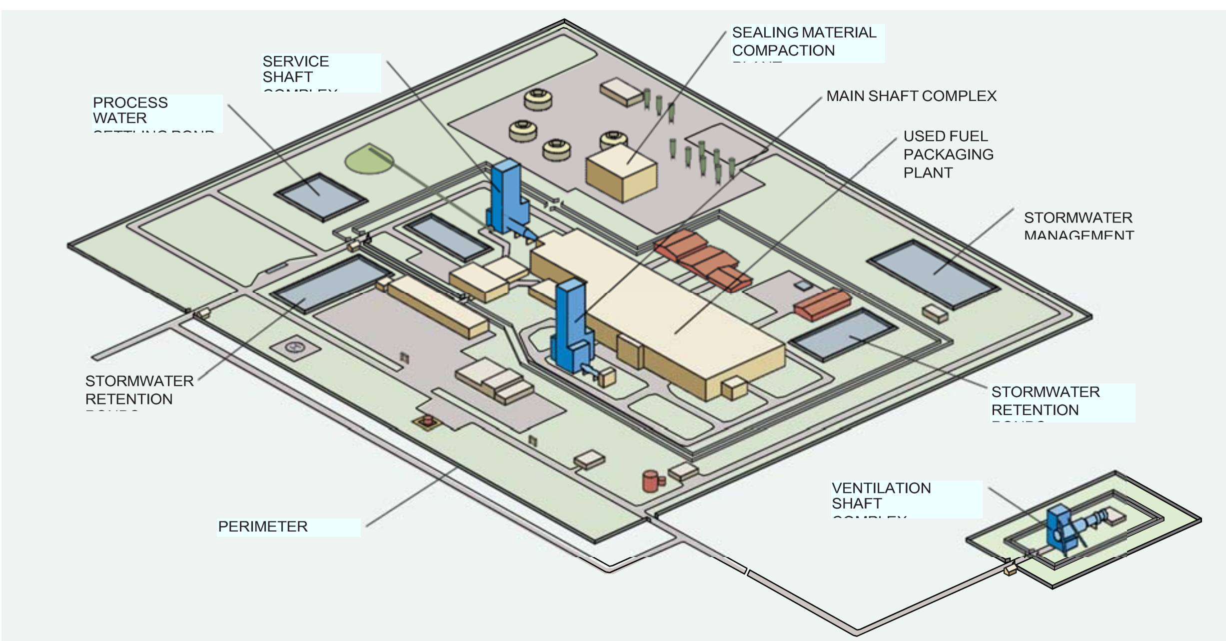

Figure 1: Conceptual Illustration of Surface Facilities at the APM DGR Site

3.1.1.1 Used Fuel Packaging Plant

The used fuel packaging plant would be designed to receive and repackage used nuclear fuel from the transport packages into long-lived, corrosion-resistant containers for placement in the repository suitable for used nuclear fuel. The reference used fuel packaging plant has the capacity to package approximately 120,000 used fuel bundles per year.

To ensure continuing reliable delivery of used fuel containers to the deep geological repository, the plant includes warehouse storage areas for used fuel transportation containers, empty used fuel storage containers and filled used fuel storage containers. It is intended that used nuclear fuel would be packaged and placed in the repository as it is received. As a result, there would only be minimal storage required for used fuel on the surface.

3.1.1.2 Shafts and Hoists

The reference design for the facility includes three shafts with hoists to enable the transfer of used fuel containers, rock, material, equipment and personnel between surface facilities and the repository. The final number of shafts and their location would depend on the site-specific design. The shafts include:

- The Main Shaft: Conveys used fuel containers within a shielded transfer cask.
- The Service Shaft: Conveys personnel, equipment, waste rock and sealing materials.
- The Ventilation Shaft: Handles most of the repository exhaust to surface and has a hoist for personnel emergency exit. It would be equipped with monitors and filters.

Headframes for the shafts would be durable structures that provide a high level of protection against weather-related disturbances. All shafts would be concrete-lined to help control inflow of water and to provide a durable, easy-to-maintain surface.

3.1.1.3 Seals Preparation Facilities

The sealing material compaction plant would take clay and aggregates or sand, and produce the compacted bentonite blocks and gapfill materials required for used fuel container placement and for sealing of the placement rooms.

The concrete batch plant would produce the concrete mixes needed for the repository, including the concrete required for the bulkheads to be placed at the entrance of the filled container placement rooms.

3.1.1.4 Surface Support Buildings

Surface support buildings provide support to the main site facilities. The administration building would include offices and services for staff, and be the main building for visitors.

3.1.1.5 Site Utilities

The total electrical power demand for the APM facility is estimated to be about 20 megawatts (MW). The site would be supported by several three-MW diesel emergency power generators or similar equipment for use in the event of main line power failure.

The water supply system would provide water for domestic water use, for process use, and for emergency use (fire-fighting). The domestic water system would supply potable water for both surface and repository level facilities. Process water would be primarily used for preparation of sealing materials, notably the concrete and clays.

Water for the DGR facility would be sourced from a local river or water body. The siting would consider the capacity of the local water body to supply sufficient water and to take back treated discharge water. A water supply rate of about 100 m^3/day may be needed.

3.1.1.6 Water Treatment and Stormwater Control

Ponds would be established on the APM DGR site to manage mine water, process water and stormwater run-off. All of the ponds would be lined, as required, over their base and embankments for protection and to prevent water infiltration back into the ground. The ponds would be designed to settle out suspended particles with any collected mud and silt deposits cleaned out on a periodic basis to maintain design retention volumes and times.

Collected flows would be quality monitored and potentially treated before being discharged off the site. Water quality would be in compliance with the applicable limits for any water released to a natural watercourse.

<u>Mine Dewatering Settling Pond</u>

Mine water pumped from the underground sumps would be piped to a dewatering settling pond. An estimated 500 m^3/day of groundwater has been assumed to be pumped from the sumps and discharged to the settling pond (this value would depend on the site).

This mine water may contain sediment, nitrogen compounds (arising from blasting residue of excavated rock), high salinity (especially sedimentary rock, due to saline groundwater inflow) and possibly dissolved uranium from the rock (generally low in sedimentary rock). If concentration of these potential contaminants is above acceptable levels, then the mine water would be treated to meet applicable limits before discharge.

<u>Process Water Settling Pond</u>

Process water would be directed to this pond.

Sewage collected from all serviced buildings would be piped to an on-site sewage treatment plant for treatment. Sewage waste from below-ground operations would also be treated in this plant. Treated effluent from the plant would be monitored for compliance before being discharged to a natural watercourse or for other uses (e.g., dust control).

<u>Storm Water Management Ponds</u>

A perimeter ditch around the site surface facilities would direct precipitation to a few storm water management ponds.

3.1.1.7 Security and Safeguards

Security and safeguards would be implemented in accordance with the requirements of the *Nuclear Safety and Control Act (NSCA)*, and its Regulations. The site would be surrounded by a perimeter fence that restricts access to the site from land or water. Only authorized personnel and vehicles would be allowed on site. There would be an inner protected area with further security provisions. Safeguards would be implemented in accordance with Canada's international commitments.

3.1.2 Waste Rock Management Area

A portion of excavated rock from the repository may be used in backfilling and sealing operations. The remaining rock may have some public or commercial use as aggregate for construction. In this project description, it is assumed to be stored at a rock management location located off-site.

The volume of excavated rock for a repository in sedimentary rock for 4.6 million bundles is about 1.58 million cubic metres. An excavated rock management area could require a surface area of about 470 metres by 380 metres (18 hectares), with a height of 15 metres. The footprint, height and location(s) of excavated rock would be planned in a way that takes into account community preferences. The area would include a storm water management pond to collect and manage surface water. Surface water run-off from the excavated rock management area would be controlled, monitored and if required, treated to meet provincial water quality standards prior to discharge.

3.1.3 Deep Geological Repository

3.1.3.1 Underground Layout

The deep geological repository is a network of tunnels and placement rooms for used fuel containers. It is assumed to be constructed on a single level at a depth of about 500 metres below ground surface. The actual depth could be between 400 and 1000 metres, depending on site-specific rock characteristics.

The repository would require an underground footprint of about two kilometres by three kilometres (about 600 hectares) for the current estimated number of 4.6 million used fuel bundles.

Figure 2 shows an illustrative layout that could be used in an unfractured rock mass setting. The actual underground footprint would depend on a number of factors, including the site-specific characteristics of the rock, the final design of the repository and the total inventory of used fuel to be managed. The spacing of the rooms is determed by the thermal power generated by the used nuclear fuel.

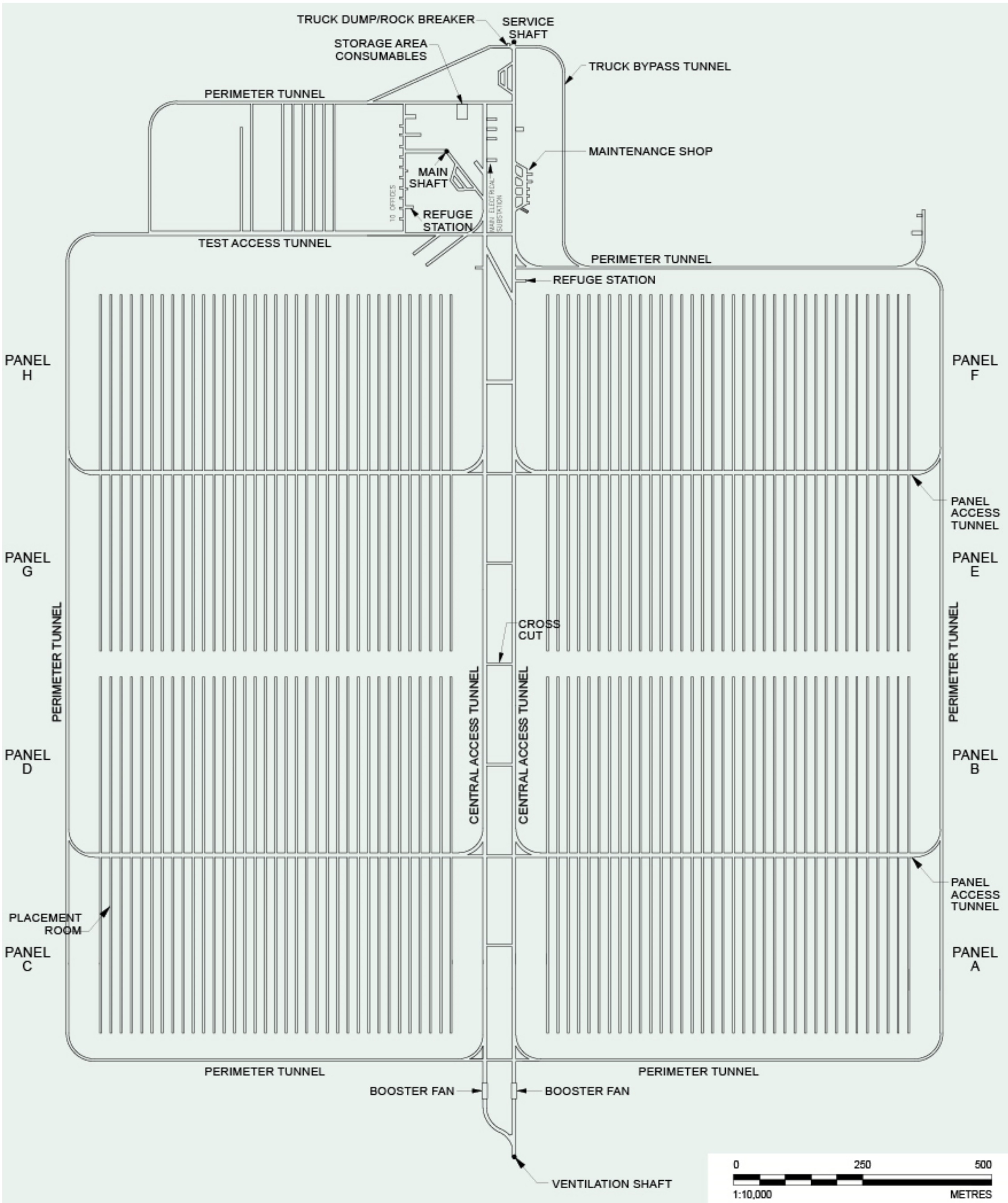

Figure 2: Illustrative drawing of underground repository layout in an unfractured rock mass setting showing a series of tunnels, panels and placement rooms, and service areas.

3.1.3.2 Shafts, Access Tunnels and Service Area

The underground repository would be accessed through a set of three shafts – a Main Shaft, a Service Shaft and a Ventilation Shaft. These shafts would provide underground access for waste containers, supplies, workers, air, communications and other infrastructure, as well as transport of excavated rock and mine dewatering from the underground.

Near the main shafts there would be a service area, with space for worker offices and amenities, plus storage of underground supplies and equipment, and maintenance of underground equipment.

Tunnels would extend out from the main shaft through the repository for access to the emplacement rooms.

3.1.3.3 Underground Ventilation

The underground equipment is expected to be primarily diesel; these engines would comply with applicable emission limits. Air flow underground would be sufficient to keep the concentration of diesel combustion products sufficiently low, per mining requirements.

The used fuel containers themselves are welded and sealed before being moved underground, so would not be a source of release of radioactivity underground. The primary underground source would likely be natural radon.

High-efficiency particulate air (HEPA) filtration systems would be established where underground air exhausts to surface. These systems would be activated in the remote event that radioactivity is detected in the underground ventilation air at above-background concentration levels.

3.1.3.4 Underground Verification and Demonstration

The repository design includes provision for underground verification and demonstration activities located near the main shaft area. The purpose of underground verification activities is to confirm the characteristics of the rock at the repository horizon, and in particular to ensure it is consistent with safety case expectations based on the previous surface-based measurements.

Demonstration activities would include placement and retrieval of used fuel containers, and long-term tests of the engineered barrier systems.

Monitoring equipment would also be installed throughout the facility underground to confirm the performance of the repository system during operations and the extended monitoring period. Surface-based monitoring of boreholes, including those from the site characterization phase, would continue throughout the construction, operations, extended monitoring and decommissioning phases. Some monitoring would likely continue into the postclosure phase.

3.1.3.5 Emplacement Rooms

The conceptual design for each emplacement room is shown in Figure 3. Within each placement room, used fuel containers encased in a bentonite clay “buffer box” would be emplaced using remote handling equipment. Containers would be stacked in two rows. Any void space would be backfilled with bentonite clay pellets. Each container and buffer box would be separated from the next buffer box by bentonite clay spacer blocks. This spacing provides passive dispersion of the thermal power produced by the used fuel.

A thick bentonite clay seal and concrete bulkhead are planned to be used to seal the entrance to each of the placement rooms.

Each group of placement rooms, also known as a placement panel, would require about three to four years to develop. Each placement panel would be excavated in parallel with container placement operations in other panels of the repository.

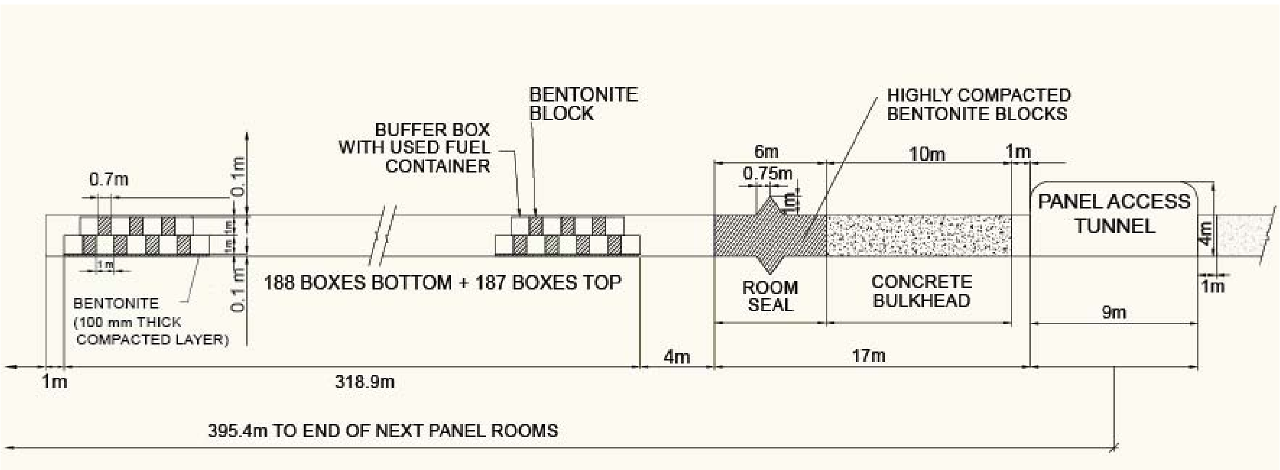

Figure 3: Conceptual Layout of Filled Emplacement Room

3.2 PROJECT PHASES AND ACTIVITIES

The major phases for the APM project are:

- Site Selection
- Site Preparation and Construction
- Operations
- Extended Monitoring
- Decommissioning and Closure
- Postclosure Monitoring.

3.2.1 Site Selection Phase

The NWMO initiated the site selection process in 2010. The site selection process is designed to ensure safety, security and protection of people and the environment.

As described in Section 2, the siting process includes a multi-year phased technical assessment process and community engagement effort. As studies become progressively more detailed and more information is known about the area, the NWMO will focus its studies on areas with strong potential to meet project requirements and where communities continue to be interested in exploring the project.

NWMO is presently focused on 9 interested communities and nearby First Nation and Métis communities and surrounding communities.

At the completion of these assessments, a preferred site with an informed and willing host will be selected for more detailed site characterization.

With the selection of a preferred site, detailed surface and subsurface investigations would be similar to those carried out during geological investigation stages of typical mining projects and would include further drilling and testing of boreholes, and environmental studies. Detailed investigations could require roughing in access roads to the candidate site. These activities may result in environmental effects associated with noise, vegetation clearing for site access, drilling and increased traffic. An environmental management plan would be implemented to reduce the effects through proper mitigation measures. Input from the interested communities would also be sought to aid in minimizing effects.

The last part of this phase is the regulatory approvals process, where NWMO would seek a license for site preparation and construction.

For planning purposes, the NWMO has assumed the site selection phase, including site siting, detailed site characterization and the regulatory approvals process, could take about 15 years from present to complete.

3.2.2 Site Preparation and Construction Phase

The underground repository would likely cover an area of approximately 2 km × 3 km (about 600 hectares) at a depth of several hundred metres, depending on the geology. The total surface land area has not been defined yet, but would be at least 600 hectares to cover the underground footprint. The land use of this total area has also not been defined yet; for example some of the area may have restricted access, while some may be accessible but have institutional control to ensure no future deep drilling or mining.

The actual surface area used for facilities and infrastructure would be a small part of this total area - about 60 hectares total, or 40 hectares for the surface facilities and 18 hectares for the waste rock management area. (Note that the waste rock may be in a separate area not part of the main site.)

During site preparation, the activities would include clearing existing vegetation, grading the site, fencing and installing initial project infrastructure such as that required for water management. Storm water management would be developed to control potential effects associated with any sediment-laden run-off into local waterways. Diesel and propane fuel storage and grade-level water storage tanks would be located at the site to facilitate construction activities.

Infrastructure development may include road access to the site and installation of a regional high voltage power line to meet the facility's electrical demands.

Temporary infrastructure to support the workforce during early activities, including sewage treatment, water supply and conventional waste management facilities, would be made available at the project site until permanent facilities are established.

Accommodation would be required for construction personnel. These workers would likely be housed in the community and surrounding area for an APM DGR located in southern Ontario. NWMO would work with the community and surrounding area to plan for and contribute to development of community infrastructure required during construction and operation to house and integrate personnel into the area.

The next significant activity would be the initial development of underground facilities. It would begin with constructing shafts and developing underground tunnels and service areas. This phase would include the development of the underground verification and demonstration facility.

During this period, construction of surface nuclear facilities would also start (i.e., the used fuel packaging plant).

After initial geological verification activities have been completed and reviewed, the initial placement rooms for the deep geological repository would be excavated (remaining placement rooms would be excavated during the operations phase of the project). A portion of excavated rock may be kept on site to use for backfilling during operations, with the remainder assumed to be transferred to a location to be determined in collaboration with the community. Remaining surface facilities would also be constructed at this time.

For planning purposes, the NWMO has assumed the site preparation and construction phase could require about 10 years.

3.2.3 Operations Phase

3.2.3.1 Transportation to Site

Nuclear fuel waste would be loaded into certified transportation packages and shipped from interim storage facilities to the repository site. The main storage sites are Pickering, Darlington, Bruce (including Douglas Point), Gentilly, Point Lepreau, Chalk River and Whiteshell.

Used fuel would be placed into certified transport packages. For this preliminary description, it is assumed that transport would be by road. Figure 4 shows a cutaway drawing of NWMO's current licensed used fuel transport package. Each package holds up to 192 CANDU used fuel bundles.

Table 1 provides an estimate of the total number of road shipments from the various nuclear sites to the APM DGR for the reference scenario of 4.6 million total fuel bundles. As a general estimate, there would be about 625 package shipments received each year at the DGR site.

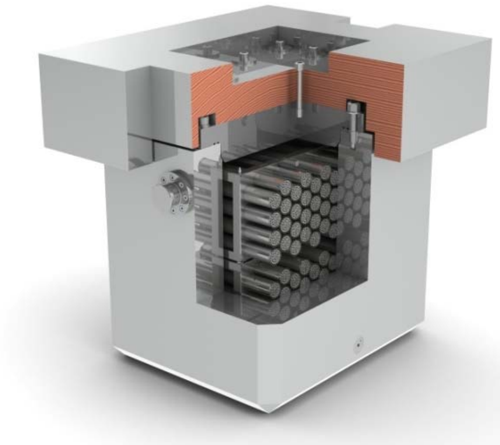

Figure 4: Cutaway Drawing of NWMO Used Fuel Transportation Package

Table 1: Estimated Number of Road Shipments from Various Sites to APM DGR
(4.6 million bundle case)

Interim Storage Site	Estimated Number of Shipments *
Bruce	10,600
Darlington	7,000
Pickering	4,200
Chalk River and Whiteshell	40
Gentilly and Point Lepreau	2,100

‘* Based on 192 bundles/shipment.

3.2.3.2 Site Operations

At the APM DGR site during the operations phase, the site would receive both empty used fuel repository containers, and transportation packages filled with used nuclear fuel.

Within the packaging plant at the site surface location, used fuel bundles would be transferred from the transportation packages to the containers. These would be sealed, inspected and dispatched for placement in the underground repository. The APM DGR site would be designed to receive and process about 120,000 used fuel bundles per year. These would be placed into about 2,500 containers each year, which would be supplied from an off-site contractor facility.

Most steps in the packaging process are remotely operated, taking place in radiation-shielded rooms. Ventilation air is filtered and monitored before it leaves the facility.

The operations phase includes continued excavation of additional placement rooms (beyond the initial panels to be built during the construction phase) which would likely involve drilling and blasting, removal of rock and continued operation of the waste rock management area.

Water for the site would be sourced locally at the rate needed to meet the demands of site personnel, concrete and sealing material production, and dust control. Water is not required for cooling used nuclear fuel at this facility.

Several ponds would be established for either process water or stormwater control. Water would be monitored and treated required before being discharged off-site.

The NWMO would monitor the repository site, the workers and the surrounding environment throughout the operations phase. It would need to ensure that it meets provincial Environmental Compliance Approval limits on non-radiological emissions, and Canadian Nuclear Safety Commission (CNSC) worker dose limits and Derived Release Limits on radiological emissions.

An environmental monitoring system would be established to monitor potential environmental effects, optimize facility performance and demonstrate regulatory compliance. The environmental monitoring program would include, at a minimum, the following components:

- Groundwater monitoring;
- Radiation monitoring;
- Stormwater / surface water monitoring;
- Air quality monitoring (above and below ground);
- Meteorological monitoring; and
- Seismicity and vibration monitoring.

There would be a radiation monitoring program that ensures that any dose to workers, public or the environment during this period is within criteria. In particular, based on current practice and conceptual design analyses, it is expected that nuclear workers at the site would receive dose rates below an occupational dose target of 10 mSv/a, and any public dose from the facility would be well below the regulatory limit of 1 mSv/a (with the highest dose likely at the site boundary, decreasing rapidly with distance).

The operations phase would require about 40 years, assuming a used fuel inventory of about 4.6 million used fuel bundles.

3.2.4 Extended Monitoring Phase

Following placement of used fuel containers in the repository, the NWMO would continue to monitor long-term safety and performance of the repository for an extended period. During this period, the placement rooms remain backfilled and sealed, but access tunnels and perimeter tunnels and shafts would be open and maintained to support in-situ monitoring activities.

The extended monitoring phase could last several decades; 70 years has been assumed for planning purposes. The actual duration of this period would be informed by discussion with the regulator, with input from the community.

3.2.5 Decommissioning and Closure Phase

Decommissioning activities would begin after sufficient performance monitoring data have been collected to support a decision to decommission and close the repository. The main activities undertaken during the decommissioning and closure phase would include:

- Sealing of access tunnels, perimeter tunnels, service areas and shafts;
- Decontamination and removal of surface and underground infrastructure and facilities;
- Sealing of all subsurface boreholes and those surface boreholes not required for postclosure monitoring; and
- Closure of any other remaining facilities.

On completion, the repository would be closed and sealed, and the site graded and landscaped consistent with the community agreement on the end-state land use.

It is anticipated that permanent markers would be installed to inform future generations of the presence of the sealed repository.

For planning purposes, the NWMO has assumed the decommissioning and closure phase would require about 30 years.

3.2.6 Postclosure Phase

The repository is designed to be passively safe after closure, with no need for human intervention and maintenance.

A preliminary estimate of the long-term safety of a repository is provided in (NWMO 2013). This is an illustrative postclosure case study for a hypothetical repository and site in sedimentary rock. Although each site and design would be different, the conclusions from that case study are illustrative of the expected behavior of an appropriately sited and designed DGR in southern Ontario sedimentary rock.

A key point is that a repository would be sited and designed so that the potential impacts would be very low even to a future person assumed to be living directly over the repository, and drawing water from a local well. The low permeability of the sedimentary rock layers surrounding the repository would limit movement of radionuclides through the surrounding rock and into any permeable groundwater systems.

Postclosure monitoring would be in place for as long as desired in order to verify that the repository is operating safely.

3.3 EMISSIONS, DISCHARGES AND WASTES

3.3.1 Atmospheric Emissions

The main air emissions from the facility are expected to be:

- Dust as a result of on-site construction and underground excavation;
- Combustion products from use of diesel equipment;
- Combustion products from use of gas or oil heating and power supply equipment; and
- Low levels of radioactivity from the packaging plant as a result of fuel handling, and from the underground ventilation and the waste rock pile as a result of natural radon in the rock.

The primary locations of the air emissions would be the waste rock management area, the underground exhaust shafts and the used fuel packaging plant. Other sources would be smaller and distributed, for example, vehicles.

Dust would be mitigated through good management practices, such as water spraying of surfaces.

The combustion product emissions would be mitigated through design and good management practices. Some equipment would be electric, but the underground excavation equipment is planned to be largely diesel consistent with current mining practice. However diesel equipment and vehicles would be procured to meet the relevant emissions standards. Exhaust from stacks would be designed and monitored to comply with relevant air emission requirements.

Radiological emissions from the facility operations would be primarily from the used fuel packaging plant, where the used fuel bundles are transferred from the transport packages and sealed into their final containers. This handling may generate small amounts of gaseous or particulates within this facility, and any air emissions would then be controlled through the filtered ventilation system. Radon released underground or from the waste rock management area would occur. The sedimentary rocks within the Michigan basin are not expected to contain significant amounts of uranium. Therefore radon would be present but it is not expected to be a major factor in emissions. This would be consistent with the conclusions from the Radon Assessment conducted for the OPG DGR project (NWMO 2011). Radiological emissions would be monitored to ensure they are within the site licence limits.

The facility would also generate noise and ground vibration during site preparation construction and operation. The noise would be from the equipment, and from blasting during the initial stage of the shaft construction. As there would be continued excavation of underground emplacement rooms throughout the operations period, there would be continued noise at surface due to the movement of the waste rock to the waste rock management area. The ground vibration would occur during site preparation briefly as part of seismic studies, and during initial construction due to near-surface blasting for the shafts. Once underground, excavation at the repository horizon would not create noticeable ground vibration at surface. The noise and vibrations would be monitored and managed. Noise levels would meet regulatory limits and guidelines, including provincial noise guidelines and municipal bylaws.

The used fuel generates heat, approximately several watts per bundle initially when emplaced. The cumulative heat from all the bundles would heat the rock mass directly around the repository; however, the rock temperature at surface would not be noticeably affected.

The transport of used fuel and materials to the APM DGR would generate air emissions and noise from the vehicles over the travel routes. Assuming road transport, it is estimated that there would be about two shipments per day of used fuel to the APM DGR on average, so this would be an intermittent source along the route. The transport vehicle fleet would meet current vehicle emission standards and would be maintained, which would minimize emissions and noise.

The site location and facility design has not yet advanced enough to provide specific quantitative estimates of atmospheric emissions. However, the location and facility would be designed to limit releases, and monitored and controlled to be within regulatory requirements for protection of public, workers and the environment. An Environmental Compliance Approval would be required from the province for non-radiological emissions, and radiological emissions would be monitored and controlled within the site licence limits set by the CNSC. An environmental management program would be in place to minimize environmental impacts.

3.3.2 Liquid Discharges

The main water discharges from the facility are expected to be:

- Normal stormwater;
- Stormwater which has contacted rock in the waste rock management area;
- Underground discharge water;
- Sanitary and industrial process water.

There are no significant liquid discharges other than the above. Any waste oils would be collected, treated as a waste and sent to an appropriate disposal facility.

All underground and process waters would be monitored and treated as necessary before release. It is presently assumed that these would be discharged first into mine and process water ponds, and then via the main stormwater management system.

The storm water from the main waste rock management area would have its own monitored discharge point if this area is located away from the site surface facilities.

The site location and facility design has not yet advanced enough to provide specific quantitative estimates. However these would be designed and mitigated to minimize discharges, and monitored and controlled to be within applicable environmental and regulatory requirements for protection of the public, workers and the environment.

3.3.3 Waste Rock

The excavated rock from the underground would be sent to a dedicated waste rock management area, which is assumed here to be located off-site from the DGR site surface facilities. See discussion in Section 3.1.2.

3.3.4 Active Solid and Liquid Wastes

Small volumes of low- and intermediate-level radioactive wastes would be generated, mostly in the used fuel packaging plant.

The modules from the incoming used fuel transport packages would be the most significant source of active solid waste. When a module has been emptied of used-fuel bundles, it would be decontaminated and released, or stored for future reuse. Active solid waste would also include HEPA filters used in ventilation exhaust air, as well as spent filters from the treatment of active liquid wastes. Solid low-level waste (LLW) streams would include that from general decontamination and cleaning activities, and used personal protective equipment.

Underground and process waters may contain low levels of natural radioactivity (from uranium in the rock) or from maintenance activities at surface primarily in the used fuel processing plant. Active liquid waste from the used fuel packaging plant would originate from the decontamination of used-fuel modules and used fuel transportation packages, and from packaging cell washdown. However the general design basis avoids use of water especially in contact with the used fuel. For example, fuel would arrive dry and would be stored, handled and packaged dry. Also the final container copper coating process is cold spray, which avoids water. These will minimize the amount of active liquid wastes.

These active wastes would be handled according to the specific waste stream. For example, active liquid wastes would be filtered to remove most radioactivity. Some of the solid active wastes may be placed in a dedicated underground emplacement area within the APM DGR. Others would be sent to licensed external waste management facilities.

The site location and facility design has not yet advanced enough to provide firm quantitative estimates of waste amounts after on-site processing.

3.3.5 Non-Radiological Industrial Waste

There would be a number of conventional waste streams generated at the DGR. To the extent practical, the quantity of these wastes would be minimized and segregated by type for recycling.

Various non-radiological, hazardous solid and liquid wastes would also be generated from the on-going operation and construction activities. These would include: solvents used in decontamination and cleaning in non-radiological areas; lubricants and greases; petroleum based fuels; and explosive residues. All conventional waste materials would be sent to a disposal facility that is licensed to accept these types of waste materials.

The routine industrial wastes would be sent to a commercial landfill site or to a licensed landfill site that may be created within the repository area.

The site location and facility design has not yet advanced enough to provide firm quantitative estimates of waste amounts.

3.3.6 Postclosure

After repository decommissioning and closure, there are not expected to be further noticeable releases of any kind from the repository. The site would be monitored for as long as is desired to ensure this is the case. There may be measureable changes in some physical parameters as the site equilibrates to its new end-state, for example, as the groundwater around the site adjusts to the closure of the shafts and underground excavations, and as new vegetation matures.

A preliminary estimate of the long-term safety is provided in the NWMO Fifth Case Study, which is an illustrative postclosure case study for a hypothetical repository and site in sedimentary rock (NWMO 2013). Although the details of this hypothetical case study site and design may be different from a future APM DGR if sited in this area, the conclusions are still illustrative of the expected behavior.

The radioactivity within the used fuel naturally decays with time. The repository would be placed within thick, low-permeability sedimentary rock formations that would contain and isolate the wastes. Postclosure assessments indicate that for an appropriate site and design, in the very long time frame (thousands of years in the future), any releases of radioactivity to surface are expected to be well within regulatory limits and natural ranges, even for a variety of unlikely events.

3.4 MALFUNCTIONS, ACCIDENTS AND MALEVOLENT ACTS

The APM DGR would be sited, designed and operated to be safe, including consideration for risk from malfunctions, accidents and malevolent acts. However, as no site has been selected for an APM DGR, there is presently no detailed design or safety assessment for an APM DGR in southern Ontario which would include a quantitative assessment of malfunctions, accidents and malevolent acts.

For the preclosure phase, there is a published assessment of potential accidents and malfunctions for a generic DGR facility for used fuel prepared by Ontario Hydro (OH 1994), and a preliminary paper on dose considerations for surface operations presented in (Kremer and Garisto 2011). A more recent assessment of hazards that could lead to radioactivity release is provided in the NWMO Preliminary Hazard Assessment report (NWMO 2016c). Collectively these indicate that the public dose consequences from credible malfunctions and accidents during preclosure would be below the public dose limits for a suitable site.

During the postclosure phase, the facility would be closed and sealed with no activities taking place. The safety assessment would consider normal evolution and disruptive scenarios, rather than accidents and malfunctions. Normal evolution considers how the repository is likely to evolve in the future. Disruptive scenarios consider unlikely or “what if” scenarios. For the postclosure phase, a preliminary assessment of scenarios that could affect a used fuel repository in sedimentary rock is provided in the NWMO Postclosure Safety Assessment of a Used Fuel Repository in Sedimentary Rock (NWMO 2013).

4. PROJECT LOCATION

At present, there is no site selected for an APM DGR in any area.

For the purpose of responding to the request of the Minister of the Environment and Climate Change for an updated analysis of the cumulative environmental effects of the OPG DGR, this document has assumed an APM DGR is located within one of the three Municipalities of Huron-Kinloss, South Bruce or Central Huron.

If a site were to be selected in one of these areas, it would be identified based on a full site process, including geological, engineering, environmental and social assessments. Some constraints have already been identified, and others would be identified through discussion with the area communities, with respect to siting an APM DGR.

Figure 5 shows a map of these three municipalities relative to the proposed OPG DGR. As this siting processhas not been completed, it is not presently possible to identify a more specific location for an APM DGR within these communities.

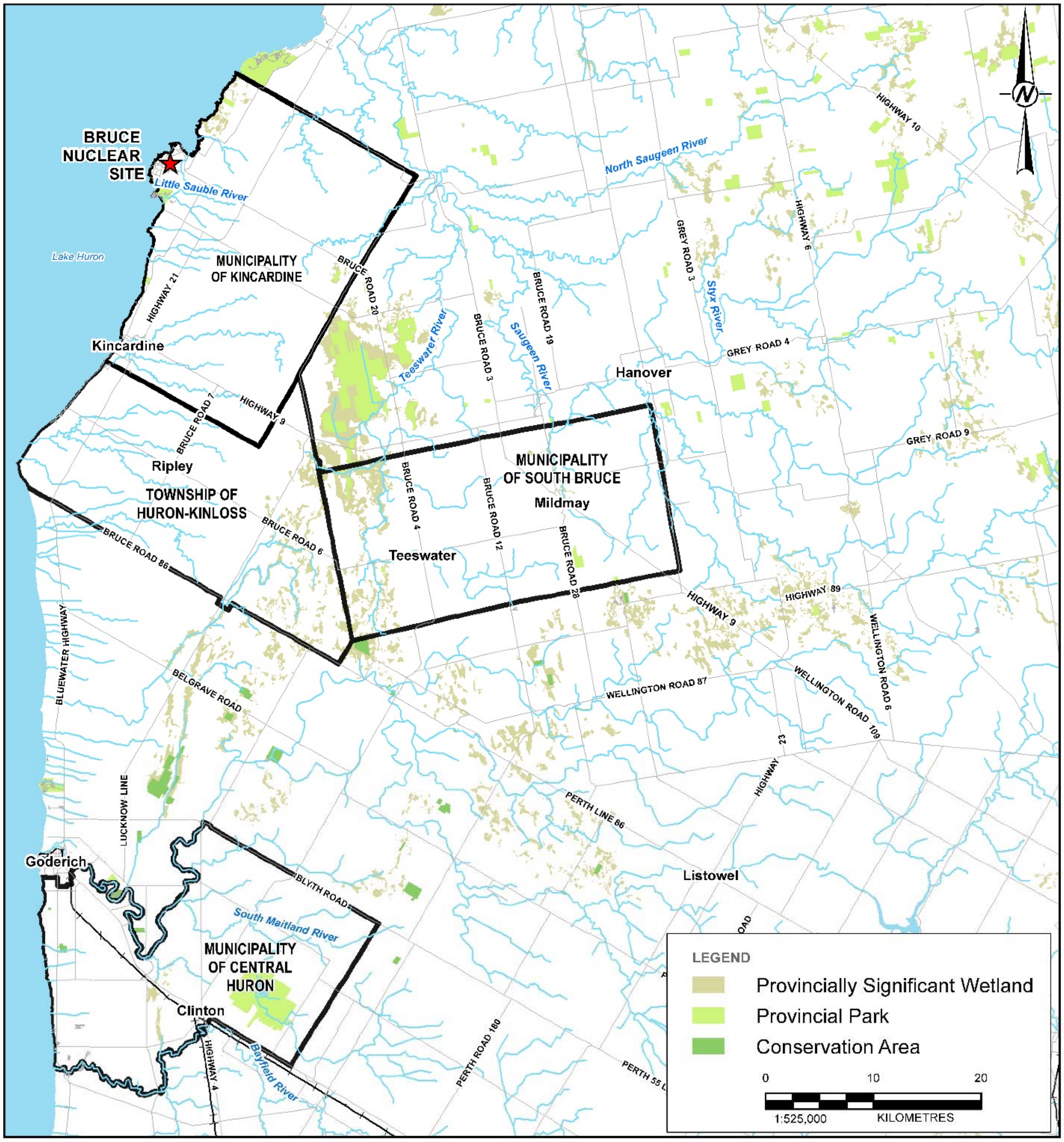

Figure 5: Map showing the location of the Township of Huron-Kinloss, the Municipality of South Bruce and the Municipality of Central Huron relative to the proposed OPG DGR site at the Bruce nuclear site in the Municipality of Kincardine.

5. ENVIRONMENTAL CONTEXT AND MITIGATIONS

5.1 PHYSICAL AND BIOLOGICAL SETTING

For purposes of this preliminary description, an APM DGR site is assumed within the general area of Huron-Kinloss, South Bruce or Central Huron. A general physical and biological description of their environment is described in this section.

Geoscientific background information on the areas around these municipalities was also summarized in the APM Phase 1 reports, available on the NWMO website (NWMO 2014a, NWMO 2015a).

Environmental background information on the areas around these municipalities was summarized as part of the APM Phase 1 reports for Huron-Kinloss, South Bruce and Central Huron, and is available on the NWMO website (NWMO 2014b, NWMO 2015b).

5.1.1 Geology

The bedrock geology of southern Ontario consists of a thick Paleozoic sedimentary sequence from Cambrian to Mississippian in age, deposited approximately 540 to 329 million years ago. This sedimentary sequence lies over the Precambrian crystalline basement of the Grenville Province. The Grenville Province comprises 2,690 million to 990 million year old metamorphic rocks, deformed during orogenic events 1,200 million to 970 million years ago. The Paleozoic sedimentary stratigraphy includes mostly layers of shale, carbonate and evaporate units. Within the Salina Formation of this sedimentary stratigraphy, salt beds are present beneath Central Huron. Within this stratigraphy, there are Ordovician age, very low permeability shale and limestone formations.

5.1.2 Physiography

Huron-Kinloss, South Bruce and Central Huron are located in the western St. Lawrence Lowland, a low relief, gently undulating land surface that occupies much of southwestern Ontario and is covered with Quaternary glacial sediments. The land surface within the area of the three municipalities ranges from a maximum of 366 metres above sea level in Central Huron, to a minimum of 176 metres along the shore of Lake Huron. The land surface shows a general slope down towards Lake Huron from southeast to northwest.

5.1.3 Hydrology

These municipalities are located within the St. Lawrence Drainage Area, which drains into the Atlantic Ocean through the St. Lawrence River. Most of the northern part of Central Huron is within the Maitland tertiary watershed while the southern part is within the Ausable tertiary watershed. Most of the eastern part of the Huron-Kinloss and South Bruce areas are within the Saugeen tertiary watershed while the western part along the Lake Huron shoreline lies within the Penetangore tertiary watershed. Drainage is generally from east to west into Lake Huron.

5.1.4 Background Radiation

The dominant source of background radiation in the Huron-Kinloss, South Bruce and Central Huron is attributed to naturally occurring radioactive materials in the soil and rock, specifically potassium, uranium and thorium-bearing minerals. The resulting range of dose rates is consistent with regional rates for southwestern Ontario.

5.1.5 Terrestrial Features and Wildlife

Huron-Kinloss, South Bruce and Central Huron and surrounding area is a predominantly agricultural landscape located at the transition of Ontario forest zones.

Huron-Kinloss, South Bruce and Central Huron lie within the Deciduous Forest Region where woodlands consist primarily of American beech and sugar maple, together with basswood, red maple and oak on the northern limit of the Carolinian Forest. Eastern white cedar is also a common tree species in the area. In areas where agriculture dominates, terrestrial features and areas are generally associated with valley lands along watercourses and within wetlands. Woodlands cover approximately 8.5-10% of the land area.

Known bird migration routes follow along the eastern shore of Lake Huron.

Beaver and muskrat are harvested by trappers, predominantly on privately owned lands. Hunting of white-tailed deer, waterfowl and wild turkey is common in permitted areas.

5.1.6 Aquatic Features and Fish

Central Huron is located within the Maitland and Ausable watersheds. Huron-Kinloss and South Bruce are located within the Saugeen and Pentangore watersheds.

The prominent water body in Central Huron is the Maitland River. Fish that are commonly found in the Maitland River include rainbow trout, chinook salmon and smallmouth bass.

The most prominent water body in Huron-Kinloss and South Bruce is the Saugeen River. The Saugeen River’s feeder streams and lakes are prime waters for brook trout, brown trout, bass and northern pike.

Aquatic habitats (not including wetlands) represent approximately 1% of the Municipality of Central Huron, and less than 1% of the area in Huron Kinloss and South Bruce.

5.1.7 Endangered Species

Endangered species potentially occurring within the Municipality of Central Huron include provincially endangered American badger, eastern cougar, eastern small-footed myotis (bat), little brown myotis (bat), northern myotis (bat), barn owl, Henslow’s sparrow, loggerhead shrike, yellow-breasted chat, queensnake, wood turtle, American eel, redside dace, shortnose cisco, gypsy cuckoo bumble bee, American ginseng and butternut, and the federally endangered tricolored bat, lake chubsucker, pugnose shiner and wavy-rayed lampmussel. An additional

14 species are classified as provincially threatened, and 20 species are classified as provincially species of concern within the Municipality of Central Huron.

Endangered species potentially occurring within Huron Kinloss and South Bruce include the provincially endangered American badger, eastern cougar, little brown myotis (bat), northern myotis (bat), barn owl, king rail, yellow rail, loggerhead shrike, piping plover, yellow-breasted chat, queensnake, Blanding's turtle, spotted turtle, wood turtle, American eel, pugnose shiner, redside dace, shortnose cisco, Hungerford's crawling water beetle, rusty-patched bumble bee, American ginseng, butternut, eastern prairie fringed orchid, Gattinger's agalinis and small white lady's slipper and the federally endangered pitcher's thistle. An additional 18 species are classified as provincially threatened, and 24 species are classified as provincially species of concern within these areas.

5.1.8 Air Quality

Based on the air quality monitoring station located in Tiverton, Ontario, the ground-level ozone in Huron-Kinloss and South Bruce and surrounding area is slightly elevated, and particulate matter is slightly ower than, the national average. Air quality monitors in southwestern Ontario indicate ground-level ozone and particulate matter fall within normal values compared to the national average.

5.1.9 Water Quality

In southern Ontario, the regional conservation authorities maintain water quality report cards that document the health of the water systems within their boundaries. Each conservation authority has multiple report cards for each watershed within its boundaries. The latest report cards were released in 2013.

Most of Huron-Kinloss and South Bruce are within the Saugeen Valley Conservation Authority (SVCA) region. The SVCA does not provide an overall rating, but in general the relevant watersheds within the SVCA are rated as A to D for wetlands, C for surface water, and A for groundwater, where A is excellent and D is marginal (SVCA 2013). The range of values for wetlands reflects the extent of wetlands preserved within the various watersheds. The low value for surface water are due to phosphorus levels (related in part to high erosion) and/or *E. coli* levels exceeding the Provincial Water Quality Objectives.

Central Huron is largely within the Maitland Valley Conservation Authority (MVCA). With respect to wetlands, the sub-basins scores ranged from A to D, similar to SVCA. With respect to surface water, overall the Maitland watershed scored B for total phosphorus, C for benthic macroinvertebrates and C for *E. coli*. When compared to the prior 2006 report card, a decline in grades for benthic macroinvertebrates occurred in most sub-basins. With respect to groundwater, the MVCA sampled groundwater in four sub-basins, and all these areas scored A (MVCA 2013).

5.2 POTENTIAL MITIGATIONS

This section presents a high-level summary of mitigations that could be undertaken during the project to minimize potential adverse effects on the physical and biological environment.

Since a specific site has not been defined and a design developed, the assessment reflects general conditions across the area and a general assessment of effects and mitigations, rather than site specific analyses.

5.2.1 Potential Mitigations during the Site Selection Process

The site selection process includes the identification of potential sites within the smaller number of communities and subsequent detailed investigations of preferred sites in communities that continue in the site selection process. These investigations could involve airborne and ground surveys to better characterize the site-specific environment, drilling and testing of boreholes, and environmental surveys. Activities may include line cutting and construction of access routes to sites undergoing detailed evaluation.

These activities may result in environmental effects associated with noise, vegetation clearing for site access and increased traffic.

Implementation of an environmental management plan for these activities would be expected to reduce the effects. For example, drilling fluids associated with site exploration boreholes would be contained at the site and disposed off-site appropriately. In addition, the location of drill sites and the alignment of roads for access to drill sites (if required) would be determined collaboratively with the local community, and be designed to avoid protected areas, habitat areas for species of conservation concern, and heritage sites. Timing of activities would be managed to mitigate effects on biota if any potential interactions are identified.

5.2.2 Potential Mitigations during Construction

The Construction Phase comprises the development of the selected site, construction of facilities, utilities and infrastructure necessary to support development and operation of the project, and excavation of the underground facilities and some of the placement rooms. During this phase, surface and underground facilities would be installed and commissioned.

This phase is the most disruptive to the biophysical environment. Construction activities may result in environmental effects associated with vegetation clearing, drilling and blasting, excavation, excavated rock storage, hardening of surfaces, placement of infrastructure, surface water and groundwater management, emissions from vehicles and equipment, dust, noise, and increased traffic.

The siting process would take into account environmental factors for the specific surface facility locations, including the waste rock management area and shaft locations. Measures would include selection of infrastructure and corridor locations to avoid protected areas, habitat areas for species of conservation concern, and heritage sites. In the three municipalities, there is generally only a small amount of tree cover at present; so the siting would consider placing the surface facilities so as to retain existing tree cover. Where permitting is required from the local

Conservation Authority or municipal bylaws, these would be obtained prior to site clearing and conditions outlined in the permit would be implemented.

Implementation of an environmental management plan would reduce the environmental effects. For example, Huron-Kinloss, South Bruce and Central Huron are in line with known bird migration routes along the eastern shore of Lake Huron. During site preparation, tree clearing may be required depending on the site. Any impact on migratory birds would be minimized by avoiding tree clearing during the migratory birds breeding season.

The extent of in-water work cannot be evaluated until the site is known. However the siting and design would seek to avoid or mitigate any impacts. In-design mitigation may include measures such as selection of infrastructure and corridor locations to avoid protected areas and aquatic habitats, or species of conservation concern. Timing of activities would be managed to mitigate effects on aquatic biota (i.e., outside of critical periods). Dewatering for subsurface construction, surface water drainage management, operational and potable water supply, and waste water management would be designed and implemented in compliance with applicable regulations.

Equipment and vehicles would meet current emission standards. Design and management practices would be used to control and attenuate noise to ensure that they meet regulatory limits and guidelines, including municipal bylaws and the Ministry of the Environment and Climate Change guidelines. An Environmental Compliance Approval and a CNSC Site Preparation and Construction Licence would be obtained for the site.

5.2.3 Potential Mitigations during Operation

The Operation Phase includes the receipt, packaging, and placement of used fuel in the repository. The site would settle into a steady mode with continued excavation of new rooms, transport and receipt of waste packages and other materials at site, repackaging and transport underground of the wastes, and sealing of the underground rooms.

Implementation of the in-design mitigation measures (including siting), an environmental management program, a radiation monitoring program, and good management practices (e.g., well-defined operating procedures) would avoid or reduce environmental effects. An Environmental Compliance Approval and a CNSC Operating Licence would be obtained, and any additional mitigation measures identified through these processes would be implemented.

5.2.4 Potential Mitigations during Decommissioning and Closure

The Decommissioning and Closure Phase of the project would begin once placement operations have been completed, sufficient performance monitoring data have been collected to support approval to decommission, a decommissioning licence has been granted, and the community has agreed to proceed to this phase.

Once the repository is sealed and all buildings and facilities are removed, the area must be shown to meet regulatory limits for the agreed-upon end-state land use. This would include landscaping and restoration of natural habitat on the site.

Before the facility is closed, used fuel handling activities would cease, all the underground placement rooms would be sealed and any related radiological emissions would stop. During closure, any residual radioactive materials would be removed. Structures used for radioactive work would be carefully dismantled to limit the amount of dust produced. Any radioactive soil would be managed in accordance with applicable regulations or guidelines. The radiological releases are anticipated to be a small fraction of regulatory limits and no greater than those during the Operation Phase.

The potential environmental effects are expected to be similar to those encountered during site preparation and construction, with the exception of the presence of residual radioactive materials.

The implementation of an environmental management plan specific to this phase of the project, along with continued occupational dose management programs, would reduce potential effects on humans and the environment.

More generally, the net effect of the decommissioning would be to reduce the surface footprint of the repository and therefore would be, in general, beneficial to the environment after completion. For example, rehabilitation measures would likely be implemented such as tree planting, depending on the desired end state of the site.

5.2.5 Potential Mitigations during Postclosure

As part of the closure of the repository, the site would be turned into an agreed end-state. It is not possible to define that end-state now, as it is a decision to be made in consultation with government, regulator and local community in 100 years or more. It could be that the site is kept as an industrial location, or it could be that the site is turned into a natural reserve or park state. However other than monitoring, there would be no further activities required to support the postclosure phase of the repository.

Monitoring activities may require human presence. Such activities could include managing borehole and acoustic monitors, and conducting air, water, and biology surveys. These would likely use existing borehole sites and roads. When compared with the environmental effects associated with the earlier project phases, potential environmental effects associated with conducting this monitoring are likely to result in few environmental effects.

There would be effects within the deep rock mass enclosing the repository as it equilibrates with the closed repository, including a return to chemically reducing conditions, establishment of natural hydrostatic pressures, and an increase in deep rock temperature. In the long postclosure period, the deep rock mass and engineered barriers would contain the used fuel while the radioactivity decays. Releases of radioactivity to surface are expected to be well within regulatory limits, even for a range of unlikely events.

The primary surface effect during this period would be the changes in the surface biophysical environment as it responds to the closure of the repository and transitions to its planned post-repository condition. During this postclosure time, the surface environment could also change due to other causes, including the possible occurrence of glaciation on very long time frames.

6. EFFECTS ON ABORIGINAL PEOPLES

The APM site selection process involves working in partnership with local communities, and specifically with local Aboriginal peoples. This approach means that any selected site would have considered Indigenous Knowledge, would have identified relevant effects, and the plans would have included appropriate mechanisms to avoid or mitigate any effects.

NWMO has specifically committed that an APM DGR would not be sited in the traditional territory of Saugeen Ojibway Nation (SON) - the Chippewas of Nawash Unceded First Nation and Saugeen First Nation - without their consent. Any siting within this territory would be informed by discussions with the SON regarding potential effects and their mitigation.

Other First Nations may also have interests, depending on the proposed location.

There are two Métis organizations in the area– the Historic Saugeen Métis and the Métis Nation of Ontario. The NWMO will continue to work closely with these communities to ensure their rights are respected, their input is included and that they are part of the APM process.

7. REFERENCES

Kremer, E. and N. Garisto. 2011. *Dose considerations for a site boundary for surface operations at a deep geological repository.* Presented at Waste Management, Decommissioning and Environmental Restoration Conference, Canadian Nuclear Society, Toronto, Canada.

MVCA. 2013. *Maitland Valley Watershed Report Card 2013*. Maitland Valley Conservation Authority. Available from MVCA website or http://conservationontario.ca.

NWMO. 2010. *Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*. Nuclear Waste Management Organization. Toronto, Canada.

NWMO. 2011. *OPG's Deep Geologic Repository for Low & Intermediate Level Waste, Radon Assessment*. Nuclear Waste Management Organization Report NWMO DGR-TR-2011-34 R000. Toronto, Canada.

NWMO. 2013. *Postclosure Safety Assessment of a Used Fuel Repository in Sedimentary Rock, Pre-project Report*. Nuclear Waste Management Organization Report NWMO TR-2013-07. Toronto, Canada.

NWMO. 2014a. *Phase 1 Geoscientific Desktop Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel. Municipalities of Arran-Elderslie, Brockton and South Bruce, Township of Huron-Kinloss and Town of Saugeen Shores, Ontario*. Prepared by Geofirma Engineering Ltd. Nuclear Waste Management Organization Report APM-REP-06144-0108. Toronto, Canada.

NWMO. 2014b. *Phase 1 Desktop Assessment, Environment Report. Communities of Huron-Kinloss, Brockton and South Bruce, Ontario*. Prepared by Golder Associates Ltd. Nuclear Waste Management Organization Report APM-REP-06144-0107. Toronto, Canada.

NWMO. 2015a. *Phase 1 Geoscientific Desktop Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel*. Municipality of Central Huron, Ontario. Prepared by Geofirma Engineering Ltd. Nuclear Waste Management Organization Report APM-REP-06144-0126. Toronto, Canada.

NWMO. 2015b. *Phase 1 Desktop Assessment, Environment Report. Municipality of Central Huron, Ontario*. Prepared by Golder Associates Ltd. Nuclear Waste Management Organization Report APM-REP-06144-0125. Toronto, Canada.

NWMO. 2016b. *Deep Geological Repository Conceptual Design Report Crystalline / Sedimentary Rock Environment*. Nuclear Waste Management Organization Report APM-REP-00440-0015 R001. Toronto, Canada.

NWMO. 2016c. *Preliminary Hazard Identification for the Mark II Conceptual Design*. Prepared by Saanio & Riekkola Oy and Empresarios Agrupados Internacional S.A. NWMO-TR-2016-02. Toronto, Canada.

OH. 1994. *The Disposal of Canada's Nuclear Fuel Waste: Preclosure Assessment of a Conceptual System*. Ontario Hydro report N-03784-940010 (UFMED). Toronto, Canada.

OIC. 2007. Order in Council, PC 2007-0834, *Selection of an Approach for the Long-Term Management of Nuclear Fuel Waste*. Government of Canada.

SVCA. 2013. *Saugeen Conservation 2007-2011 Watershed Report Cards Executive Summary*. Saugeen Valley Conservation Authority. Available from SVCA website or http://conservationontario.ca.

8. ABBREVIATIONS AND ACRONYMS

APM	Adaptive Phased Management
CANDU	CANada Deuterium Uranium
CNSC	Canadian Nuclear Safety Commission
DGR	Deep Geological Repository
EA	Environmental Assessment
HEPA	High-Efficiency Particulate Air
L&ILW	Low and Intermediate Level Waste
LLW	Low Level Waste
MVCA	Maitland Valley Conservation Authority
NFWA	Nuclear Fuel Waste Act
NSCA	Nuclear Safety and Control Act
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation
SON	Saugeen Ojibway Nation
SVCA	Saugeen Valley Conservation Authority