ONTARIO POWER GENERATION

Brian E. McGee
Vice President

Nuclear Waste Management Division

1340 Pickering Parkway, Fourth Floor, Pickering, Ontario L1V 0C4 Tel. (905) 421-9494 Ext. 3400 Fax (905) 421-2393
brian.mcgee@opg.com

June 6, 2014

File: 00216-00531 P
CD#: 00216-CORR-00531-00226
Project ID: 10-60004

Dr. Stella Swanson
Chair, Joint Review Panel
Deep Geologic Repository Project

c/o Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, Ontario
K1P 5S9

Dear Dr. Swanson:

Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Chapter 4 of Environmental Impact Statement with Annotations

The purpose of this letter is to provide an annotated version of Chapter 4, Description of the Project for EA Purposes, of the Environmental Impact Statement (EIS) (Reference 1).

The attached annotated version of Chapter 4 was developed for internal use. We are submitting it so that it is available for the upcoming additional hearing session. It provides a description of the project that includes or cross-references the updates, clarifications and additional information provided to date to the Panel in all OPG's written submissions, as publicly available on the Canadian Environmental Assessment Registry website. No new information is provided.

The source references used for developing the annotated Chapter 4 are based on cross-references documented in Rev. 10 of the Tracking Tables for Information Request Responses, Design Updates and Corrections (Reference 2) for items pertaining to EIS Chapter 4. They also include selected items pertaining to the Preliminary Safety Report considered to be relevant and appropriate for the level of detail documented in Chapter 4 of the EIS. Additional sources of references include OPG's written submissions and presentations at the Technical Information Sessions and the Public Hearing sessions. Transcripts from these sessions were not included as source references.

Description updates (i.e., design updates, corrections, and other project description updates) are provided in boxed blue italic text in the main body of the text. Cross-references to clarifications and additional information are provided in footnotes as appropriate.

If you have questions on the above, please contact Mr. Allan Webster, Director, Nuclear Regulatory Affairs, at (905) 623-6670, ext. 3326.

Sincerely,

6 June 2014

Brian E. McGee
Vice President, Nuclear Waste Management Division
Ontario Power Generation

Attach.

cc. Dr. J. Archibald	– Joint Review Panel c/o CNSC (Ottawa)
Dr. G. Muecke	– Joint Review Panel c/o CNSC (Ottawa)
P. Elder	– CNSC (Ottawa)
D. Wilson	– NWMO (Toronto)

References:

1. OPG's Deep Geologic Repository for Low and Intermediate Level Waste - Environmental Impact Statement. Ontario Power Generation report 00216-REP-07701-00001 R000. Toronto, Canada.

2. Tracking Tables for Information Request Responses, Design Updates and Corrections, Rev.10, submitted with OPG letter from Laurie Swami to Dr. Stella Swanson, "Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Response to Information Request EIS-12a-512", April 4, 2014, CD# 00216-CORR-00531-00227.

ATTACHMENT

Attachment to OPG letter, Brian E. McGee to Dr. Stella Swanson, “Deep Geologic Repository Project for Low and Intermediate Level Waste – Submission of Chapter 4 of Environmental Impact Statement with Annotations”

June 6, 2014

CD#: 00216-CORR-00531-00226

Chapter 4 of the EIS with Annotations

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

[PAGE LEFT INTENTIONALLY BLANK]

4. DESCRIPTION OF THE PROJECT FOR EA PURPOSES

4.1 INTRODUCTION

This section provides a description of the main features of the DGR Project and the wastes to be emplaced in the DGR, and identifies the works and activities that are required to construct and operate the facility, focusing on those activities that could potentially affect the environment. Decommissioning and eventual abandonment activities are described conceptually, thus providing information for the entire project-life cycle.

This DGR Project description is largely derived from documentation that supports the application for a licence to prepare the site and construct the DGR, namely the Preliminary Safety Report [26], Postclosure Safety Assessment [27] and Geosynthesis [28].

4.2 THE PROJECT

The DGR Project includes the site preparation, construction, operations, decommissioning, abandonment and long-term performance of above-ground and below-ground facilities for the long-term management of OPG's L&ILW. The DGR Project, if approved, will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site. The DGR is designed to be safe in the long term, relying on the favourable and stable geology at the site which, combined with effective sealing of the repository, provides a good basis for long-term containment and isolation arguments.

The design for the DGR Project takes into account the OPG-retained lands within the Bruce nuclear site and the reference waste volumes to be placed in the repository (see Section 4.5). Two panels of waste emplacement rooms will be constructed nominally 680 m below ground surface (mBGS) within low permeability limestone in the Cobourg Formation.

Overall, the DGR Project will be constructed in sequential stages. All site preparation activities will be completed, followed by construction of the surface infrastructure, including the shaft headframes. The two shafts (main and ventilation) will be developed simultaneously, followed by the construction of the underground services area infrastructure and access and exhaust ventilation tunnels. The emplacement rooms will then be developed. All construction activities will be completed prior to commencement of operations. The operations phase of the DGR Project is expected to last 40 to 45 years, followed by decommissioning. Once decommissioning activities are completed, the DGR Project will enter the abandonment and long-term performance phase. A timeline for these DGR Project phases is shown on Figure 4.2-1.

The following sections present the different phases of the DGR Project and describe the works and activities anticipated in each phase. Emphasis is placed on the systems, components and activities of the DGR Project that may be expected to affect the environment. All activities will be carried out in compliance with appropriate health, safety and environmental protection requirements. The DGR Project works and activities provide the Basis for the EA, and are summarized in Section 4.18.

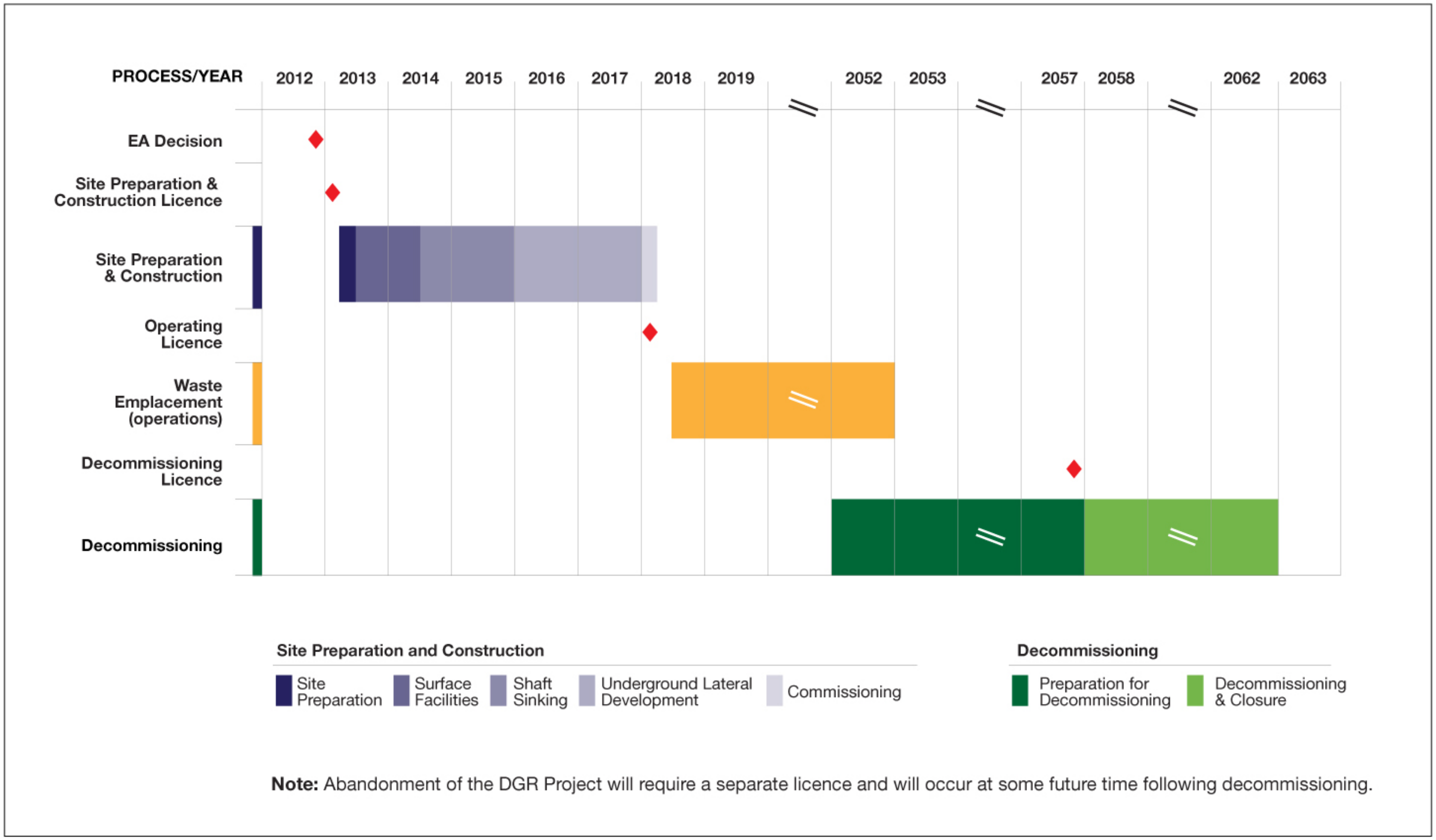


Figure 4.2-1: Timeline for Project Implementation

4.3 LOCATION

The DGR Project will be situated on the Bruce nuclear site, which is located about mid-way between Kincardine and Port Elgin, at a longitude of 81°34' west and latitude of 44°19' north. The location of the 932-hectare (ha) Bruce nuclear site is shown on Figure 1.1.1-2. Although OPG is the owner of the Bruce nuclear site, the majority of the site is controlled under a leasing agreement with the current operator, Bruce Power. Bruce Power also controls all access to the site. Under the leasing agreement between OPG and Bruce Power, OPG has retained control of a portion of the Bruce nuclear site, including the WWMF and adjacent lands.

The DGR Project will be located on the OPG-retained lands at the centre of the Bruce nuclear site. Figure 1.1.1-1 shows an overview of the Bruce nuclear site and the general extent of the OPG-retained lands centred on the WWMF. The DGR Project will be located in the area immediately north of the WWMF, approximately 1 km from the Lake Huron shoreline. The operating Bruce A nuclear generating station is situated to the north of the DGR Project site and the operating Bruce B nuclear generating station is located to the southwest.

The size of the DGR Project surface facilities will be approximately 30 ha, including the construction laydown areas and the area designated for waste rock management. The areal extent of the underground facilities will be approximately 40 ha. An overall schematic of the DGR Project is shown on Figure 1.1.1-3.

4.4 DGR CONCEPT AND FACILITY DESCRIPTION

The surface infrastructure for the DGR Project consists of a waste package receiving, staging and transfer area, shaft headframes and ancillary areas. The waste packages will be transferred underground via the main shaft to the repository level, nominally 680 mBGS. The main shaft will be the intake for repository ventilation, with the heater house and intake fans located adjacent to the headframe. The ventilation shaft and headframe complex will be used to transport the rock generated from the repository development to the surface, and to pull the exhaust air out of the repository. Waste rock piles, some temporary in nature, for the full excavated volume of rock will be accommodated on the DGR Project site, within a waste rock management area (WRMA).

The underground facilities comprise access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. All surface and underground facilities will be located within the boundaries of the DGR Project Area, which is delineated on Figure 1.1.1-2.

Information on the construction, operation and eventual decommissioning of the DGR Project is provided in Sections 4.7, 4.8 and 4.11, respectively. The following sections highlight key features of the DGR Project. Section 6.1.2 of the Preliminary Safety Report [26] includes a listing of the regulations and major standards and codes applicable to the design and operation of the DGR.

4.4.1 Surface Buildings and Infrastructure

The DGR surface buildings and infrastructure are located in one of three areas on the DGR Project site: main shaft area; ventilation shaft area; and the WRMA. An artist's rendering of the DGR surface facilities including the access roadway to the WWMF is shown on Figure 4.4.1-1. Descriptions of the structures and facilities within these areas, as well as descriptions of the various ancillary areas, are provided in the following sections. The general layout of the surface facilities and the roadway connecting the DGR Project site with the WWMF are shown on Figure 4.4.1-2.

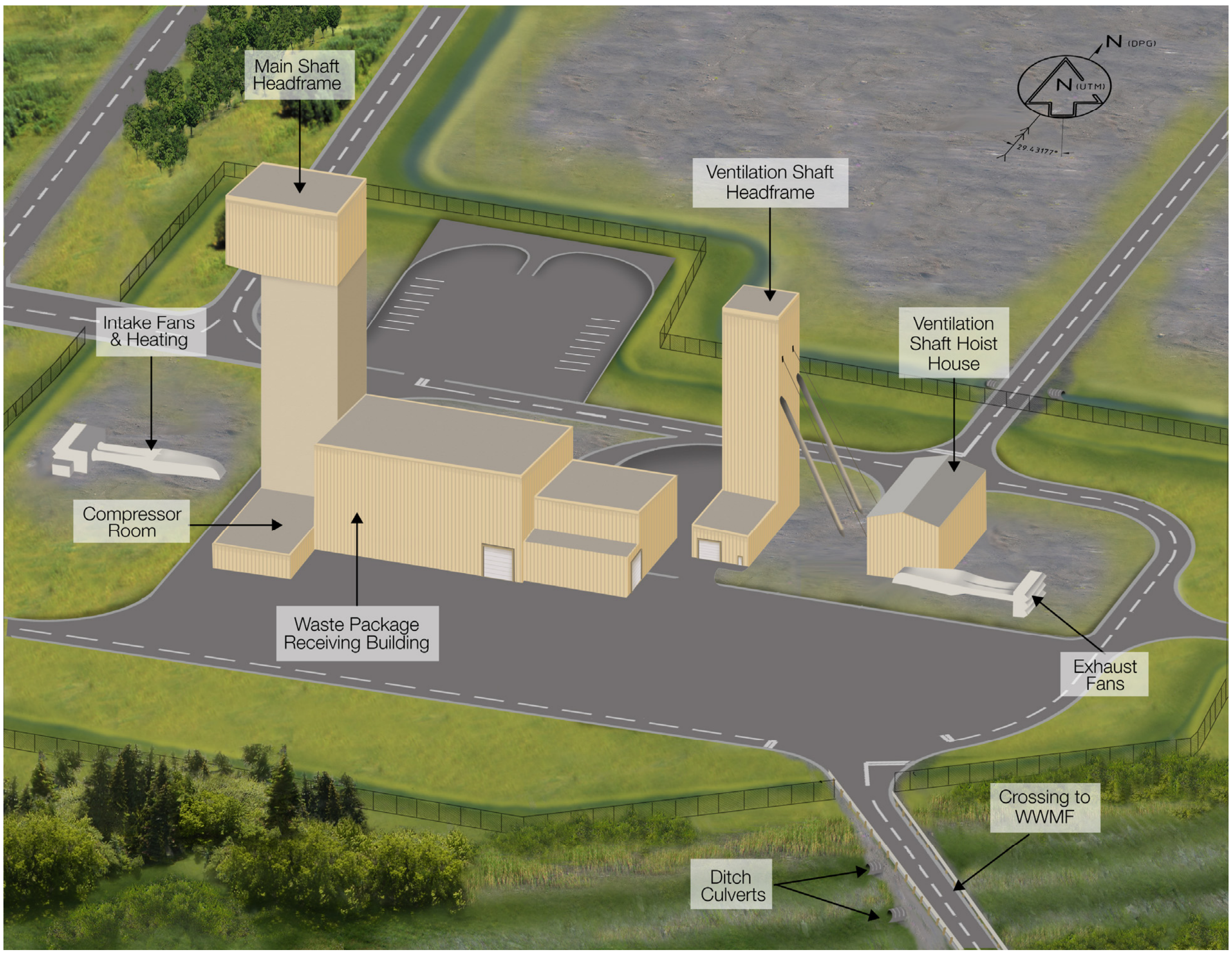
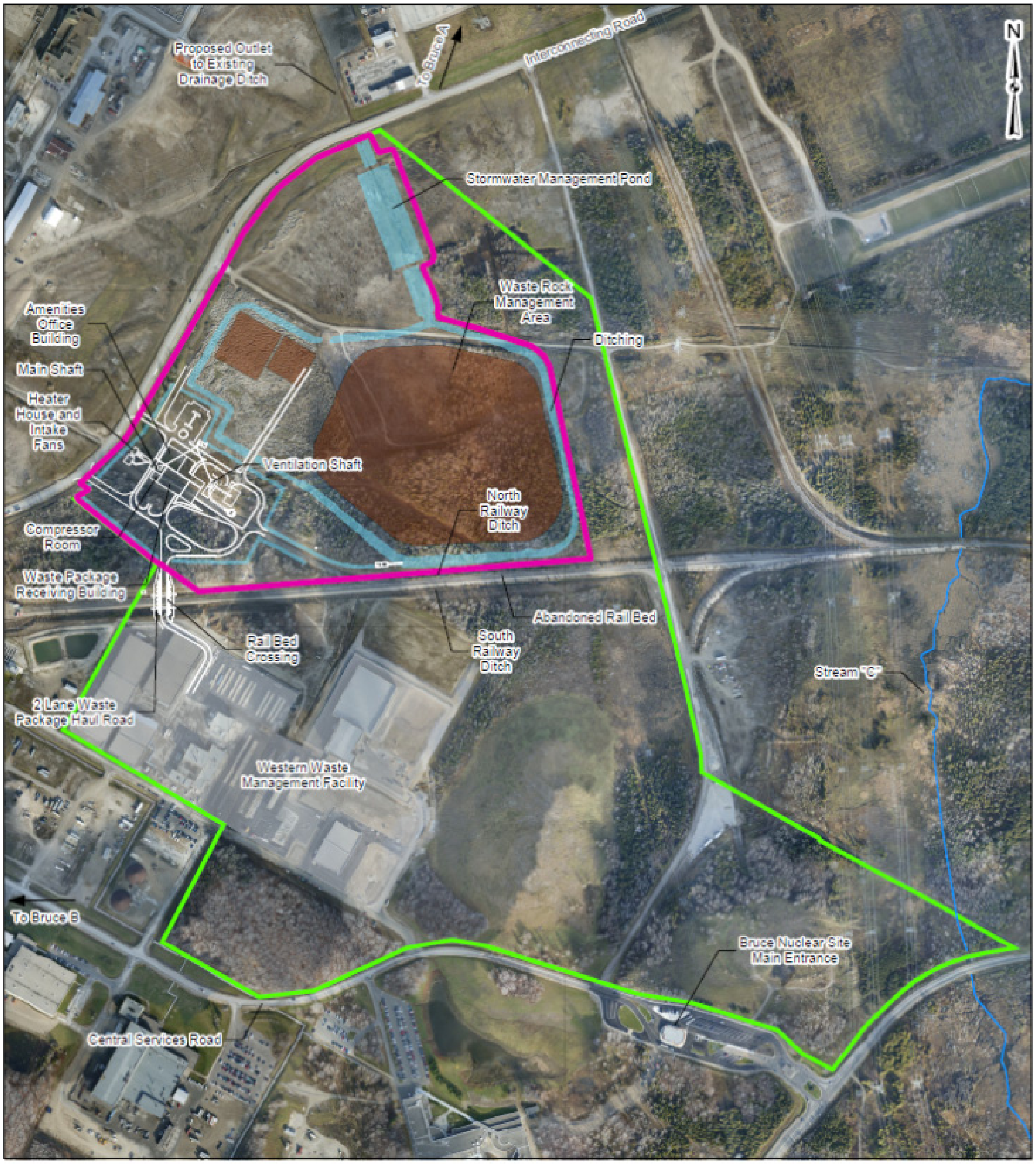


Figure 4.4.1-1: Artist's Rendering of DGR Surface Infrastructure



LEGEND

- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Soils and Rock Stockpile
- Stormwater Management System

REFERENCE

Base Data Provided by 4DM, Nov 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT
DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE
LAYOUT OF DGR SURFACE INFRASTRUCTURE

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	AB	16 Mar. 2010		
GIS	BC	25 Nov. 2010		
CHECK	KC	25 Nov. 2010		
REVIEW	AB	25 Nov. 2010		

FIGURE 4.4.1-2

[PAGE LEFT INTENTIONALLY BLANK]

4.4.1.1 Main Shaft Area

The main shaft area includes buildings and equipment that provide the fresh air requirements for the repository and primary access underground for transfer of waste packages, personnel, equipment and materials. The main shaft area includes the following structures:

- **Main Shaft Headframe:** The main shaft headframe is a nominal 60 m high reinforced concrete structure with a plan area of 225 m² (15 × 15 m). The headframe contains tower-mounted 4.27 diameter and 1.4 diameter Koepe friction hoists and other related equipment. The main shaft hoist room is located at the top of the main shaft headframe and has nominal external dimensions of 15 × 22 m with a height of 12.5 m. This height provides an open area for large equipment to be received at the top of the headframe for construction and maintenance activities. The hoist room houses all the controls and electrical equipment necessary to operate the hoist along with a local operating station.
- **Waste Package Receiving Building (WPRB):** The WPRB is immediately adjacent to and connected with the main shaft headframe. The WPRB is nominally 40 × 25 m and 20 m high. A receiving area allows delivery of waste packages by forklift or flatbed truck, as well as a covered docking area. The WPRB has a staging area for up to 24 LLW bin-type packages and two ILW packages. Waste packages will be loaded onto self-propelled rail carts inside the WPRB and then the loaded carts will be moved into the main shaft cage for transfer to the underground repository. A maintenance and storage area adjoins the WPRB. This building is nominally 20 × 20 m and 16 m high, and provides storage space for materials and spare equipment. Minor repairs and preventative maintenance tasks for the shaft components and equipment used within the WPRB will be carried out in this area, while major overhauls of equipment, if required, will be performed off-site.
- **Compressor Building:** This building, located nearby the main shaft, houses two compressors that will provide compressed air for surface and underground maintenance. One compressor will normally operate with the other compressor on stand-by[6]. In the unlikely event of an underground emergency, these compressors will provide breathing air to the underground refuge stations. The building has an approximate footprint of 9 × 10 m, and will be designed to act as an acoustic enclosure.
- **Intake Fans and Heater House:** This system includes the surface intake fans and electric heating plant located at the main shaft intake plenum. The site layout includes provision for a refrigeration plant and bulk air cooler if required in the future, as noted in Section 4.10.1. The fresh air intake will be constructed west of the main shaft headframe, and is positioned with consideration of the exhaust fans and prevailing wind conditions to minimize potential for intaking exhaust ventilation. The main purpose of the surface intake fans is to provide the required air flow to the DGR. Two fans, including silencers as required, will be located at the intake of the heater house. The function of the surface heaters is to raise the ambient air temperature of the air drawn in to a minimum of 5°C so that services within the main shaft and headframe are not influenced by cold weather conditions. The approximate footprint of the heater house is 7 × 10 m.

---

[6] *Additional clarification regarding the compressed air system was provided in OPG response to IR-LPSC-01-09 (CEAA Registry Doc# 363).*

- **Offices, Main Control Room and Amenities Building**: The offices and main control room are part of the amenities building that will be attached to the north side of the main shaft headframe and WPRB. The approximate size of the building is 25 × 25 m and two storeys high. There is parking available to the north of the building. Staff and visitors will all report to this complex through the Zone 1 area. Radiological badging will be received prior to entry into Zone 2 areas. Section 4.15.1.1 discusses the application of zoning to the DGR Project. Lockers, change room and showering facilities, lunch room and training/visitors area are located in this complex. The main control room, forming a part of the amenities area, will be equipped with computing, control, and monitoring equipment to marshal all signals and data transmitted from underground. Other facilities include a lamp room, mechanical equipment rooms and storage.

4.4.1.2 Ventilation Shaft Area

The ventilation shaft area includes the ventilation headframe and hoist house, as well as buildings and equipment supporting the exhaust ventilation system. Additionally, the ventilation shaft provides the means to remove excavated rock from the repository during construction. It also provides a second egress from underground, which will be available for use in emergency situations[7,8]. The ventilation shaft area includes several key structures, namely: ventilation headframe and collar house, hoist house, and exhaust fan building. Brief descriptions of these structures follow:

- **Ventilation Shaft Headframe and Collar House**: The ventilation shaft headframe will be an insulated and clad steel structure. The headframe is nominally 43 m high and includes a tipping path and chutes that will be used during the site preparation and construction phase for discharge of waste rock**.** During the operations phase, the ventilation shaft is the primary conduit for repository services (e.g., service water, power, communications), and could be used for emergency secondary egress. The collar house will be a nominal 15 × 10 m and 5 m high clad steel-framed building that is used for general maintenance and storage of shaft hardware and equipment spares.
- **Ventilation Shaft Hoist House**: The hoist house (nominally 13 × 24 m and 12 m high) will be an insulated and clad steel-framed building that houses the 3.66 m diameter double drum hoist for the ventilation shaft. The hoisting equipment is common for shaft sinking, waste rock removal during repository development and egress during operations. The double drum configuration of the hoist allows a two-compartment conveyance. The building contains all the electrical equipment and control station, roll up doors for access, and a monorail for installation and maintenance of the hoist.
- **Exhaust Fan Building**: Exhaust fans will be located at the exit of the ventilation shaft plenum. Although the main exhaust ventilation fans are located near the ventilation shaft on the repository level[9], the surface fans assist in directing the exhaust through the

---

[7] The ventilation shaft will not be used as an egress point from underground on a day-to-day basis.

[8] *Further clarification on the ventilation shaft as second egress was provided in OPG response to IR-LPSC-03-60 (CEAA Registry Doc# 608).*

[9] *Clarification on the location of the main exhaust ventilation fans was provided in OPG response to IR-LPSC-01-14 (CEAA Registry Doc# 363) and in OPG letter dated Feb.10,2012 (Item #1, CEAA Registry Doc# 336).*

plenum and not up through the ventilation headframe. The building will be steel with cladding and the fans will be equipped with acoustic baffled silencers to reduce noise.

DESCRIPTION UPDATE

Updated design description of the ventilation shaft hoist arrangements was provided in OPG letter dated Feb.10, 2012 (Item #4, CEAA Registry Doc# 336).

Updates to the ventilation shaft hosting arrangements:

- *The ventilation shaft will now include a single skip – counterweight configuration with a double drum hoist to be utilized for waste rock removal during construction, rather than the two-skip arrangement described in the PSR. The skip and counterweight will be guided by rope guides rather than fixed steel guides.*
- *During the construction phase the ventilation shaft will also be fitted with an auxiliary Blair hoist (double-rope) which will operate as a service hoist. After construction the auxiliary Blair hoist will remain in operation for shaft inspections and emergency escape. The Blair auxiliary hoist will be outfitted with a double deck cage capable of transporting 12 persons.*
- *The ventilation shaft double drum configuration used during the construction phase will be driven by a reducer and coupled motor. Arresting gear will not be required for a double drum arrangement.*
- *The ventilation shaft drum hoist with the single skip – counterweight configuration will be removed after construction.*

These design updates will improve the transition from construction to operation and improve maintainability during operation.

4.4.1.3 Waste Rock Management Area (WRMA)

The WRMA[10] is the location where all rock excavated during underground construction of the DGR is managed. Approximately 1,000,000 m³ of waste rock will be produced during underground construction of the DGR. The waste rock produced from the repository level development will be transferred from underground to surface via the ventilation shaft, as noted previously. At surface, it will be loaded from the muck bay by front-end loader into off-highway trucks and delivered to the WRMA[11]. The waste rock will be stored in adjacent piles according to material type. Approximately 80,000 m³ of soil and rock is identified as being re-usable for site construction. The balance of the rock (832,000 m³ of limestone) will be managed over the long-term in a rock pile that covers 9 ha and measures 15 m high. The overall footprint of the WRMA, including its stormwater management system (see Section 4.4.1.5) is approximately 17 ha.

[10] *Additional description of WRMA construction was provided in OPG response to IR-LPSC-01-28 (CEAA Registry Doc# 363), and in OPG's written submission (Sec. 2.5) and presentation to JRP Technical Information Session (TIS) #1 (CEAA Registry Doc# 636).*

[11] *Additional information on waste rock dumping facility and muck bay was provided in OPG response to IR-LPSC-01-33 (CEAA Registry Doc# 363).*

Clearing and grubbing is required in portions of the WRMA to remove existing vegetation. The entire site requires grading to promote run-off to a system of ditches that surrounds the WRMA. This ditch network ties into the stormwater management system as described in Section 4.4.1.5. Berms and vegetation along the perimeter of the DGR Project site will be used to control dust and noise, as well as to limit views of the rock piles.

4.4.1.4 Road Connection to WWMF

A crossing over the abandoned rail bed is required to provide direct access between the WWMF and the DGR Project site (Figure 4.4.1-2). This crossing will be a two-lane road situated on a fill embankment over the abandoned rail bed and existing ditches (i.e., the North Railway Ditch and the South Railway Ditch). Culverts will be used to provide for water flow in the two existing ditches. The road allows for vehicle and personnel passage and will be fenced along both sides, connecting with the fencing around the WWMF and the DGR surface facilities. While decommissioning (Section 4.11) is only described in a preliminary manner at this early planning stage, it is assumed this crossing will remain in place after operations have ceased.

4.4.1.5 Stormwater Management System[12]

The surfaces around the DGR surface facilities are designed with suitable gradients so that drainage is directed away from all structures to a system of perimeter ditches. These ditches are described in more detail in Section 4.7.1.3. This ditch system will also receive water that is pumped to surface from the underground dewatering sump.

All stormwater run-off from the DGR surface infrastructure area, the WRMA and underground water will drain into the stormwater management pond[13]. The pond is sized to retain stormwater run-off for a sufficiently long period of time to settle out suspended solids[14]. The entire stormwater management system is sized to safely pass run-off from a large storm event (e.g., 1:100 storm event) with no damage to the system. The stormwater management pond will be constructed with a low permeability base (e.g., natural or composite) and will discharge into the existing Bruce nuclear site drainage ditch network for release to MacPherson Bay (Lake Huron). Additional details on the stormwater management system design are provided in Chapter 6 of the Preliminary Safety Report [26].

The assessment of surface water effects (Hydrology and Surface Water Quality TSD) has identified suspended solids, un-ionized ammonia and some trace metals as the primary project-related parameters that may occur in run-off from the WRMA[15]. The stormwater management

---

[12] *Additional information on DGR site water management was provided in OPG's written submission (Sec. 3.0) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[13] *Additional information on the site drainage and stormwater management was provided in OPG response to undertaking TIS-10 (CEAA Registry Doc# 692).*

[14] *Further clarification was provided in OPG response to IR-EIS-03-56 regarding the effect of stormwater management pond on groundwater quality, provision for prolonged retention and deployment of water treatment (CEAA Registry Doc# 608).*

[15] *Additional information on predicted surface water effects and mitigation measures was provided in OPG response to IR-EIS-04-130 (CEAA Registry Doc# 759).*

pond is sized to provide a retention area for settling of particles and the ability to retain the 6 hour, 25 mm rain event. Additionally, water treatment[16] will be employed in the drainage system upstream of the stormwater management pond for the duration of the site preparation and construction phase, and possibly the first two years of operations depending on monitoring results. This temporary water treatment plant is further described in Section 4.7.5.4. In the unlikely event that monitoring detects concentrations exceeding established limits, it is possible to close the gate at the discharge location, thereby containing the contaminated water. Appropriate actions would then be taken to treat the water so that it could be safely discharged from the pond[17].

4.4.2 Description of Underground Facilities

The preliminary layout of the underground repository is shown on Figure 4.4.2-1. Access to the underground repository from ground surface is via two vertical concrete-lined shafts that lead to the shaft and services area at the repository level. The underground repository consists of two panels of emplacement rooms that are nominally 250 m in length and arranged in parallel to the assumed direction of the major principle horizontal in situ stress of east-northeast (ENE). Panel access and exhaust ventilation tunnels run parallel to one another. End walls, or bulkheads, are constructed at the end of the emplacement rooms where they meet with the exhaust ventilation tunnel. These end walls allow for the installation of ventilation regulators and personnel access doorways for egress when rooms are empty. The repository has 31 rooms, accommodating approximately 200,000 m³ of waste (emplaced volume).

DESCRIPTION UPDATE

Updated description and layout of the configuration of underground services area were provided in OPG letter dated Feb.10, 2012 (Item #1, CEAA Registry Doc# 336).

The underground services area has been updated. Changes are:

- *The removal of the south services tunnel and the relocation of some services to the north services area (now known as the underground services area).*
- *The new underground services area has one permanent combined refuge station/lunch room/ office with a capacity for 50 people.*
- *The electrical and I&C rooms have been combined into one room.*
- *The return air tunnel provides flow-through ventilation to the maintenance shop, service garage, diesel fuel bay areas.*

This optimizes the location of some underground services and reduces the amount of underground excavation.

[16] *Additional clarification on the provision for deployment of water treatment was provided in OPG response to IR-EIS-09-472 (CEAA Registry Doc# 949).*

[17] *Additional information on the water treatment system and plant was provided in OPG response to IR-LPSC-01-27 (CEAA Registry Doc# 363).*

4.4.2.1 Shafts

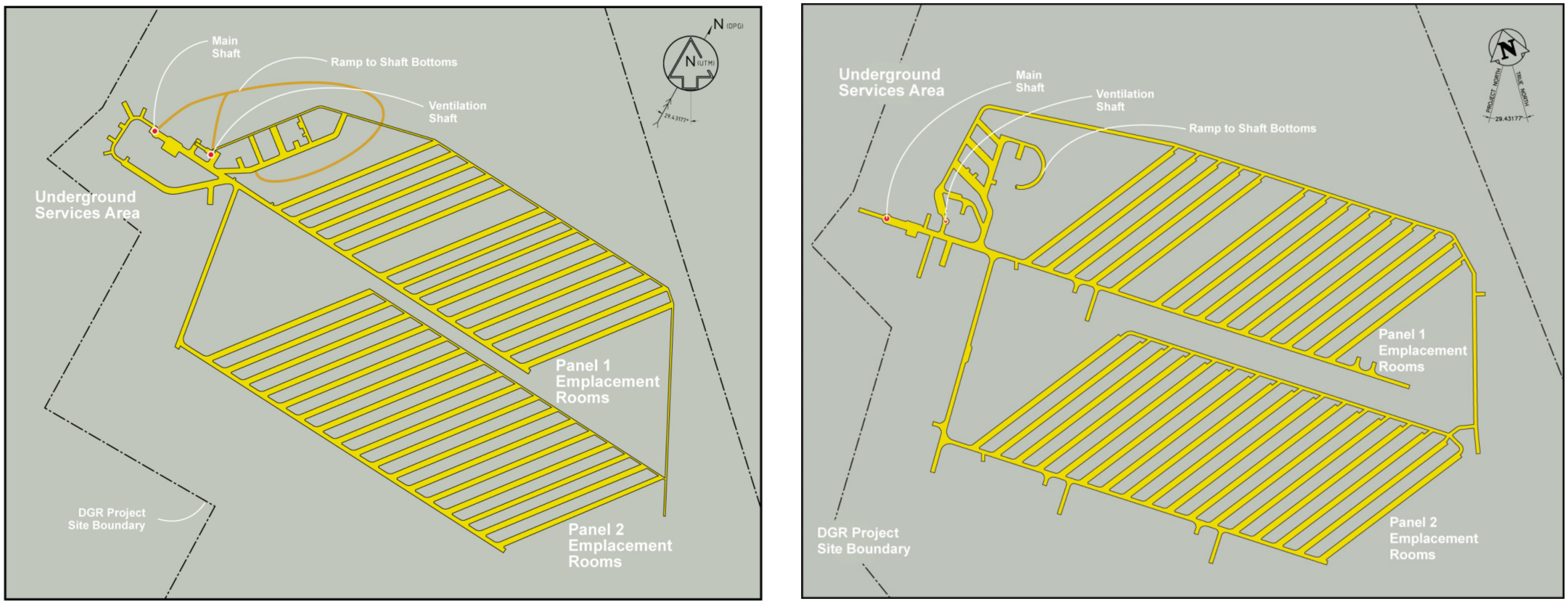
Two shafts provide access to the repository, allowing the movement of materials and waste rock to and from the repository, and provide ventilation to the repository during the construction and operations phases.

The main shaft provides the following functions:

- transporting staff to and from the repository;
- transporting materials and equipment for development and operation of the repository;
- providing a secondary conduit for supply of electricity, communications, compressed air and water;
- providing fresh air to the repository;
- providing an alternative route for transport of any collected water from underground to the surface; and
- transferring L&ILW to the repository.

The ventilation shaft provides the following functions:

- hoisting of excavated rock from the repository to the surface;
- providing the primary conduit for supply of electricity, communications, compressed air and water;
- providing emergency access for staff to and from the repository; and
- routing for exhaust air from the repository.



(a) **(b)**

Figure 4.4.2-1: Preliminary Layout of the Underground Repository

Note: (a) – as shown in March 2011 submission, (b) – updated layout as per OPG Letter Dated Feb. 10, 2012 [CEAA Registry Doc# 336])

The main shaft will have a nominal finished internal diameter of 6.5 m and the ventilation shaft will have a nominal finished internal diameter of 5.0 m. Both shafts will extend from ground surface to the repository horizon located at a nominal 680 m depth plus an additional 40 m (main shaft) and 65 m (ventilation shaft) to shaft bottom for a total excavated shaft length of 720 and 745 m, respectively. A ramp from the repository level will provide access to the loading pocket, which is used only during construction for loading waste rock into a conveyance for delivery to surface. The ramp will also provide access to the bottom of both shafts for the construction and operations phases.

4.4.2.2 Underground Services Area

The two vertical shafts are located in an "island" configuration with underground services located in close proximity. This arrangement enables most of the underground infrastructure to be kept close to the shafts, while keeping the waste emplacement areas away from areas that are normally occupied by workers. The underground services area (Figure 4.4.2-1) contains the amenity and equipment maintenance areas. The amenities include a lunchroom/refuge station, which has radiological protection controls at the entrance to prevent spread of contamination into this eating area during the operations phase. There is an additional refuge station in this area in close proximity to the ventilation shaft. Both are equipped with emergency supplies of fresh water, compressed air (with a secondary built-in scrubber air exchange unit), a fire-rated door with sealing materials and a communications link with the surface. In addition, there is a provision for placement of portable refuge stations in the panel access tunnels[18,19]. The maintenance shop and diesel fuel bay are used for servicing underground equipment. Other services in this area include the high and low voltage substations, geotechnical office and core storage, sanitary areas and general storage.

DESCRIPTION UPDATE

Additional description of the refuge stations was provided by OPG in response to IR-LPSC-01-09 (CEAA Registry Doc# 363).

[...] The permanent Refuge Station has been sized and designed for 50 people. It has as its design basis 7.645 m^3 of breathing air per person which is sufficient for 8 hours of containment without additional air supply. There are breathing air lines to the refuge station supplied by the surface-based compressors as per the requirements of Ontario Reg. 854/90 for Mines and Mining Plants, Section 26. There will not be breathing air supply in tanks or bottles in or near the permanent refuge station. In addition to the permanent Refuge Station, there will be portable refuge stations positioned closer to the emplacement rooms as they are filled during operations. [...]

The portable refuge stations will be supplied with breathing air from the surface-based compressors, as well as contained in compressed air bottles.

18 *Additional clarification on location of portable refuge stations was provided in OPG response to IR-EIS-03-60 (CEAA Registry Doc# 608), and in OPG's presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

19 *Additional clarification on the use of refuge stations was provided in OPG response to IR-LPSC-03-60 (CEAA Registry Doc# 608).*

4.4.2.3 Access Tunnels

Access to the emplacement rooms from the main shaft and ventilation shaft stations will be via two tunnels. Both access tunnels are designed for single vehicle passage and have poured concrete floors. A portion of the Panel 1 access tunnel will have rail embedded in the concrete floors to allow movement of rail carts loaded with large and heavy packages into the first three emplacement rooms of the panel[20].

Parallel to the panel access tunnels are the exhaust ventilation tunnels. The Panel 1 and Panel 2 exhaust ventilation tunnels are connected to provide a continuous path to the ventilation shaft for spent air. The exhaust ventilation tunnels are not typically occupied other than for inspection and maintenance of the ventilation regulators and monitoring equipment. These tunnels also provide a means of secondary egress until waste emplacement commences[21].

4.4.2.4 Emplacement Rooms

Emplacement rooms are arranged parallel to expected stress conditions and are dimensioned to maximize packing efficiencies. The length of the rooms will be nominally 250 m accounting for package placement orientations. The dimensions of the emplacement rooms vary 1.4 m in width and 1.2 m in height with the nominal dimensions being 8 m wide and 7 m high. The waste packages will be systematically arranged in the various room layouts based on the type of package (LLW or ILW), size of the package and whether or not the package can be stacked[22].

DESCRIPTION UPDATE

Updated dimensions of access tunnels and emplacement rooms were provided in OPG letter dated Feb.10, 2012 (Item #2, CEAA Registry Doc# 336).

Tunnel and room dimensions have been updated as follows:

	Figure (PSR)	PSR Dimensions (m)	Updated Dimensions (m)
Main Access Tunnel Showing Typical Services	6-15	8.2W x 6.4H	7.9W x 7.1H
Access Tunnel Showing Typical Services	6-16	5.9W x 6.4H	5.4W x 6.4H
Emplacement Room Section View – Bin Type Waste Packages	6-17	8.6W x 7.0H	8.6W x 7.1H
Emplacement Room Section View – Resin Liner Type Waste Packages	6-18	8.4W x 5.8H	8.6W x 7.1H

These dimensions have been updated to provide greater room-size standardization and tunnel-size optimization with respect to traffic flow. [...]

[20] *Additional clarification on the placement of waste within the two panels of the DGR was provided in OPG response to IR-EIS-03-62 (CEAA Registry Doc# 608).*

[21] *Additional clarification was provided in OPG response to IR-LPSC-03-60 regarding the use of access tunnels as a means of secondary emergency egress (CEAA Registry Doc# 608).*

[22] *Additional clarification on the emplacement rooms design was provided in OPG response to IR-EIS-03-61 (CEAA Registry Doc# 608).*

The floors of the emplacement rooms will be poured concrete, which provides a suitable surface to facilitate packing efficiencies and forklift movement. The ends of the rooms are interconnected with the exhaust ventilation tunnel and a bulkhead established to regulate ventilation from the room. The entrance of the emplacement room will allow sufficient space for end walls to be constructed once the rooms are filled to restrict access and provide shielding, as required.

4.4.3 Common Services

4.4.3.1 Ventilation System and Dust Control

Ventilation System[23]

The reliable delivery of a supply of fresh air to the underground workplaces is critical for the health and safety of workers. This air supply is used to maintain safe working conditions throughout the DGR Project. The total volume of air supplied to the DGR takes into account the nature of the work being performed, the number of active and non-active rooms and will be periodically adjusted throughout the life cycle of the repository. Ventilation air will be supplied to the DGR to ensure the following:

- there is breathable air available for all underground personnel;
- contaminants are diluted and removed;
- personnel are not exposed to levels of noxious gases that exceed regulatory limits;
- levels of explosive gases do not exceed explosive limits; and
- temperatures within the DGR are maintained so that it remains safe and acceptable for both personnel health and infrastructure integrity.

The ventilation system design, as described in Chapter 6 of the Preliminary Safety Report [26], is a flow-through system where fresh air travels from the main shaft through the access tunnels and emplacement rooms, and returns to the ventilation shaft via the exhaust ventilation tunnels.

While designed as a pull-type ventilation system, low-pressure fans will be used to deliver a controlled air volume from the surface intake fans to the collar of the main shaft so that main exhaust fans do not cause a "negative pressure" condition in the main shaft headframe. The fresh air supply fans will deliver air at a volume and pressure such that a positive pressure is imparted to the main shaft headframe. This positive pressure ensures that, should there be an incident at the surface facilities, potentially contaminated air is not sent down the shaft and through the repository level.

The primary consideration in the ventilation system requirements is the amount of diesel equipment operating at any given point underground. Taking into account the diesel equipment to be used at the same time during repository construction, it is determined that the expected

[23] *Additional information on the ventilation system was provided in OPG's written submission (Sec. 4.0) and presentation to JRP TIS #1 (CEAA Registry Doc# 636), and in OPG response to IR-EIS-04-154 (CEAA Registry Doc# 759).*

maximum airflow through the DGR is 130 m³/s. Chapter 6 of the Preliminary Safety Report [26] describes the ventilation system planned for the DGR Project in detail, and should be referred to for additional information.

The ventilation system is a critical component of the facility and a monitoring and maintenance program will be established for the operation of the system. The selection of equipment and degree of on-hand critical spares is determined by the specific fan and configuration ultimately selected for the DGR Project. It is assumed that the vendor(s) will specify the requisite inspection schedule and maintenance program for the ventilation system components, which will form the basis for the procedures implemented for ventilation equipment maintenance. Ventilation equipment and flow monitoring throughout the facility will provide information to the main control room for both specific equipment performance, as well as the performance of the overall system.

Air quality underground will be monitored to ensure that the health and safety of personnel within the repository is not compromised[24,25]. The monitoring system will ensure the following:

- levels of noxious and explosive gases do not exceed regulatory limits (s.294, R.R.O 854 [29]); and
- airflow remains adequate for the equipment and activity in active work areas.

Airflow, carbon monoxide (CO), and nitrogen dioxide (NO_2) will be measured at the ventilation shaft. Explosive gas monitors will also be installed to monitor a range of gases that may potentially occur, including methane and hydrogen. Instrumentation measuring airflow, temperature, relative humidity and other pertinent parameters will be installed at the main shaft. Emplacement room exhaust regulators will be equipped with combustible gas monitors to monitor a range of gases (e.g., methane and hydrogen). All measurements will be monitored remotely on surface at the main control room and will also be available to be monitored underground.

Dust Control

During construction, underground dust control will be through conventional mining practices of washing down and misting muck piles. Air misting through the use of foggers could be incorporated in high dust areas such as the waste rock dump and loading pocket. The ventilation system requirements set a minimum and maximum velocity of 0.5 and 6 m/s, respectively. Air flow below 0.5 m/s is not sufficient to clear dust and contaminants such as diesel exhaust, while velocities in excess of 6 m/s can contribute to airborne dust. During operations, the need for dust control is expected to be minimal since the floors will be concrete throughout the repository.

---

[24] *Additional clarification on radiological underground monitoring (air, water) was provided in OPG response to IR-LPSC-01-23 (CEAA Registry Doc# 363).*

[25] *Additional clarification on underground non-radiological air quality monitoring was provided in OPG response to IR-LPSC-01-24 (CEAA Registry Doc# 363).*

Surface dust control measures during site preparation and construction are described in the Atmospheric Environment TSD. Best management practices, such as watering, will be employed when required.

4.4.3.2 Electrical Supply

Electrical power will be supplied to the DGR's electrical switchgear and repository-level substation by a 13.8 kV transmission line from an existing Hydro One substation located on the Bruce nuclear site. The main DGR electrical substation is located on surface in close proximity to the line power supplied to the DGR Project site.

An emergency power system, using diesel generators, will be installed to maintain critical equipment in the event of a grid power failure. These generators have a capacity of about 1,750 kVA to serve the site loads that are essential for personnel safety and to maintain DGR dewatering equipment. The emergency power system is located in close proximity to the main shaft and feeds equipment through the cables and switchgear used for operations. These generators would power-up critical components within 30 seconds[26] of an unscheduled power outage; however, the emergency power system would not support continued waste placement operations. The loads that would be served by the emergency power system are as follows:

- ventilation shaft hoist to remove personnel from underground to surface in emergency situations;
- main shaft auxiliary hoist;
- main shaft Koepe hoist brakes and controls allowing for controlled lowering of the cage by gravity using the brakes without requiring use of the motor;
- repository dewatering system;
- one air compressor; and
- emergency lighting and communications at repository level and at surface.

Specialized controls and switchgear are used to initiate the start-up of the generators and shed non-critical loads following a power outage. There would be an uninterrupted switchover when the supply grid is re-energized. Preventative maintenance and inspection programs will be implemented to ensure the reliability of the emergency power system.

4.4.3.3 Communications System

The communications system will be available throughout the DGR and operates at surface and underground. The system utilizes a fibre optic network from which the various functions link. Cable will be supplied in both the main shaft and ventilation shaft for redundancy. The system accounts for telephone, emergency analogue phone, radio, and business and process control networks. Hard-wired emergency telephones will be installed at the surface main control room, at the main shaft and ventilation shaft stations, and at each refuge station[27]. These phones can

[26] *OPG's response to IR-LPSC-01-10 clarifies the time required by the generators to connect to the system in case of a grid power outage (CEAA Registry Doc# 363).*

[27] *Additional clarification on the location of hard-wired emergency phones underground was provided in OPG response to IR-LPSC-03-59 (CEAA Registry Doc# 608).*

be used for emergency communication in the event other voice communication systems (e.g., radio, ethernet-based IP telephones) fail.

The fire detection/suppression and hoist control systems will utilize dedicated signal transmission infrastructure. Outputs from these two systems will be accepted by the DGR communication system for inclusion on the operator's screens in the main control room. Additional information on the control and monitoring systems is provided in the next section (Section 4.4.3.4). Fire protection systems and emergency response are described in Section 4.17.

4.4.3.4 Control and Monitoring Systems

The main control room is the main location to monitor the system. The DGR will have a main control room. The operator can view custom-configured control screens that display equipment and system status and allow inputs to be executed through a mouse/keyboard interface. The operator can also monitor key areas through the use of closed circuit video monitors[28]. In the off-shift hours, selected main control room monitoring functions will be transferred to the WWMF main control room, which is continually staffed, allowing an operator to monitor the facility and respond to any alarms. Shaft hoisting operations are controlled from the respective control terminals. Hoisting operations can be automated or controlled manually. A certified hoist operator is on-site at all times that the hoists are in operation.

The following underground equipment will be monitored and controlled from the main control room:

- sump and dewatering pumps;
- power distribution facilities including motor starters and some switchgear; and
- ventilation fans and air heaters.

The following equipment will only be monitored in the main control room because this equipment either does not require control or will be controlled locally:

- uninterruptible power supplies (status monitoring);
- water quality monitoring, as required;
- air quality monitoring, as required;
- ground support monitoring, as required; and
- hoist system monitoring.

The fire detection and suppression system will report into the main control room but will be monitored and controlled by a separate and isolated framework or infrastructure.

[28] *Additional information on the use of closed circuit cameras for the DGR facility was provided in OPG response to IR-EIS-05-217 (CEAA Registry Doc# 776).*

The control and monitoring system allows for connection and activation of alarm devices to notify personnel of abnormal or unsafe conditions. Alarm notification devices are used within the main control room and, as necessary, underground.

4.4.3.5 Fuel Storage

Surface diesel and unleaded fuel storage for mobile equipment is limited to the site preparation and construction phase, and will be removed prior to operations with the exception of the emergency power system fuel storage. The temporary fuel storage consists of above-ground double walled tanks located within a secured area demarcated and protected by concrete bollards. During operations, diesel fuel storage at surface is limited to the emergency power system fuel supply, which is contained in a 10,600 L double walled tank located adjacent to the emergency generator.

DESCRIPTION UPDATE

Corrected volume of the emergency power diesel storage tank was provided in OPG response to IR-EIS-07-279 (CEAA Registry Doc# 843).

As discussed in the Environmental Impact Statement (EIS) (Section 4.4.3.5), surface diesel and fuel storage for mobile equipment will be limited to the site preparation and construction phase and will be removed prior to operations. The temporary fuel storage consists of 5,000 L above-ground double walled tanks equipped with metered dispensing equipment located within a secured area and protected by concrete bollards. During operations, diesel fuel storage at surface is limited to the emergency power system fuel supply, which is contained in a 5,000 L double walled tank located adjacent to the emergency generators. Section 4.4.3.5 incorrectly identified the tank size as 10,600 L; the correct volume of 5,000 L was provided in Section 4.7.5.2. [...]

Fuel requirements for operations will utilize the existing WWMF fuel station. Fuel totes for the underground diesel fuel bay and for use by underground equipment will be filled at the WWMF and transported underground via the main shaft handling equipment. The repository level fuel storage design is typical of commercially available systems, and includes two 2,700 L double walled steel fuel totes in an integrated unit with built-in leak containment and fire suppression system. Space for only one piece of mobile equipment will be provided in the underground refuelling station to reduce risk of fire incidents. Fuel pumps will be connected directly to the fuel tote, with empty totes cycled back to surface for refilling at the existing WWMF fuel station.

Both surface and underground fuel storage areas will be provided with sufficient sump capacity to collect accidental spillage that could occur during fuel transfer or leakage from any tanks or pipes. Berms will be constructed as needed to ensure that any spillage of fuel or lubricant will be retained within the storage and refuelling areas.

Fuel storage is further described in Section 4.7.5.2 for site preparation and construction and Section 4.8.5.2 for operations.

4.4.3.6 Potable, Industrial and Fire Water

Potable water for the surface facilities will be provided through connection to the existing Bruce nuclear site supply. Bottled water will be supplied for underground use[29].

Industrial water will be supplied through the existing Bruce nuclear site industrial, or process, water network via connection to the west of the DGR Project site. This water supplies both surface and underground industrial water needs. Heavy-wall steel pipe down the ventilation shaft, with back-up piping in the main shaft, provides industrial water for use in construction and operations activities at the repository level.

Fire water will be supplied[30] through the existing Bruce nuclear site network. As with the industrial water, the DGR Project site will connect into the existing lines and distribute on surface. Fire water is only used for surface fire protection as all underground suppression systems will be dry chemical based, as described in Section 4.17.

4.4.3.7 Sewage System

During the site preparation and construction phase, all sewage will be managed by the contractor using an off-site service contractor[31]. During operations, all sewage from surface facilities will be treated through the existing on-site sewerage system operated by Bruce Power. The management of materials from repository level sanitary facilities (e.g., toilets and hand washing stations) is described in Section 4.8.5.1.

4.5 WASTE TO BE PLACED IN THE DGR

The DGR will accept operational and refurbishment L&ILW[32]. The DGR will not accept used nuclear fuel or recognizable fuel fragments[33,34].

A summary of the wastes to be emplaced in the DGR is presented in this section. This includes information on waste sources, inventories, and the physical, radiological and chemical characteristics of the wastes. It also provides information on representative containers that will

---

[29] *Additional information on traffic associated with provision of potable water during construction of DGR was provided in OPG response to IR-EIS-05-199 (CEAA Registry Doc# 793).*

[30] *Additional clarification on the fire water supply to the DGR site was provided in OPG response to IR-LPSC-01-20 (CEAA Registry Doc# 363).*

[31] *Additional information was provided in OPG response to IR-EIS-05-199 on traffic associated with provision of sanitary facilities (CEAA Registry Doc# 793).*

[32] Throughout this report, refurbishment L&ILW may be referred to as reactor refurbishment waste or "RRW".

[33] *Additional clarification on use of DGR for low and intermediate level waste only was provided in OPG response to IR-EIS-04-99 (CEAA Registry Doc# 704).*

[34] *Additional clarification on exclusion criterion regarding the recognizable fuel fragments was provided in OPG response to IR-EIS-06-260 (CEAA Registry Doc# 823).*

be emplaced into the DGR. This information is based on the Preliminary Safety Report [26] and the Reference Inventory Report [30].

Radioactive wastes to be accepted by the DGR are classified as solid low-level or solid intermediate-level[35]. The classification[36] is as described below, and is consistent with Canadian Standards Association (CSA) N292.3 [31].

Low level waste (LLW) consists of non-fuel waste in which the concentration or quantity of radionuclides is above the clearance levels and exemption quantities established by the Nuclear Substances and Radiation Devices Regulations [32], and which contain primarily short-lived radionuclides (i.e., half-lives shorter than or equal to 30 years). LLW normally does not require significant shielding for worker protection during handling and storage.

Intermediate level waste (ILW) consists of non-fuel waste containing significant quantities of long-lived radionuclides. ILW often requires shielding for worker protection during handling.

The L&ILW are generated from a variety of activities. For the purposes of safety assessment and engineering, it is convenient to distinguish the operational L&ILW from refurbishment L&ILW. A third general category, decommissioning L&ILW is not included in this discussion.

A wide variety of waste types are generated as a result of the operation of nuclear generating stations. OPG currently tracks about 70 different waste types. However, many of these are small volume items, or have similar properties to other waste types. Therefore, for purposes of describing the DGR waste inventory, these waste types have been grouped into about 20 waste categories. Tables 4.5-1 and 4.5-2 provide descriptions and sources of the L&ILW categories tracked for the DGR.

---

[35] *Additional clarification of categorization of wastes arriving at DGR was provided in OPG responses to IR-EIS-03-59 (CEAA Registry Doc# 608), and IR-EIS-04-102 (CEAA Registry Doc# 704).*

[36] *Additional clarification on definitions of low-level waste, intermediate-level waste, and high-level waste was provided in OPG response to IR-EIS-11-504 (CEAA Registry Doc# 1157).*

Table 4.5-1: LLW Categories[37]

Waste Category	Description
Bottom Ash	Heterogeneous ash and clinker from waste incineration
Baghouse Ash	Fine homogeneous ash from waste incineration
Compact Bales	Generally compactible solid LLW; for example empty waste drums, rubber hoses, rubber area floor matting, light gauge metals, welding rods, plastic conduit, fire blankets and fire retardant material, metal cans, insulation, ventilation filters, air hoses, metal mop buckets and presses, electric cable (<1/4" diameter), lathe turnings, metal filings, glass, plastic suits (Mark III/IV), rubbers, Vicraft hoods, rubber gloves
Box Compacted	Same as compact bales
Non-Processible Boxed	Solid LLW that is non-compactible or has contact dose greater than 2 mSv/h; for example, heavy gauge metal (e.g., beams, ion exchange (IX) vessels, angle iron, plate metal), concrete and cement blocks, metal components (e.g., pipe, scaffolding pipes, metal planks, motors, flanges, valves), wire cables and slings, electric cables (>1/4" diameter), Comfo respirator filters, tools, paper, plastic, absorbent products, laboratory sealed sources, feeder pipes
Non-Processible Drummed	Generally small, granular or solidified LLW; for example, floor sweepings, cleaners and absorbents (e.g., Dust Bane, Stay Dry), metal filings, glassware, light bulbs, bitumenized low-level waste
Non-Processible Other	Large and irregularly shaped objects such as heat exchangers, Encapsulated Tile Holes (ETH), shield plug containers, and other miscellaneous large objects (e.g., fume hoods, glove boxes, processing equipment)
LL/ALW Resin	Spent Low-level (LL) IX resin arising from light water auxiliary systems, and/or Active Liquid Waste (ALW) treatment systems
ALW Sludge	Sludge from Bruce two-stage ALW Treatment System
Steam Generators	Steam generators removed from service

[37] *Clarification on alternative means of dealing with combustible (incinerable) waste was provided in OPG response to IR-EIS-03-50 (CEAA Registry Doc# 608).*

Table 4.5-2: ILW Categories, including Reactor Refurbishment Waste

Waste Category	Description
Moderator Resin	Spent IX resin arising from moderator purification systems
Primary Heat Transport (PHT) Resin	Spent IX resin arising from PHT purification systems
Miscellaneous Resin	Spent IX resin arising from station auxiliary systems (e.g., heavy water upgraders)
CANDECON Resin	Spent IX resin from chemical decontamination process for nuclear heat transport systems
IX Columns	Spent IX resin mainly arising from Pickering PHT purification system; comes as package with steel container
Irradiated Core Components	Various replaced core components, notably flux detectors and liquid zone control rods
Filters and Filter Elements	Filters and filter elements from various station process systems
Retube – Pressure Tubes [a]	Fuel channel waste from large scale retube
Retube – End Fittings [a]	Fuel channel waste from large scale retube
Retube – Calandria Tubes [a]	Fuel channel waste from large scale retube
Retube – Calandria Tube Inserts [a]	Fuel channel waste from large scale retube

Note:
a Reactor Refurbishment Waste

4.5.1 Waste Volumes

Most L&ILW is inherently heterogeneous, with considerable variability both across waste categories, and also from package to package within a waste category. OPG has therefore supported a waste characterization program for many years. The characteristics of various waste types have been identified, and information recorded on waste packages in an electronic records system called IWTS, the Integrated Waste Tracking System.

The amount of waste and number of packages projected over the life of OPG's nuclear program is calculated based on the existing inventory tracked in IWTS, and a future waste receipt projection. Based on the existing plus projected inventory, it is estimated that approximately 53,000 packages representing a total emplaced volume of approximately 200,000 m^3 will be sent to the DGR. The actual number of packages may be different (e.g., depending on future decisions about processing and packaging new wastes and repackaging current wastes); however, the information provided in this section is sufficient for EA planning.

Table 4.5.1-1 shows the waste volume breakdown for the reference forecast. Figure 4.5.1-1 shows the relative distribution of waste by volume. As can be seen on the figure, about 75% of the emplaced volume is operational LLW. Note that while refurbishment L&ILW only makes up about 10% of the emplaced volume, it accounts for more than 60% of the radionuclide inventory at 2062.

Table 4.5.1-1: Waste Volumes in Reference Forecast (Rounded)

Volume	Operations LLW	Operations ILW	Refurbishment L&ILW	Total
Net waste volume (m^3)	95,100	9,300	11,200	115,600
As-stored volume (m^3)	135,000	13,500	21,700	170,200
Emplaced volume (m^3)	154,700	27,600	21,700	204,000

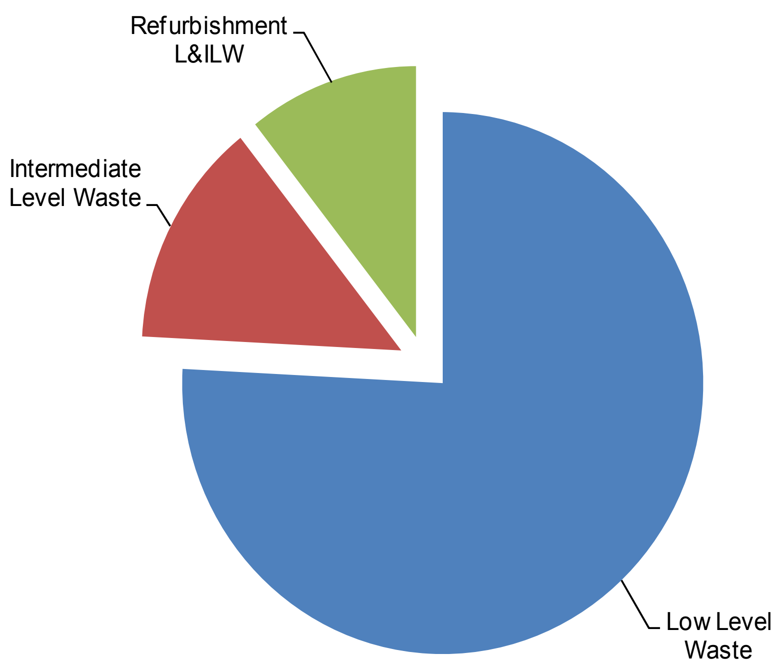


Figure 4.5.1-1: Relative Waste Volumes Planned for Emplacement in the DGR (emplaced volume) [38]

Table 4.5.1-2 summarizes the forecast of operational and refurbishment L&ILW packages as they would arrive at the receiving area of the DGR. This forecast is based on the planning assumption of refurbishment of all reactor units at or near their mid-life, and then operating for a further 25 to 30 years after refurbishment.

[38] *Additional clarification on waste volumes was provided in OPG response to IR-EIS-08-378 (CEAA Registry Doc# 886).*

The waste volume forecast is subject to changes to the nuclear operating and refurbishment program; standardization across stations; improvements to waste processing technology; and changes to repository storage technology. For example, this forecast does not take into account OPG's recent decision not to refurbish Pickering B. However, approximately half of the projected waste volume is already stored at the WWMF site, and the projection is based on actual experience with the stations. Therefore, the overall waste volumes are expected to be similar to this forecast. The total emplaced waste volume will be limited by the excavated volume of the repository.

Table 4.5.1-2: Forecast of Operational and Refurbishment L&ILW Packages

Container Type	Number of Containers	Emplaced Volume (m³)	Dimensions L×W×H (m)	Avg. Full Mass (kg)	Comments
Representative LLW Packages					
Bale Racks	1,383	4,702	2.29 × 1.22 × 1.2	1,400	—
Compactor Boxes	6,135	17,177	1.84 × 1.12 × 1.3	2,722	—
Non-Processible Bins	24,164	73,483	1.96 × 1.32 × 1.19	1,460	Volume/mass based on NPB47 container
Drum Racks	2,903	9,870	2.29 × 1.22 × 1.2	1,490	6 drums per Rack
Drum Bins	4,615	12,922	1.96 × 1.32 × 1.03	1,450	6 drums per Bin
LL Resin Pallet Tanks	2,085	5,627	1.24 × 1.24 × 1.68	2,000	Without overpack
LLW Container Overpacks	3,212	27,303	2.54 × 1.78 × 1.88	Max 5,400	Overpacking for 1,100 ash bins, 80 LL resin boxes, 1,709 ALW sludge boxes, and 323 drum racks
Shield Plug Containers	26	309	3.0 × 1.8 × 1.8	26,000	—
Heat Exchangers	98	2,775	Various e.g., 2 (OD) × 4.6 (OL)	10,000 – 30,000	Assume 25% of 98 heat exchangers will be segmented in half
Encapsulated Tile Hole	66	504	1.5 (OD) × 4.6 (OL)	25,000	—
Steam Generator Segments	512	8,387	1.8–3.6 (OD) × 2.0–4.3 (OL)	25,730	Does not include grout

Container Type	Number of Containers	Emplaced Volume (m³)	Dimensions L×W×H (m)	Avg. Full Mass (kg)	Comments
Representative ILW Packages					
Resin Liners	286	858	1.63 (OD) × 1.8 (OL)	4,545	Does not include sacrificial pallet
Resin Liner Overpacks	400	1,640	1.68 (OD) × 1.91 (OL)	6,000	Does not include sacrificial pallet
Resin Liner 250 mm Shield	646	10,467	2.2 (OD) × 4.25 (OL)	26,850	Two resin liners per shield
Resin Liner 350 mm Shield	164	3,295	2.4 (OD) × 4.45 (OL)	36,150	Two resin liners per shield
Resin Liner 350 mm Shield with Steel Insert	140	1,925	2.53 (OD) × 2.74 (OL)	28,965	One resin liner per shield
Alternative Tile Hole Equivalent Liner (ATHEL) Waste Package 350 mm Shield	300	4,140	2.53 (OD) × 2.74 (OL)	23,500	One ATHEL package per shield
Tile Hole Liners	201	176	0.61 (OD) × 3.4 (OL)	2,000	Without shield/rack
Retube Waste Containers	1,353	13,298	1.70 × 3.35 × 1.92	33,500	Volume/mass based on Bruce A RWC-EF container
ILW Shield	3,952	5,137	1.63 (OD) × 1.8 (OL)	2,290	Replaces T-H-E Liners
Total (rounded)	**52,600**	**204,000**	—	—	—

Notes:
OD = Outer Diameter
OL = Outer Length

As indicated in the table above, the waste packages encompass a variety of waste container types. In fact, there are currently in excess of 100 different waste containers used for storage of L&ILW at the WWMF (see Figure 4.5.1-2 for examples of some of these containers)[39]. The primary purpose of the waste container is to act as a convenient vessel to safely hold the waste during handling, transportation, and storage. It provides a uniform way to handle the waste and allows for stacking to improve storage efficiency. The container may also provide shielding for higher activity waste. The waste acceptance criteria (WAC) for the DGR Project are summarized following Figure 4.5.1-2. Details regarding treatment that some waste packages may require prior to being emplaced in the DGR are included in Section 4.8.2.1.

[39] *Additional detail on waste containers/packages was provided in OPG response to IR-EIS-09-474 (CEAA Registry Doc# 949).*

B25 Compacted Waste Box

DBIN Drum Bin

BINOPK LLW Container Overpack

NPB47 Non-Processible Waste Container

RLSS 3 m³ Resin Liner

SPC Shield Plug Container

RWC-EF Retube Waste Container – Endfittings

ETH Encapsulated RWOS 1 Tilehole

Figure 4.5.1-2: Examples of Waste Containers for Emplacement in DGR

All LLW and ILW will be transferred to the DGR in waste packages that meet the DGR WAC. The DGR WAC were developed to ensure that the wastes emplaced in the DGR are within the bounds of the safety assessment, design basis and regulatory requirements. The criteria are summarized in Table 4.5.1-3.

Table 4.5.1-3: Summary of Waste Acceptance Criteria[40]

Criteria	Summary Description
Waste characterization	• physical, chemical, radiological characteristics of each package
Documentation	• waste packages must be tracked in OPG Integrated Waste Tracking System (IWTS) with waste characteristics, dose rates, and description of contents • verified load statements • supplemental info such as radiological surveys, chemical analyses, loading checklists • notes on package design documentation, such as drawings, technical specifications, and design requirements • transfer documents for wastes subject to additional controls
Acceptable waste package designs	• all DGR waste package designs must be approved
Condition of waste container	• no significant rusting • sound structural integrity • no leakage • no wobbling or tilting
Mass limits	• 35 Mg, subject to maximum design limit for each waste package type
Size limits	• must fit within internal dimensions of the DGR cage
Containment	• wastes and contamination shall be contained during handling • all containers shall have lids
Venting	• where the potential for gas build-up exists and containers are not designed to withstand the pressure, the containers shall be vented
Identification/labelling	• containers bar-coded with IWTS tracking number on two adjacent vertical sides • additional information including gross mass, dose rate, and significant non-radiological hazards to be marked on packaged with lettering at least 25 mm high
Stackability	• stable, self supporting stack of up to 6 m high • use of standard footprints strongly encouraged

[40] *Additional clarifications on Waste Acceptance Criteria were provided in OPG responses to IRs EIS-08-342, EIS-08-343, EIS-08-347, EIS-08-348, EIS-08-350 (CEAA Registry Doc# 886), and EIS-10-488 (CEAA Registry Doc# 990).*

Criteria	Summary Description
Handling	• conventional material handling equipment such as forklifts with loads of up to 35 Mg[41]
Fire resistance	• non-combustible containers
Dose rate limits	• 2 mSv/h on contact with external surface of waste package or shielding • 0.1 mSv/h at 1 m from transportation package • exceptions approved by responsible health physicist
Radionuclide composition	• package amount must be reported for tritium, carbon-14, chlorine-36, cobalt-60, strontium-90, zirconium-93, niobium-94, technetium-99, iodine-129, cesium-135, cesium-137, uranium-235, uranium-238, plutonium-239, plutonium-240, plutonium-241
Contamination limits	• removable surface contamination on package exterior to be less than 4 Bq/cm^2 beta-gamma and 0.4 Bq/cm^2 alpha when averaged over 300 cm^2
Heat load limits	• no restriction if less than 0.01 W/m^3 of waste package external dimensions • up to 10 W/m^3 by prior notification and approval for special cases
Waste form	• solids only • sludges must have slump of less than 150 mm
Residual liquids	• generally must be less than 1% free liquid by volume • bulk IX resins must be less than 5% free water by volume
Gas generation	• must not generate toxic gas on exposure to water
Excluded wastes	• reactive wastes, polychlorinated biphenyl (PCB) wastes, pathological wastes, ignitable wastes[42] • explosives, corrosives, compressed gases • used nuclear fuel and recognizable fuel fragments • high thermal cobalt-60 sources
Special notice wastes	• wastes containing significant levels of Occupational Health and Safety Act (OHSA) designated substances • leachate toxic wastes[43]
Chelating agents	• must be less than 1% by weight of package
Petroleum oils	• must be less than 1% by weight of package

[41] *Additional clarifications on waste package transfer stability were provided in OPG responses to IRs EIS-08-344 (CEAA Registry Doc# 886) and EIS-10-496 (CEAA Registry Doc# 990).*

[42] *Definition of "ignitable waste" as used in the category of wastes excluded from DGR was provided in OPG response to IR-EIS-03-58 (CEAA Registry Doc# 608).*

[43] *Additional clarification regarding the "leachate toxic" wastes was provided in OPG response to IR-EIS-04-147 (CEAA Registry Doc# 704).*

4.5.2 Total Radionuclide Inventory of Waste[44]

The radionuclide inventory described in this section includes the increase each year as more waste is emplaced in the DGR and the decrease each year attributable to decay. The total inventory estimate is based on assuming that the DGR will start operations in 2018 and be filled by around 2052, with 2062 as the assumed date for completing decommissioning. The estimated total decay corrected radionuclide inventory of operational and refurbishment L&ILW in the DGR at 2062 is summarized in Table 4.5.2-1. The values are based on the L&ILW characteristics given in the Reference Inventory Report [30], and the projected L&ILW volumes calculated for each year (past and historical) with decay-correction. The results for the assumed repository decommissioning date of 2062 indicate the total radioactivity will be dominated by tritium (H-3), carbon-14, niobium-94 and nickel-63. A more complete listing of radionuclides in the waste is given in the Reference Inventory Report [30].

[44] *Additional clarifications on characterization of the inventory of radionuclides were provided in OPG responses to IRs EIS-01-05, EIS-01-07 (CEAA Registry Doc# 363).*

DESCRIPTION UPDATE

Updated information on characterization of uncertainty with radioactive measurements was provided in OPG response to IR-EIS-01-06 (CEAA Registry Doc# 363).

The projected total inventory of radionuclides in the DGR is provided in the OPG Reference Inventory report. It is based on radionuclide specific activities in the various waste types, and the projected total volume of the waste types. The specific activities are derived from measurements and calculations for the OPG waste types. The projected total volume is based on the existing waste volume and a reference scenario for future operation of the OPG owned or operated reactors; a significant fraction of these wastes are already present at the Western Waste Management Facility site.

Radionuclide activities typically vary significantly between waste packages of a given type. However, the total repository inventory is less uncertain because it is based on the inventories summed over a large number (often thousands) of packages.

From the DGR postclosure safety assessment, the key radionuclides with respect to potential dose impacts are C-14, Cl-36, I-129, Nb-94, Ni-59 and Zr-93. The characterization of uncertainty in these radionuclide activities is addressed in [...] report [OPG DGR: Key Radionuclide Activity Uncertainty. NWMO Technical Memorandum NWMO-TM-03130][45].

For these radionuclides, the uncertainty is estimated to be within a factor of 10 relative to the Reference Inventory value. This is considered to provide sufficient confidence in the scaling factors and inventory to support the postclosure safety assessment because the peak dose results for the postclosure Normal Evolution Scenario are many orders of magnitude below the dose criterion, and the unlikely Disruptive Scenarios are well within the risk criterion (Chapter 8, Preliminary Safety Report). The conclusion on the repository safety is not sensitive to these inventory uncertainties.

Continuing work is underway which will improve the estimates of total projected DGR radionuclide activity. A revised reference inventory will be presented as part of the application for the Operating Licence.

[45] *Additional clarifications on radionuclide inventory were provided in OPG responses to IRs EIS-01-06 and EIS-01-20 (CEAA Registry Doc# 363), as well as supplementary responses to IRs EIS-01-06 and EIS-01-20 (CEAA Registry Doc# 606), and in OPG response to IR-EIS-06-264 (CEAA Registry Doc# 832).*

Table 4.5.2-1: Estimated L&ILW Radionuclide Inventory at 2062[46,47]

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Ag-108m	1.3E+02	3.3E+07	1.0E+09	2.0E+13	2.0E+13
Am-241	4.3E+02	5.5E+10	2.2E+11	2.1E+12	2.4E+12
Am-242m	1.5E+02	5.1E+07	0.0E+00	2.3E+09	2.4E+09
Am-243	7.4E+03	6.8E+07	1.7E+08	2.9E+09	3.1E+09
Ba-133	1.1E+01	7.1E+08	0.0E+00	0.0E+00	7.1E+08
C-14	5.7E+03	1.4E+12	5.4E+15	6.6E+14	6.1E+15
Cf-252	2.6E+00	1.2E+06	0.0E+00	0.0E+00	1.2E+06
Cl-36	3.0E+05	5.4E+08	7.4E+08	1.4E+12	1.4E+12
Cm-243	2.9E+01	0.0E+00	0.0E+00	2.7E+09	2.7E+09
Cm-244	1.8E+01	2.7E+09	7.0E+10	2.2E+11	2.9E+11
Co-60	5.3E+00	1.7E+11	3.5E+12	9.0E+14	9.0E+14
Cs-134	2.1E+00	5.6E+07	3.1E+10	3.1E+06	3.1E+10
Cs-135	2.3E+06	4.3E+06	1.3E+08	2.3E+08	3.6E+08
Cs-137 + Ba-137m[b]	3.0E+01	1.3E+13	9.4E+13	5.4E+11	1.1E+14
Eu-152	1.3E+01	3.7E+07	1.5E+12	1.2E+09	1.5E+12
Eu-154	8.8E+00	7.1E+09	1.2E+11	3.2E+09	1.3E+11
Eu-155	5.0E+00	5.1E+07	1.7E+09	3.3E+08	2.1E+09
Fe-55	2.7E+00	3.8E+10	3.8E+11	5.5E+13	5.5E+13
H-3	1.2E+01	8.5E+14	1.5E+14	4.8E+12	1.0E+15
I-129	1.6E+07	1.2E+06	1.3E+08	1.0E+06	1.3E+08
Ir-192m	2.4E+02	0.0E+00	4.9E+07	1.1E+10	1.1E+10
Mn-54	8.6E-01	0.0E+00	0.0E+00	2.7E+02	2.7E+02
Mo-93	3.5E+03	0.0E+00	4.5E+08	1.0E+12	1.0E+12

[46] *Additional clarification was provided in OPG response to IR-EIS-08-345 regarding the primary waste type source for each radionuclide (CEAA Registry Doc# 902).*

[47] *Additional clarifications on waste inventory are provided in OPG response to IR-EIS-13-514 (CEAA Registry Doc# 327).*

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Nb-93m	1.4E+01	0.0E+00	2.9E+10	9.2E+12	9.2E+12
Nb-94	2.0E+04	2.2E+10	1.2E+11	4.6E+15	4.6E+15
Ni-59	7.5E+04	2.1E+09	3.6E+11	3.6E+13	3.6E+13
Ni-63	9.6E+01	2.4E+11	3.9E+13	3.9E+15	3.9E+15
Np-237	2.1E+06	3.2E+06	1.1E+07	1.2E+08	1.3E+08
Pb-210	2.2E+01	3.2E+10	0.0E+00	0.0E+00	3.2E+10
Pt-193	5.0E+01	0.0E+00	3.1E+09	1.1E+13	1.1E+13
Pu-238	8.8E+01	8.5E+09	2.7E+10	4.6E+11	5.0E+11
Pu-239	2.4E+04	2.2E+10	7.7E+10	8.2E+11	9.2E+11
Pu-240	6.5E+03	3.0E+10	1.1E+11	1.2E+12	1.3E+12
Pu-241	1.4E+01	6.8E+10	1.6E+12	1.9E+11	1.9E+12
Pu-242	3.8E+05	3.2E+07	1.0E+08	1.2E+09	1.3E+09
Ra-226	1.6E+03	3.8E+09	0.0E+00	0.0E+00	3.8E+09
Ru-106	1.0E+00	3.0E+06	1.5E+08	0.0E+00	1.5E+08
Sb-125	2.8E+00	3.4E+08	1.8E+11	3.9E+11	5.7E+11
Se-79	3.8E+05	1.5E+06	4.5E+06	1.3E+10	1.3E+10
Sm-151	9.0E+01	1.0E+07	3.2E+08	1.7E+09	2.0E+09
Sn-119m	8.0E-01	0.0E+00	0.0E+00	2.4E+01	2.4E+01
Sn-121m	5.5E+01	0.0E+00	5.9E+11	7.7E+13	7.8E+13
Sn-126	2.1E+05	2.3E+07	7.0E+08	1.2E+07	7.4E+08
Sr-90 + Y-90[b]	2.9E+01	3.0E+12	4.2E+13	9.3E+12	5.4E+13
Tc-99	2.1E+05	5.2E+07	8.4E+08	6.0E+10	6.1E+10
U-232	7.2E+01	4.9E+06	0.0E+00	2.3E+08	2.3E+08
U-233	1.6E+05	6.6E+06	0.0E+00	3.1E+08	3.2E+08
U-234	2.5E+05	3.6E+07	1.1E+08	1.3E+09	1.4E+09
U-235	7.0E+08	5.6E+05	1.9E+06	2.1E+07	2.3E+07
U-236	2.3E+07	6.4E+06	2.1E+07	2.5E+08	2.8E+08
U-238	4.5E+09	4.2E+09	1.4E+08	1.7E+09	6.0E+09

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Zr-93	1.5E+06	1.6E+06	6.7E+11	2.1E+14	2.1E+14
Total		**8.7E+14**	**5.7E+15**	**1.1E+16**	**1.7E+16**

Notes:
a Isotope half-life in years
b Activity listed is total for parent plus progeny in secular equilibrium
0.0E+00 indicates value is not significant.

DESCRIPTION UPDATE

Corrected Pu-241 inventories (refurbishment L&ILW and total values) were provided in OPG response to IR-EIS-08-345 (CEAA Registry Doc# 902).

[...] *The (Pu-241) inventory (for Refurbishment L&ILW inventory) should be 3.0E+12 Bq instead of 1.9E+11 Bq. [...] Therefore, the total Pu-241 inventory in EIS Table 4.5.2-1 should be 4.7E+12 Bq instead of 1.9E+12 Bq. The correct value was used in the calculations.*

Figures 4.5.2-1 and 4.5.2-2 display the time dependence of the projected L&ILW inventory. As shown, the LLW radioactivity decreases relatively quickly because of the tritium. ILW decays more slowly due primarily to the presence of carbon-14 in the ILW resins. The peak refurbishment wastes inventory is assumed to occur in 2020, coinciding with the forecasted end of retubing activities followed by the decay of iron-55. After a few hundred years, the total DGR radioactivity will be dominated by carbon-14 and niobium-94, and eventually zirconium-93.

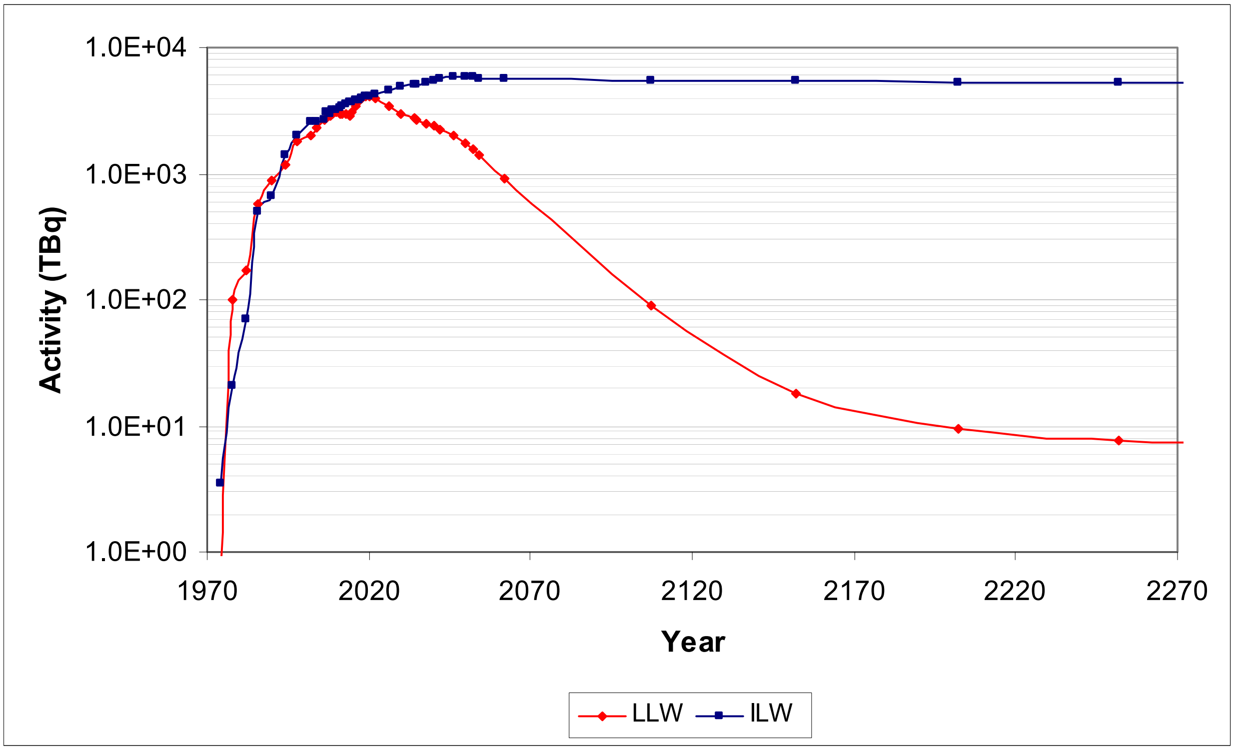


Figure 4.5.2-1: Change in Radioactivity for Operational L&ILW as a Function of Time

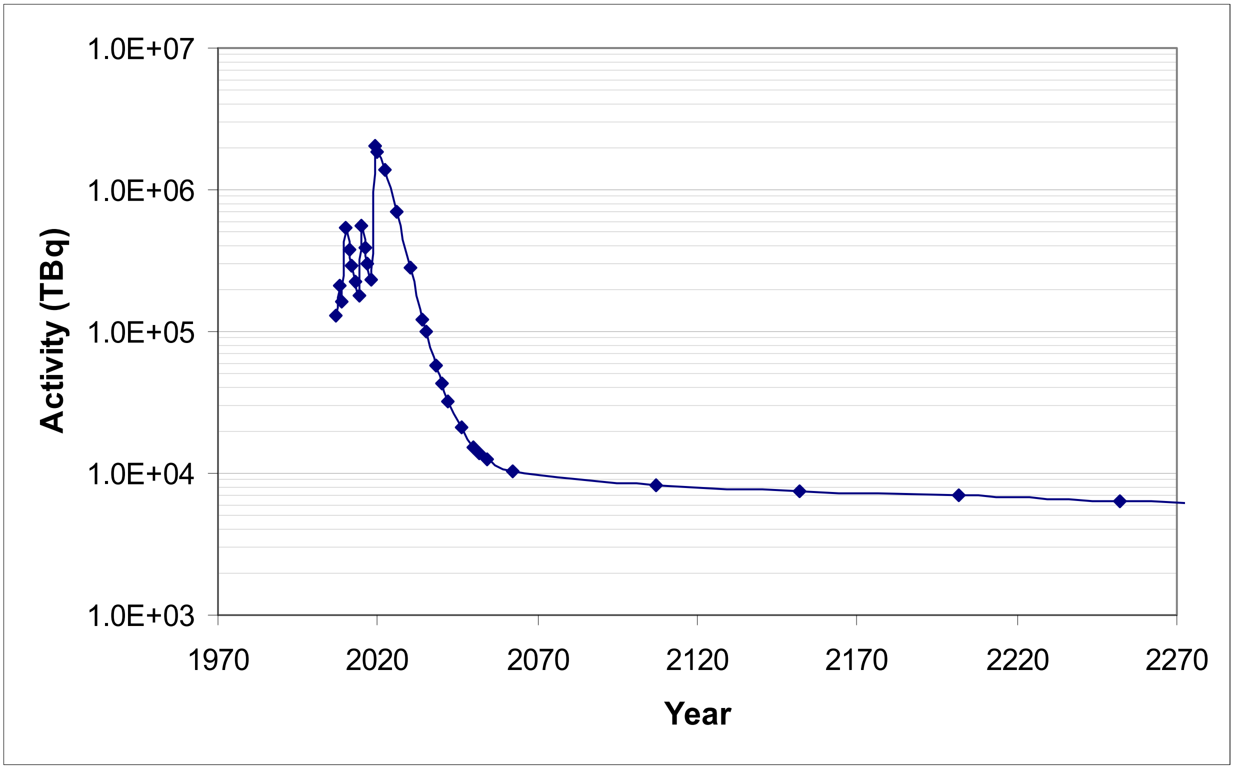


Figure 4.5.2-2: Change in Radioactivity for Refurbishment L&ILW as a Function of Time

One important radiological characteristic of the wastes to be emplaced in the DGR is that they are non-fissile. As noted previously, used fuel and recognizable fuel fragments will not be accepted for emplacement. The amount of fissile radionuclides that will be present in the DGR will be small, and will be dispersed across approximately 200,000 m³ waste (emplaced volume) in many separate packages in different emplacement rooms. In particular, the total mass of plutonium-239 and plutonium-241 is estimated at 0.4 kg, and the plutonium will not be present in pure form in any location.

Similarly, the total mass of fissile uranium-235 at the time of repository closure is approximately 1 kg. Most of this uranium-235 is present in trace amounts from failed fuel and from depleted uranium shielding. Fissile uranium present in the waste is dispersed within the DGR and is mostly diluted in uranium-238 at less than natural isotopic concentrations.

Taking the preceding paragraphs into consideration, criticality is not a credible scenario for the DGR Project.

4.5.3 Chemical Inventory of Wastes

Most of the wastes to be emplaced into the DGR are normal industrial materials, which are further described in Section 4.5.4. The L&ILW may contain varying amounts of chemicals or elements that can be hazardous. These include asbestos (originally used as insulating material in some stations), heavy metals like uranium, cadmium, mercury, chromium, and lead, and certain organic materials such as polycyclic aromatic hydrocarbons (PAHs), chlorinated benzenes and phenols, and dioxins and furans produced in the incinerator and trapped in the ash. There are also metals like chromium, nickel, and lead that are present in container materials (i.e., stainless steel, lead shielding).

The main chemical (non-radioactive) components of the operational and refurbishment L&ILW are summarized in Table 4.5.3-1. The DGR will not accept liquid wastes (except for small amounts of incidental liquids associated with the solid wastes), highly reactive or pressurized wastes.

Table 4.5.3-1: Chemical Inventory of Operational and Refurbishment L&ILW

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
Aluminum	2.8E+05	3.8E+03	6.6E+02	2.8E+05
Antimony	3.2E+03	2.0E+00	2.2E+01	3.2E+03
Arsenic	2.8E+02	1.2E+01	1.3E+02	4.3E+02
Barium	9.4E+03	1.6E+02	1.1E-02	9.6E+03
Beryllium	1.1E+02	2.1E+01	5.2E-03	1.3E+02
Bismuth	5.4E+00	5.2E+00	5.6E-02	1.1E+01
Boron	1.5E+03	5.2E+03	2.4E+00	6.7E+03
Bromine	1.3E+02	4.2E-01	4.5E-02	1.3E+02
Cadmium	1.1E+04	1.9E+01	7.9E-01	1.1E+04
Calcium	3.5E+05	4.1E+03	2.3E+01	3.5E+05
Cerium	1.3E-01	8.2E-02	7.1E-02	2.8E-01
Cesium	5.5E-01	2.1E-01	1.6E-02	7.7E-01
Chlorine	8.2E+04	4.9E+03	2.6E+00	8.7E+04
Chromium	4.1E+05	3.6E+04	5.4E+05	9.8E+05
Cobalt	3.4E+02	2.2E+01	2.8E+02	6.4E+02
Copper	3.3E+06	4.0E+03	3.0E+03	3.4E+06
Fluorine	0.0E+00	1.3E+02	2.4E+00	1.3E+02
Gadolinium	0.0E+00	5.4E+03	6.7E+01	5.5E+03
Hafnium	0.0E+00	0.0E+00	2.6E+02	2.6E+02
Iodine	6.6E+01	1.1E-01	8.8E-03	6.6E+01
Iron	7.9E+06	9.0E+05	1.1E+07	2.0E+07

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
Lead	1.5E+06	2.8E+02	3.8E+00	1.5E+06
Lithium	4.5E+01	5.9E+03	1.3E-02	5.9E+03
Magnesium	7.2E+04	9.1E+02	4.7E+00	7.3E+04
Manganese	6.8E+05	6.2E+03	1.6E+05	8.5E+05
Mercury	6.8E+01	2.9E-01	8.7E-02	6.9E+01
Molybdenum	2.2E+02	4.8E+01	9.3E+02	1.2E+03
Nickel	3.0E+04	4.5E+04	1.6E+06	1.7E+06
Niobium	1.0E+02	0.0E+00	1.2E+04	1.2E+04
Phosphorus	1.1E+05	3.3E+03	6.0E+02	1.1E+05
Potassium	1.1E+04	1.5E+03	8.7E-02	1.3E+04
Rubidium	2.4E-01	0.0E+00	1.4E-01	3.8E-01
Scandium	2.3E+01	5.6E-02	5.6E-01	2.3E+01
Selenium	8.1E+01	4.9E+00	1.8E-01	8.6E+01
Silicon	3.2E+06	9.4E+04	7.7E+03	3.3E+06
Silver	5.1E+00	9.7E-01	1.2E+00	7.3E+00
Sodium	2.1E+05	1.2E+04	9.3E-02	2.2E+05
Strontium	3.2E+03	3.3E+01	1.7E-01	3.2E+03
Sulphur	2.0E+05	3.0E+05	3.1E+00	5.0E+05
Tellurium	2.0E+02	0.0E+00	6.6E-02	2.0E+02
Thallium	2.4E-01	2.8E-01	2.3E-02	5.4E-01
Thorium	5.5E+00	1.8E+00	1.1E-01	7.7E+00
Tin	1.4E+02	1.6E+01	2.4E+03	2.5E+03
Titanium	1.5E+05	3.3E+01	8.8E+01	1.5E+05
Tungsten	1.2E+00	1.0E+01	1.3E+02	1.5E+02
Uranium	3.4E+02	2.4E+01	1.4E+02	4.9E+02
Vanadium	9.0E+01	4.3E+00	9.5E+02	1.0E+03
Zinc	1.5E+05	2.0E+03	1.6E+01	1.5E+05
Zirconium	7.4E+02	1.2E+00	6.0E+05	6.0E+05
Asbestos	3.0E+05	0.0E+00	0.0E+00	3.0E+05
EDTA	0.0E+00	4.8E+04	0.0E+00	4.8E+04
PAH	3.4E+00	0.0E+00	0.0E+00	3.4E+00

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
Cl-Benzenes & Cl-Phenols	2.8E+00	0.0E+00	0.0E+00	2.8E+00
Dioxins & Furans	9.3E-02	0.0E+00	0.0E+00	9.3E-02
PCB	1.3E-01	0.0E+00	0.0E+00	1.3E-01

Notes:
Does not include full amount of common elements, especially carbon, hydrogen, oxygen and nitrogen.
EDTA Ethylenediaminetetraacetic acid
PAH Polycyclic aromatic hydrocarbons
PCB Polychlorinated biphenyls
0.0E+00 indicates value is not significant.

4.5.4 Physical and Chemical Characteristics of the Bulk Material Inventory

The physical composition of most of the waste is normal industrial materials. The bulk material compositions in the LLW, ILW, and Refurbishment L&ILW to be emplaced in the DGR are shown in Tables 4.5.4-1, 4.5.4-2 and 4.5.4-3, respectively. Figure 4.5.4-1 shows the relative distribution of waste by mass.

Over long periods of time, it is expected that the wastes and their containers will degrade. The various metals present will degrade into inorganic salts, oxides or minerals consistent with the local saline, reducing conditions that are present at the DGR Project site (refer to Section 6.2 for a description of the relevant existing conditions). The organic materials will degrade into simpler compounds under microbially-mediated reactions that will be slow under the saline, reducing environment. The degradation products will encompass a wide range of compounds from simple volatile species like methane to recalcitrant bitumen-type compounds. The potential effects of the key chemical elements and species were assessed as part of the Postclosure Safety Assessment [27] and the Preliminary Safety Report [26].

[PAGE LEFT INTENTIONALLY BLANK]

Table 4.5.4-1: Inventory of Bulk Materials in LLW

Waste Type	Ash (kg)	Cellulose (kg)	Rubber (kg)	Plastics (kg)	Resins[a] (kg)	Bitumen (kg)	Other Organic (kg)	Carbon Steel (kg)	Stainless Steel (kg)	Other Metal (kg)	Concrete (kg)	Other Inorganics (kg)
Bottom Ash	1.2E+06	—	—	—	—	—	—	—	—	—	—	—
Baghouse Ash	1.4E+05	—	—	—	—	—	—	—	—	—	—	—
Compact Bales	—	4.9E+05	1.2E+05	6.4E+05	—	—	5.2E+04	2.6E+05	—	—	—	—
Box Compacted	—	4.0E+06	9.9E+05	5.2E+06	—	—	4.2E+05	2.1E+06	—	—	—	—
Non-Processible	—	2.2E+06	2.6E+05	6.4E+05	—	1.9E+05	2.6E+05	1.3E+06	1.4E+06	3.4E+06	7.7E+05	3.6E+06
Non-processible Drummed	—	4.9E+05	9.4E+04	2.4E+05	—	—	3.3E+05	4.7E+05	4.7E+05	—	2.8E+05	1.3E+06
Non-processible Other	—	—	—	—	1.6E+04	—	—	4.8E+03	—	—	—	—
LL /ALW Resin	—	—	—	—	1.5E+06	—	—	—	—	—	—	—
ALW Sludge	—	—	—	—	—	—	—	—	—	—	—	4.0E+06
TOTAL	**1.3E+06**	**7.2E+06**	**1.5E+06**	**6.7E+06**	**1.5E+06**	**1.9E+05**	**1.1E+06**	**4.1E+06**	**1.9E+06**	**3.4E+06**	**1.1E+06**	**8.9E+06**

Notes:
a Resin weight does not include bound water (approximately 40% by weight) or interstitial water.
— Not applicable

[PAGE LEFT INTENTIONALLY BLANK]

Table 4.5.4-2: Inventory of Bulk Materials in ILW

Waste Type	Total Mass (kg)				
	Resins	Carbon Steel	Stainless Steel	Inorganics	Plastic
ILW Resin (PHT, Moderator, Misc., CANDECON)	3.7E+06	—	—	—	—
IX Columns	1.9E+05	4.0E+05	—	—	—
Filters and Filter Elements	—	5.0E+05	9.2E+04	7.4E+04	9.8E+04
Irradiated Core Components	—	1.3E+04	4.8E+02	—	—
TOTAL	**3.9E+06**	**9.1E+05**	**9.2E+04**	**7.4E+04**	**9.8E+04**

Notes:
ILW resin weight does not include bound water (approximately 40% by weight) or interstitial water.
— Not applicable

Table 4.5.4-3: Inventory of Bulk Materials in Refurbishment L&ILW

Waste Type	Total Mass (kg)				
	Zircaloy	Carbon Steel	Stainless Steel	Other Metals	Concrete
Pressure Tubes	4.4E+05	—	—	—	—
Calandria Tubes	1.7E+05	—	—	—	—
Calandria Tube Inserts	—	—	2.1E+04	—	—
End Fittings	—	—	2.3E+06	—	—
Steam Generators	—	8.4E+06	—	2.8E+06	1.9E+06
TOTAL	**6.1E+05**	**8.4E+06**	**2.3E+06**	**2.8E+06**	**1.9E+06**

Note:
— Not applicable

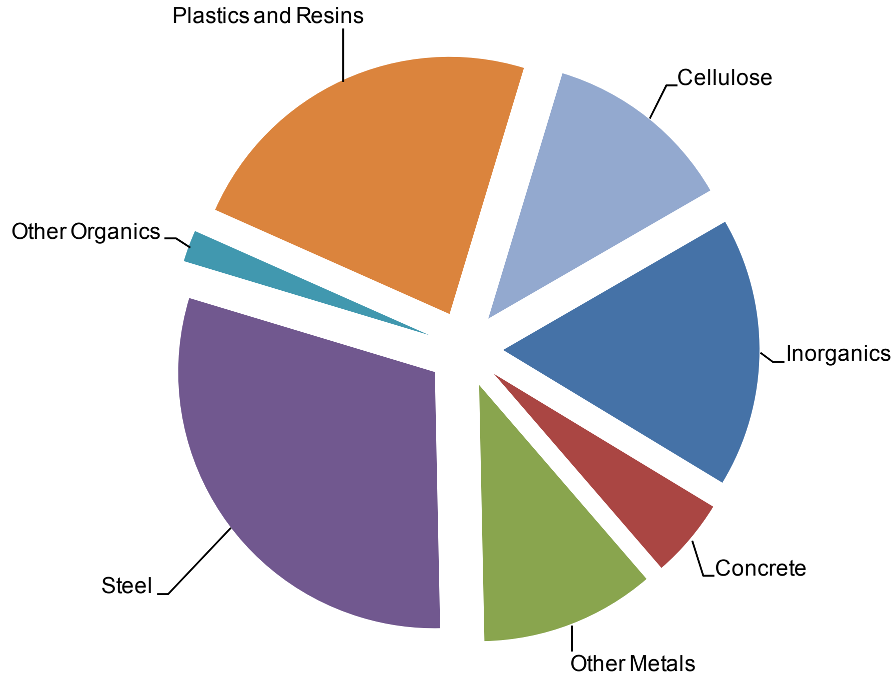


Figure 4.5.4-1: Mass of Main Waste Materials Planned for Emplacement in the DGR

4.6 PROJECT PHASES

For the purpose of this assessment, the DGR Project is divided into four phases, as named in the bulleted list, below. An overall DGR Project timeline is shown on Figure 4.2-1. This approach is consistent with the EIS Guidelines. The DGR Project phases are as follows:

- Site preparation and construction phase, which includes all activities associated with developing the DGR Project up until operations commence with the placement of waste. This phase is expected to last five to seven years. The works and activities in this phase are described in Section 4.7.
- Operations phase, which includes the period during which waste is emplaced in the DGR, as well as a period of monitoring prior to the initiation of decommissioning activities. This phase is expected to last approximately 40 to 45 years, with waste being placed for the first 35 to 40 years and the subsequent monitoring carried out for a period that would be decided at some future time in consultation with the appropriate authority. The works and activities during this phase are described in Section 4.8.
- Decommissioning phase, which includes dismantling surface buildings and sealing the shafts, is expected to begin immediately following operations and to take approximately five to six years to complete. The activities associated with this phase are described in Section 4.11.

- Abandonment and long-term performance phase, which begins once decommissioning is completed. This phase includes institutional controls for a period up to three hundred years, and is described in Section 4.12.

The following sections describe the main works and activities that are expected to occur during the different DGR Project phases. The descriptions of the DGR Project works and activities are focused on identifying and characterizing aspects of the DGR Project that have the potential to interact, and thus result in a likely change to the surrounding environment during site preparation and construction, operations, and decommissioning of the DGR Project. The abandonment and long-term performance phase of the DGR Project is also described at a conceptual level; however, there are no specific works and activities during this phase.

Credible malfunctions, accidents, and malevolent acts postulated for consideration in this assessment are described in Section 4.13.

The information provided in the following sections provides the Basis for the EA, which is presented in Section 4.18. Several DGR Project works and activities identified in the Basis for the EA are not discussed in the following sections since they are not specifically related to design aspects of the DGR Project. For example, the "presence of the DGR facility" work and activity is linked to intangible feelings people may associate with the existence of the DGR Project within their community. Similarly, certain activities addressed under specific DGR Project works and activities in the basis table (Table 4.18-1) are not discussed in the following sections since, again, they are not design features of the DGR Project.

4.7 SITE PREPARATION AND CONSTRUCTION PHASE

All surface facilities and underground facilities will be constructed during the site preparation and construction phase. A high-level schedule for construction is shown on Figure 4.7-1[48,49,50]. For shaft sinking, the two headframes will be constructed, complete with the ventilation shaft hoist house, intake fans, heater house and the exhaust fan building. Temporary hoist houses for the main shaft sinking hoist and sinking winches for both shafts will be constructed. Temporary systems are used for ventilation during shaft sinking. The permanent intake fans, heater house and exhaust fans will be installed after shaft sinking.

An environmental management plan (Section 4.7.8.7) will be implemented for site preparation and construction to control environmental effects associated with above-ground construction activities. The environmental management plan will be similar to that used in other recent construction projects at the WWMF and includes measures such as water spraying to control dust, vehicle maintenance standards to reduce noise and emissions, and scheduling of certain activities during daylight hours.

---

[48] *Additional clarification on site preparation and construction schedule, including completion of engineering details and construction activities, was provided in OPG response to IR-LPSC-01-25 (CEAA Registry Doc# 363).*

[49] *Additional clarification on the proposed sequencing for design development was provided in OPG supplementary response to IR-LPSC-01-25 (CEAA Registry Doc# 606).*

[50] *Additional clarification on construction activities of the underground facility was provided in OPG response to IR-LPSC-01-35 (CEAA Registry Doc# 363).*

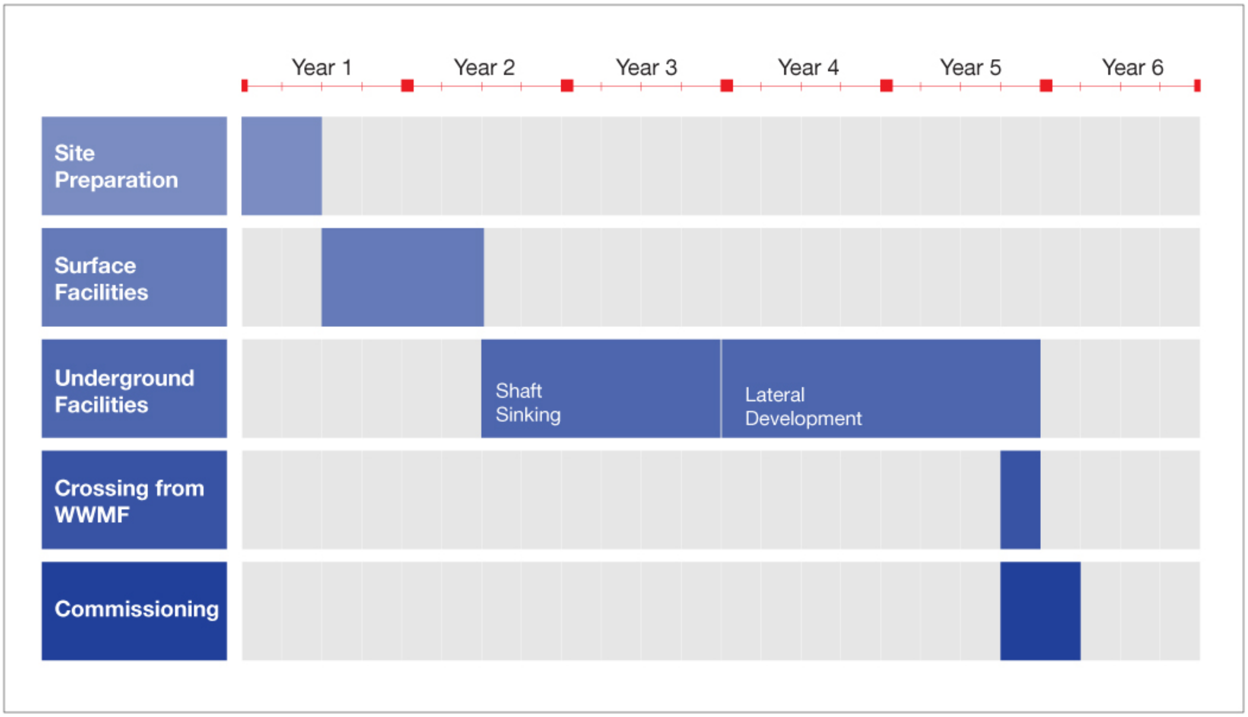


Figure 4.7-1: Conceptual Schedule for Site Preparation and Construction Activities

4.7.1 Site Preparation

Site preparation[51] involves the preparation of the site infrastructure for construction activities. Site preparation will begin following receipt of a licence to prepare the site and construct the DGR, and includes clearing approximately 30 ha of the DGR Project site and preparing the construction laydown areas. The site preparation activities will take approximately six months to complete. Infrastructure, such as waste rock and stormwater management areas and roads, will also be constructed as part of site preparation activities. A workforce of approximately 10 heavy equipment operators is required to complete these activities.

Site preparation activities include earth-moving activities and conventional civil construction activities. Equipment typically used in these activities is shown in Table 4.7.1-1. Note this equipment is not required over the full duration of these activities. A feller buncher and chipper are also used for clearing treed areas of the site.

[51] *Additional information on site preparation activities was provided in OPG's written submission (Sec. 2.1) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

Table 4.7.1-1: Equipment Used in Site Preparation Activities

Typical Equipment	Estimated Quantity
Excavator	1
Front End Loader	1
Bulldozer	1
Articulated Rubber-tired Truck	2
Compactors	1
Grader	1
Feller Buncher	1
Paver	1

Specific activities associated with site preparation include the following:

- removing brush and trees and transferring for storage or use as mulch on OPG-retained lands;
- excavating, removing and stockpiling topsoil for later use elsewhere on the DGR Project site or on other OPG-retained lands on the Bruce nuclear site;
- grading the DGR Project site, including grading of construction access roads, construction laydown areas, the WRMA and various building locations;
- constructing the site drainage system including excavating all ditches and constructing the stormwater management pond; and
- implementing a ground improvement program (grouting), if required, for the main shaft and ventilation shaft in advance of shaft sinking to control potential groundwater inflows[52].

It is not anticipated that blasting is required to complete site preparation activities, and explosives will not be on-site until excavation activities are initiated.

Although line power should be available at the start of the site preparation and construction phase, diesel generators may be used for emergency back-up power. During this time period, fuel will be stored within the construction island (Section 4.7.5.2).

4.7.1.1 Land Clearing, Grubbing and Site Grading

The total land area to be cleared is approximately 30 ha, some of which is treed. Where required, trees will be felled, skidded and piled in the cut area, and if salvageable, chipped and reused for landscaping on the DGR Project site or elsewhere on the Bruce nuclear site. Unsalvageable cuttings may be disposed of by chipping or piling. Roots, stumps, embedded

[52] *Clarifications on ground treatment equipment were provided in OPG responses to IRs EIS-05-201 (CEAA Registry Doc# 776), and EIS-09-467 (CEAA Registry Doc# 949).*

logs and debris will be removed by grubbing and disposed of according to existing management practices. Stripping of the soil is required to remove top soil and organic material, where necessary. The top soil will be protected and kept in segregated piles until it is reused for finished grading. Grading will be completed for stormwater drainage (Sections 4.4.1.5 and 4.7.1.3), waste rock storage (Section 4.4.1.3 and 4.7.5.3), and building locations[53,54].

4.7.1.2 DGR Site Access

All personnel and materials necessary to implement each phase of the DGR Project will arrive through the main gates to the Bruce nuclear site, where access is controlled by Bruce Power security staff. The entire DGR construction island, including the WRMA, will be fenced to isolate the DGR Project from other OPG, Bruce Power, AECL and Hydro One facilities. A separate gated entrance to the DGR Project site will be established directly off the Interconnecting Road and/or a new road along the abandoned rail bed to the east of the DGR Project site. There is no direct connection with the WWMF during site preparation and the majority of construction. The construction entrance(s) will not regularly be used after construction, but will remain available throughout operations.

As part of site preparation, granular construction roads will be installed for access to the main and ventilation shafts, and the construction laydown, waste rock management, and stormwater management pond areas. Additionally, temporary construction roads will be established for accessing trailers and material storage. The construction roads are designed to accommodate heavy construction traffic and maximize construction laydown areas, including the concrete batch plant[55]. The location of the construction entrance(s) and roads are shown on Figure 4.7.1-1.

4.7.1.3 Site Drainage and Stormwater Management

A network of trapezoidal drainage ditches will be constructed around the DGR Project site including the perimeter of the WRMA[56]. These trapezoidal ditches will be vegetated to reduce erosion. Vegetation will be managed to ensure that it does not hinder the flow of stormwater through the drainage ditch network. As noted in Section 4.4.1.5, the entire drainage network established for the DGR Project directs run-off to a stormwater management pond, shown on Figure 4.4.1-2. The specific geometry of the stormwater management pond will be determined during detailed design. Section 4.4.1.5 also provides additional detail on the stormwater management pond.

---

[53] *More detailed information of the existing site conditions of the Bruce nuclear site and proposed DGR grading topography was provided in OPG response to undertaking TIS-12 (CEAA Registry Doc# 715).*

[54] *Additional clarifications on the DGR site leveling and grading plan were provided in response to DGR Hearing – Undertaking No. 35 (CEAA Registry Doc# 1624).*

[55] *Additional information on temporary concrete batch plant and site services shown in Fig. 9-2 of the PSR and Figure 4.7.1-1 of this EIS chapter was provided in OPG response to IR-LPSC-01-26 (CEAA Registry Doc# 363).*

[56] *Additional information on site drainage and stormwater management was provided in OPG response to undertaking TIS-10 (CEAA Registry Doc# 692).*

During site preparation, surface run-off that drains to the ditch along the abandoned rail bed (the North Railway Ditch) under existing conditions will be redirected into the aforementioned drainage ditch network. This design ensures that no run-off from the DGR Project is allowed to discharge into portions of the existing drainage network that interconnect with Stream C. No re-alignment of the existing drainage ditch network servicing the WWMF and the Bruce nuclear site is planned as part of the DGR Project. If necessary, improvements will be made to the existing drainage network downstream of the stormwater management pond discharge location to ensure unobstructed flow of water to Lake Huron (via MacPherson Bay). These improvements could include replacing the existing culverts beneath the Interconnecting Road, and cleaning and/or enlarging the existing ditch between the Interconnecting Road and Lake Huron[53].

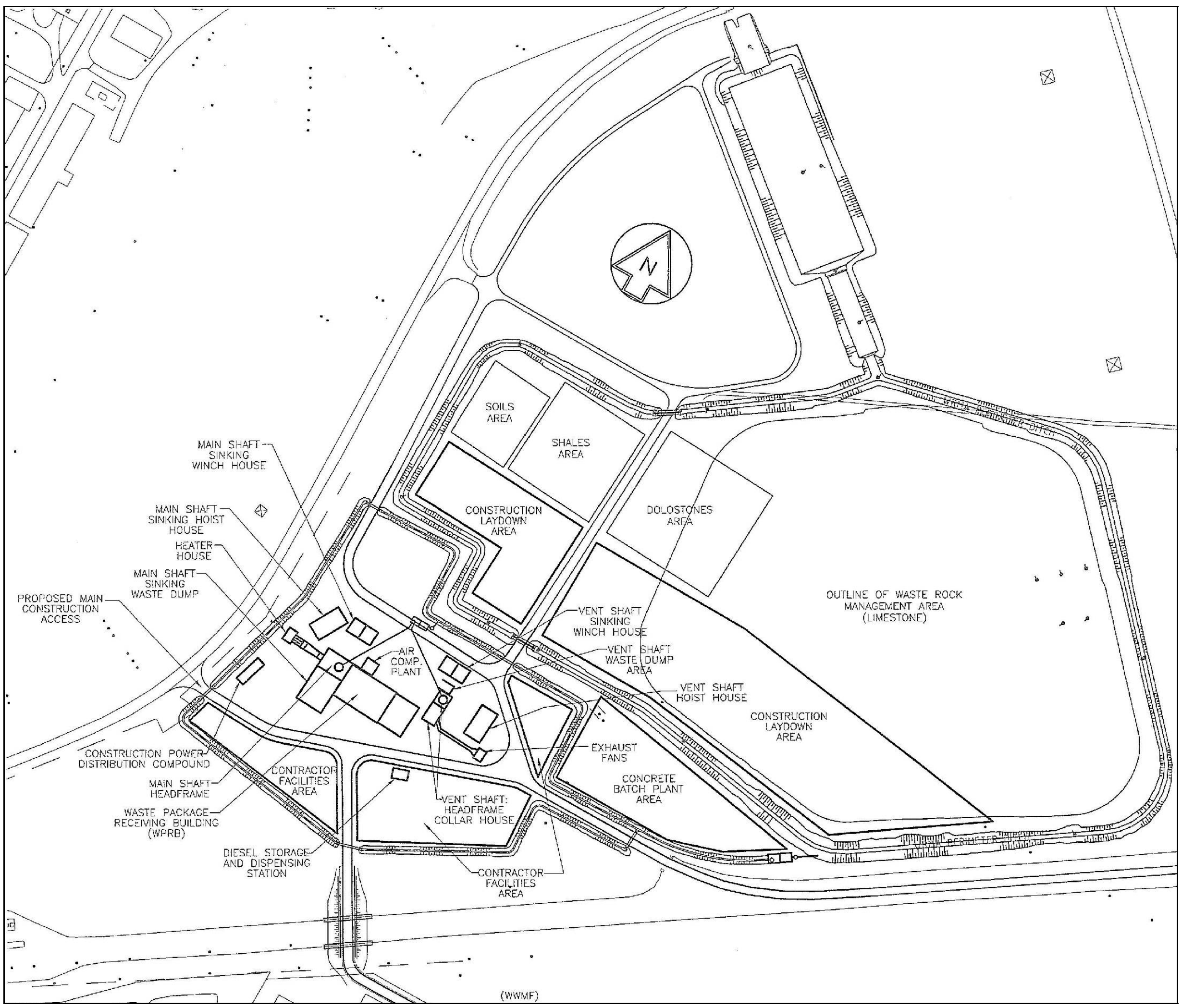


Figure 4.7.1-1: Site Preparation and Construction Phase Layout

4.7.2 Workers, Payroll and Purchasing

4.7.2.1 Construction Labour

Shaft sinking and underground development will be performed on a 24/7 basis over 350 days per year. Table 4.7.2-1 summarizes the expected averaged labour requirements during construction including contractors. Allowance is made for reduced productivity during winter to account for extreme weather conditions that could halt external activities for short durations of time. However, further planning can enable the heavy construction work to be scheduled for summer months with internal works (e.g., headframe furnishings, hoist installation) performed in winter.

The construction is planned over five to seven years and has a variable labour force depending on the number of parallel activities being performed. The averaged labour force over the duration of the phase is in the order of 160, with peak manpower expected to be close to 200 persons.

Table 4.7.2-1: Ranges of Labour Requirements for the Site Preparation and Construction Phase

Category	Number of Workers
DGR Project and Construction Management	30 – 40
Technical Support Staff	10 – 20
Miner	100 – 130
Surface Equipment Operator	10 – 20
Skilled Trade	60 – 80
General Labour	40 – 60

The construction of the DGR facility will be regulated under Ontario's Occupational Health and Safety Act. Given the nature of the DGR Project, it is expected that the Ontario Ministry of Labour will administer their regulatory supervision of the DGR Project primarily under the Mines and Mining Plants Regulation, RRO 1990, O. Reg 854 [29].

4.7.2.2 DGR Project-related Traffic

It is expected that most construction workers will reside in the Local and Regional Study Areas while employed by the DGR Project. Conservatively, it is assumed workers will commute to the DGR site using their own vehicle; however, in reality some people may choose to carpool or possibly bicycle. In addition to DGR Project worker-related traffic, it is assumed that up to 10 trucks per day will be used to ship materials on and off the DGR Project site throughout the site preparation and construction phase.

4.7.2.3 Construction Capital Costs

Capital costs for the DGR Project are incurred while the facility is under construction. These include expenditures on necessary equipment, engineering, and labour. For the purposes of the EA, a capital cost for the site preparation and construction phase of $1,000,000,000 (CAD, 2010$) is used. Of this total cost, about one fifth is attributed to labour expenditures and one tenth is associated with equipment expenditures. The remaining costs represent contract lump sums, consumables, and undefined allowances.

4.7.3 Construction of Surface Facilities[57]

The key surface structures are the Waste Package Receiving Building (WPRB), the headframes and hoisting structures, and the ventilation complexes. Since shaft sinking is planned to occur 24/7, 350 days per year, a temporary heating and fan house is installed to provide controlled air temperatures to the shaft crew.

Surface construction methods will be consistent with those used for typical light industrial buildings. A concrete batch plant will be established to support construction activities. The pre-sink activities (shaft collars) will require dewatering, and the infrastructure for shaft sinking dewatering will be established at that time. All other building foundations will be well above grade in comparison and will not require dewatering.

The proposed layout of the site preparation and construction phase surface facilities is shown on Figure 4.7.1-1. A description of the DGR Project site utilities is provided in Section 4.4.3.

4.7.3.1 Permanent Surface Structures

After completion of shaft sinking, the temporary structures associated with sinking activities (e.g., temporary main shaft sinking hoist house, main shaft and ventilation shaft winch houses) will be removed. The main shaft headframe will be furnished for the permanent operations including installation of the main and auxiliary Koepe hoists. Figure 4.4.1-2 illustrates the main surface infrastructure in place for the operations phase, including the crossing from the WWMF to the DGR Project site. This crossing is briefly introduced in Section 4.4.1.4, and is described in more detail in Section 4.7.3.3, below.

4.7.3.2 Temporary Structures

All temporary structures will be removed from the site following completion of construction activities. In addition to the structures identified in Section 4.7.3.1, the temporary offices, fuel storage, storage structures and concrete batch plant will be removed from the DGR Project site.

[57] *Additional information on final surface facilities was provided in OPG's written submission (Sec. 2.6) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

4.7.3.3 Site Access and Roadways

Roadways will be developed to support construction activities as required. The majority of site preparation and construction phase roads will be granular, and will be maintained with graders and water trucks to manage fugitive dust. Following the majority of underground development and waste rock management, permanent roads on the DGR Project site and the connection to the WWMF will be constructed. The majority of permanent roads in the main facilities area will be paved.

The crossing from the WWMF provides short, direct access between the WWMF and the DGR, and is designed to support the maximum weight of transport packages and vehicles. It is expected the crossing will be a two-lane road situated on a fill embankment, with culverts to accommodate water flow, over the existing ditches and abandoned rail bed. Excavated material from shaft sinking and lateral development will be used as embankment fill material. The assumed general layout of the crossing is shown on Figure 4.7.3-1. The location of the crossing is shown on Figure 4.4.1-2.

A 20 m width embankment will accommodate wide road lanes (4 m minimum), shoulders (1.5 m minimum), walking area (2 m on each side), and adequate space for snow storage (1.5 m minimum) during winter operations, and a concrete barrier (1 m) on both sides of the road.

These works will be undertaken towards the end of the site preparation and construction phase (Figure 4.7-1) so that operations roads are not damaged during construction activities. This scheduling also maintains the isolation of the DGR Project site from operating OPG facilities. The work carried out directly within the two ditches along the abandoned rail bed is expected to be completed in several days, limiting the period of direct disturbance to the aquatic habitat and its associated biota.

4.7.4 Excavation and Construction of Underground Facilities

4.7.4.1 Shaft Excavation

Pre-sink activities for the main and ventilation shafts will commence near the end of the first year of construction. The main shaft and ventilation shaft will be excavated in parallel to depth.

The depth of the overburden layer in the area of the shafts is in the range of 10 to 14 m. Construction of the shaft collars through the overburden will be done using conventional civil construction methods (e.g., excavator, bulldozer and trucks). The overburden will be removed to the bedrock contact and sloped to maintain a safe excavation. The shaft collar will be excavated, formed and poured, and the excavation backfilled with the exception of the plenum location to allow for its construction[58].

---

[58] *Additional information on development of the shaft collar was provided in OPG response to IR-EIS-01-01 (CEAA Registry Doc# 363), and in OPG's written submission (Sec. 2.2) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

The shafts will be excavated using controlled drill and blast techniques[59,60,61]. Blasting activities are designed to address the specific requirements of the Bruce nuclear site regarding noise[62] and vibration impacts. Explosives handling will be done in accordance with the Ministry of Natural Resources and Ontario Mining Regulations and considers handling of explosives on-site, both for surface and underground usage, as well as underground storage. Chapter 6 of the Preliminary Safety Report provides details on the underground powder magazine and detonator magazine, including locations. The expected quantity of explosives stored underground will be in the range of 30 to 40 tonnes. Appendix I (Vibrations) of the Atmospheric Environment TSD provides detail regarding the use of explosives for shaft development. Final support of the shafts is cast-in-place concrete liners for the full depth of the shaft. The liner is designed to control water.

The upper 180 m of dolostones at the two shaft locations is expected to be permeable, which may lead to groundwater inflows that could impede shaft construction. If necessary, ground improvement techniques will be employed in advance of sinking activities (i.e., grouting or freezing) to limit groundwater inflows during shaft construction. As the shaft advances, holes will be drilled ahead of the excavated face, probing for permeable zones with potentially high groundwater inflow rates. Should such zones be encountered, cover grouting can be performed in advance of the shaft bottom in these permeable zones, allowing shaft excavation to continue[63].

---

[59] *Additional information on shaft sinking was provided in OPG's written submission (Sec. 2.3) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[60] *Additional information was provided in OPG response to undertaking TIS-3 regarding the total weight of ammonia nitrate that would be used per sequenced blast (CEAA Registry Doc# 692).*

[61] *Additional clarifications on the drill and blast and ground support techniques during shaft excavation considered by the project were provided in OPG response to IRs LPSC-01-32 (CEAA Registry Doc# 363) and LPSC-03-57 (CEAA Registry Doc# 608), and in OPG's written submission (Sec. 2.3.1, Sec. 2.4.1) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[62] *Additional information was provided in OPG response to IR-EIS-06-258 regarding the noise impacts on sleep and World Health Organization sleep disturbance threshold (CEAA Registry Doc# 823).*

[63] *Additional information on ground improvement approaches for shaft collar and shaft sinking activities was provided in OPG response to IR-LPSC-01-31 (CEAA Registry Doc# 363), and in OPG's written submission (Sec.2.1) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

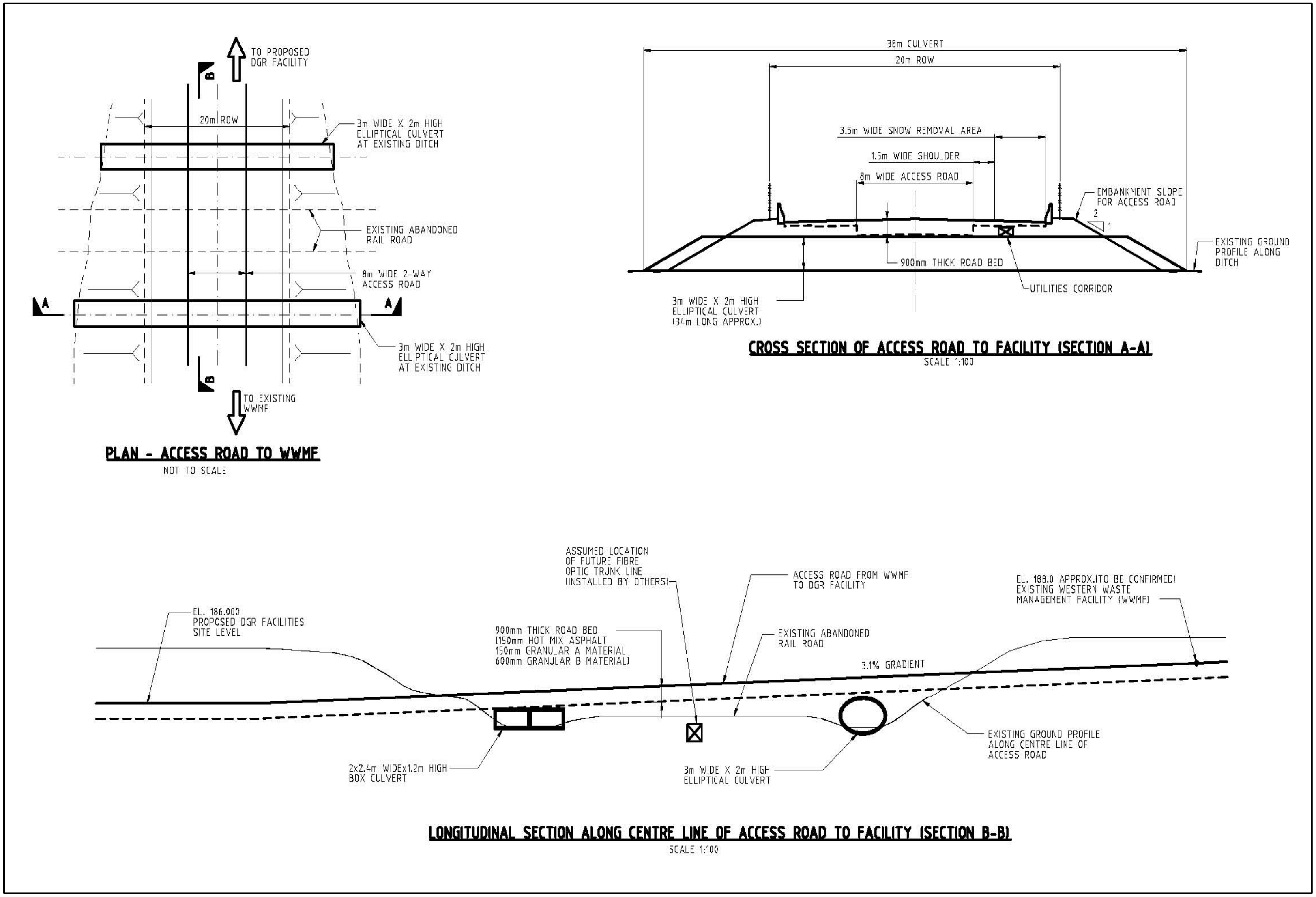


Figure 4.7.3-1: General Layout of Crossing from the WWMF to the DGR

4.7.4.2 Repository Construction

Construction of underground openings at the repository level will commence following completion of the shafts[64]. The underground services area will be developed first. Once the underground services area is developed, all access and exhaust ventilation tunnels are developed providing access to both panel areas and allowing simultaneous development of emplacement rooms in each panel[65].

The repository level will be developed using controlled drill and blast techniques[60]. Load-haul-dump (LHD) front end loaders and rubber-tired trucks will be used to remove the excavated rock. Diesel-electric equipment (e.g., bolter, jumbo, sprayer) will be used for drilling and ground support requirements. Other diesel equipment (e.g., concrete transmixers, explosives carrier/loader) will be used as required and accounted for in the ventilation design. The reference list of equipment assumed to be operating concurrently to size the ventilation system is shown in Table 4.7.4-1.

A concrete floor will be poured to provide a level floor in the access tunnels and emplacement rooms with a flat and stable surface for stacking operations and plumb waste package stacks.

Table 4.7.4-1: Diesel-powered Equipment Required for Underground Construction Activities

Equipment	Number of Units	Power (kW) per Unit
Bolter/Jumbo/Sprayer	1	58
LHD	1	200
Transmixer	2	179
Haul Truck	3	304
Explosives Carrier/Loader	1	179

4.7.4.3 Dewatering[66]

Following the completion of the shafts (shaft dewatering is discussed in Section 4.7.4.1), temporary sumps will be developed and the water collected will be pumped to surface, treated as required and then will enter the water management system as described in Section 4.4.1.5. It is expected that all sumps will receive water during construction activities and that most of the water would be process water used in the construction activities. As construction progresses,

[64] *Additional information on lateral development was provided in OPG's written submission (Sec. 2.4) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[65] *Additional clarification on panel room development procedures was provided in OPG response to IR-EIS-03-53 (CEAA Registry Doc# 608).*

[66] *Additional information on the underground dewatering system and supporting surface features as presented at the JRP TIS #1 (July 18, 2012) was provided in OPG response to IR-LPSC-04-63 (CEAA Registry Doc# 949).*

the facility sumps that will be utilized throughout operations will be excavated. Each emplacement panel will have a sump located off the access tunnel at the start of the panel. These sumps will pump via submersible pumps into the main DGR sump and pumping station located in the ramp close to the ventilation shaft. There will be two shaft sumps located off of the ramp at the base of the shafts. These sumps will also pump into the main dewatering sump.

The main dewatering sump will be equipped with large positive displacement pumps connected to a dewatering line in the ventilation shaft (with a back-up line in the main shaft). All sumps have pump redundancy and are sized to accommodate expected flows. The shaft sumps and main sump are sized considering a hypothetical shaft liner failure and inflow of 15 L/s over the expected construction flow of 5 L/s (i.e., total inflow of 20 L/s) [67]. As noted in Section 4.4.3.2, the pumps will also be connected to the emergency power system load in the event of power failure at the DGR Project site. All pumps will have the ability to operate remotely from the control room or locally at source[68].

4.7.5 Construction Waste Management

All wastes that arise as a result of site preparation and construction, and operations activities will be safely managed so as to protect the environment from avoidable adverse effects[69]. Operations phase waste management is described in Section 4.8.5. Note that construction-related gaseous and liquid releases to the environment are described in Section 4.7.6.

As discussed in Section 4.7.1, site preparation involves clearing and preparing an area of approximately 30 ha. The largest volume of waste from this activity will be brush and trees, which are managed as described in Section 4.7.1.1. During construction, waste management includes managing the waste rock and conventional wastes that are generated as part of the works and activities. No radioactive waste will be generated during the site preparation and construction phase. In the unlikely event any material is found to be contaminated with radioactive material, it will be separated and managed according to existing procedures established for the WWMF operations, which are consistent with applicable regulations.

4.7.5.1 Conventional Waste

Conventional waste generated during the site preparation and construction phase will comprise consumables and sanitary waste, where the former will be sent to a landfill that is licensed to accept these types of waste. Types of consumables include non-reusable/recyclable construction materials, and other regular waste generated at an industrial work site. Construction materials will be re-used or recycled, if possible.

---

[67] *Additional information on preliminary estimates of groundwater inflow rates were provided in OPG responses to undertaking TIS-11 (CEAA Registry Doc# 692) and IRs EIS-04-101 and EIS-04-151 (CEAA Registry Doc# 759), and EIS-08-392 (CEAA Registry Doc# 886).*

[68] *Additional clarification and information on the underground dewatering system for DGR operation were provided in OPG response to IR-LPSC-01-19 (CEAA Registry Doc# 363).*

[69] *Additional clarifications were provided in OPG response to IR-LPSC-01-29 regarding the estimated range of annual output of grey water and the estimated waste rock volume (CEAA Registry Doc# 363).*

Each contractor on-site will be responsible for their own housekeeping and waste handling/disposal. Consumables will be collected in receptacles located throughout the site, both on surface and underground. Once the receptacles are full, the collected waste will be transferred off-site for appropriate management. There is no requirement for an on-site waste collection area or temporary dumping facility. As noted in Section 4.4.3.7, the sanitary wastes will be taken off-site by the construction contractor for treatment. The main contractor selected for the site preparation and construction phase of the DGR Project is required to develop and implement a detailed Environment Management Plan (EMP), which includes conventional waste management. The EMP is further discussed in Section 4.7.8.7.

The amount of conventional waste produced during the construction of the DGR Project is estimated around 25,000 to 35,000 kg per year of domestic waste, and 8,000 to 12,000 kg per year of sanitary waste.

4.7.5.2 Hazardous Materials

A number of materials that are explosive or flammable in nature are required to construct the DGR. This includes diesel fuel and lubricants to operate the mobile equipment and explosives for miscellaneous rock excavation. Underground storage of these materials will be in the respective areas of the underground services area (i.e., explosive and detonator magazines, diesel fuel bay, mechanical shop).

During shaft construction, explosives are required on a daily basis[70]. Explosives will be delivered as required by the explosive supplier to the underground magazine once the underground services area is completed. For underground storage, explosives will be delivered directly to the main shaft headframe and transferred underground to the magazines immediately. Handling explosives on the DGR Project site (both surface and underground) will be in accordance with Part VI of the Mines and Mining Plants Regulations (O. Reg. 854 [29]). Explosives are not be necessary for the operations works and activities, and therefore, will not be present once construction is completed. The underground explosives and detonator magazines will be decommissioned at the end of underground construction activities, and the space will be prepared for general storage during operations.

Diesel fuel will be temporarily stored on surface for the site preparation and construction phase only, with the exception of the emergency power system fuel supply as described in Section 4.4.3.5. The fuel will be stored in a 5,000 L above-ground, double-walled tank equipped with metered dispensing equipment. The underground repository level fuel storage area will continue to be utilized throughout the operations phase, and is described in more detail in Section 4.4.3.5.

Used oils, lubricants, batteries, and other construction-related hazardous wastes will be generated at the DGR Project site. As such, solid waste and liquid waste will be produced and require disposal according to existing regulations. These waste streams have suitable

[70] *Additional information and clarifications regarding storage and transportation of explosives during site preparation and construction were provided in OPG responses to IRs EIS-01-02 (CEAA Registry Doc# 363), EIS-07-280 (CEAA Registry Doc# 843), and EIS-09-403 (CEAA Registry Doc# 957).*

collection and containment vessels available and will be kept separate from the conventional waste. Once collected by a licensed hazardous waste disposal company, these wastes will be transferred off-site for treatment/disposal at a licensed facility. There is not expected to be waste associated with the use of explosives; however, in the event that explosives are damaged these will be collected and transferred to surface where they will be returned to the supplier for off-site disposal. The projected range of output for hazardous materials during site preparation is as follows:

- 35,000 to 45,000 L per year of oils and grease;
- 150 to 200 kg per year of batteries; and
- 1,500 to 2,500 L per year of solvents and paints.

4.7.5.3 Waste Rock Management

The rock materials excavated during the construction of the DGR Project will be stored on-site at the WRMA and re-used in future, as applicable. The estimated quantities of excavated materials are presented in Table 4.7.5-1.

Table 4.7.5-1: Estimated Quantities of Excavated Materials by Material Type

Material Type	Approximate Depth	Volume (m^3)	
		In Situ	Bulked
Overburden	0 – 20 m	1,400	2,000
Dolostone and shale	20 – 410 m	34,300	48,000
Shale	410 – 660 m	21,200	29,700
Limestone	660 – 840 m	594,200	832,000
Total		**651,100**	**911,700**

Overburden, shales and dolostones only require interim storage as they are consumed as part of the construction activities. For EA purposes it is assumed that limestone is stored in the long-term on-site, as shown on Figure 4.4.1-2.

The WRMA is divided into sections for each rock type (i.e., dolostones, shales and limestones) as a result of different requirements and potential re-use opportunities as described in Section 4.4.1.3. The storage area also includes temporary storage of soils adjacent to the main access roadway. A silt fence barrier will be placed around the soil pile to contain any sediment run-off during storm events[71].

Materials excavated from the overburden layer during shaft sinking and creation of drainage ditches will be re-used on-site during construction. Uses of overburden materials include

[71] *Additional information on the use of silt fences and vegetation to manage siltation around the WRMA was provided in OPG response to IR-EIS-05-192 (CEAA Registry Doc# 776).*

capping of the shale storage pile, if stored longer than one year following final placement, and berms. If soils are left in place for a period of greater than one year, they will be vegetated to reduce erosion; however, it is expected that overburden materials will be re-used in less than one year. The limestone pile will not be capped, but it will be covered and vegetated with native plant stock, as appropriate, during decommissioning activities (see Section 4.11.3 for further details)[72].

All rock storage piles are designed with slope ratios of 2.5:1 to ensure stability. The largest stockpile is for the limestone and will have an area of approximately 9 ha. It is estimated this pile will be 15 m high when complete with the top of the pile graded to avoid ponding of water. As previously noted, the rock will be transferred from the ventilation shaft muck bay to the storage area via rock haulage trucks. A bulldozer would move and grade the rock accordingly. Best management practices, including application of water or misting, will be used to reduce fugitive dust creation from the haulage roads and excavated materials.

A setback or buffer of 200 m from Interconnecting Road is included in the design of the long-term rock storage area. Visual screening (i.e., trees) will be planted, but will not provide a complete visual screen of the pile. Section 8.3.3 of the Hydrology and Surface Water Quality TSD and Section 7.3.2 outline the expected constituents of the run-off from the waste rock.

4.7.5.4 Water Management[73]

For the site preparation and construction phase, the maximum underground water inflow rate is estimated to be 5.4 L/s (maximum assumed rate for purposes of preliminary sizing of sumps and pumps)[74,75]. This includes inflitation of groundwater through the shafts, water from development activities (e.g., dust control, drill water) and possible condensation in the ventilation shaft. The dewatering system is described in Section 4.7.4.3.

The sump water pumped to surface will normally discharge into the drainage network that is described in Sections 4.4.1.5 and 4.7.1.3. However, a temporary water treatment plant, provided by the selected contractor, will be located in the vicinity of the shafts to receive water pumped from underground in the event there are abnormally high concentrations of oil, grease and/or grit in the water. This temporary treatment system would also discharge to the aforementioned ditch network.

As noted, the temporary water treatment plant would be used, as required, to remove excess oil, grease and grit before discharge into the drainage network. It, however, will not be used to

---

[72] *Additional clarification was provided in OPG response to IR-EIS-05-191 on the timeframe for temporary stockpile locations for overburden, shales and dolostones (CEAA Registry Doc# 776).*

[73] *Additional information on DGR site water management was provided in OPG's written submission (Sec. 3.0) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[74] *Additional clarification was provided in OPG response to IR-EIS-04-101 on the calculations, assumptions and confidence limits of the estimates for maximum excavation discharge and sump water pumping (CEAA Registry Doc# 759).*

[75] *Additional information on predicted water inflows was provided in OPG responses to IRs EIS-04-151 (CEAA Registry Doc# 759) and EIS-08-392 (CEAA Registry Doc# 886).*

treat water in the stormwater management pond in the unlikely event contaminant concentrations in the water exceed the discharge limits established through the permitting process for the DGR Project. As indicated in Section 4.4.1.5, the gate at the discharge point from the stormwater management pond can be closed, thereby containing the contaminants. Appropriate actions would then be taken to treat the water so that it could be safely discharged from the pond[17].

4.7.6 Site Preparation and Construction Phase Emissions and Effluents

As noted previously, the site preparation and construction phase of the DGR Project will not involve handling, transporting or storing radioactive materials; therefore no radioactive releases are expected. Potential emissions to the environment and possible sources of nuisance effects are identified and assessed for groundwater quality (Section 7.2), soil/sediment quality (Section 7.2), surface water quality (Section 7.3), air quality (Section 7.7) and noise levels (Section 7.8).

4.7.7 Preliminary Commissioning Plan

After the DGR facility is constructed, commissioning work will be carried out to prepare the facility for operations. Commissioning plans for the DGR Project are discussed in Section 4.7.8.8. The activities associated with commissioning are the last carried out during the site preparation and construction phase of the DGR Project. Commissioning tests all components, systems and equipment, and verifies that they are installed and can operate in accordance with their design intent. This includes pre-start and post-start inspections, verification of vendor requirements and safety and monitoring controls. The commissioning team will verify that vendor recommended maintenance procedures are available.

4.7.8 Site Preparation and Construction Phase Program Requirements

A number of plans and procedures have been developed to protect the environment, and health and safety of the public and workers for the site preparation and construction phase of the DGR Project. These will also apply, as appropriate, over the course of the detailed design. Detailed information on these requirements including roles and responsibilities, organization, training, and reporting are provided in the Design and Construction Phase Management System [33]. The following sections provide a summary of this information. Each of the procedures, plans, standards, policies, and manuals noted in the following sections are identified in the Design and Construction Phase Management System [33].

As further explained in Section 4.14, OPG is the owner and licensee of the DGR throughout the entire lifecycle of the DGR Project. OPG, through its organization, performs DGR Project oversight to ensure that the DGR Project goals are achieved. The NWMO has been contracted by OPG to manage regulatory approvals and detailed design of the DGR, as well as the site preparation and construction phase of the DGR Project.

4.7.8.1 Engineering Project Management

The NWMO procedure for Design Management, NWMO-PROC-EN-0001 [34], describes the minimum requirements to ensure the design work for the DGR is defined, controlled and appropriately verified. The procedure requires the preparation of a Design or Engineering Management Plan.

The Engineering Management Plans for the DGR Project will be prepared by the design responsible organizations in accordance with the design management requirements. A Human Factors Engineering Plan, which identifies the scope, activities, deliverables and schedule for the human factors assessment of the design of the DGR, will normally be incorporated into the Engineering Management Plan. A Human Factors Verification and Validation Plan will support the Human Factors Engineering Plan and will identify the activities, deliverables and schedule of various verification and validation activities to be performed during construction and commissioning of the DGR facility. The Human Factors Verification and Validation Plan will normally be incorporated into the Construction Management Plan and the Commissioning Management Plan, which are described in Section 4.7.8.7 and 4.7.8.8, respectively.

4.7.8.2 DGR Project Change Control

Modifications to the DGR Project, including the process that would be followed should the design of the DGR Project be largely altered following receipt of the site preparation and construction licence, are described in Section 4.10.

4.7.8.3 Community Engagement

The DGR Community Engagement Plan, DGR-PLAN-06020-1001 [35], will be prepared to ensure that appropriate communications and engagement with the communities surrounding the DGR Project site are planned. The plan will include preparation of materials as well as a schedule of activities to continue to build community awareness and understanding of the DGR Project, and build and strengthen relationships with key stakeholders and community leaders. Communications and engagement activities following the submission of the EIS are further described in Section 2.10.

4.7.8.4 Document Management Control

The NWMO procedure for records management, NWMO-PROC-AD-0002 [36], and the NWMO standards for controlled documents, NWMO-STD-AD-0001 [37], provide overall direction for the management of documents and records for the regulatory approvals phase and the design and construction of the DGR Project. A DGR Project-specific Document Management Plan, DGR-PLAN-00121-1002 [38], and associated instructions will be prepared for the purpose of day-to-day control of various DGR Project documents. The plan will also include requirements for technical drawings numbering and equipment labeling systems.

4.7.8.5 Procurement and Contracts

A Procurement and Contracts Management Plan, DGR-PLAN-00800-1001, will be prepared for the DGR Project. The plan will be compliant with the requirements of the NWMO Procurement Procedure, NWMO-PROC-FN-0006 [39], and will be available prior to the start of procurement of materials and equipment for the DGR Project.

4.7.8.6 Training and Competency

A Training Management Plan, DGR-PLAN-08920-1001, will be prepared for the DGR Project. The plan will be consistent with the requirements of NWMO human resources policies and with the principles of a systematic approach to training. The plan will include requirements for evaluation of training programs to ensure that training is effective and the overall plan remains effective.

4.7.8.7 Construction[76]

Construction Management Plan

The Construction Management Plan, DGR-PLAN-00180-1001, will define the responsibilities of the Construction Manager and construction management staff as well as the strategies and policies to manage the construction of the facilities at the DGR Project site. It will be supported by project-specific procedures and standards, such as the Health and Safety Management Plan, DGR-PLAN-08962-1001, which also directs performance of the construction management activities. The Construction Management Plan describes the construction project and the facilities to be constructed as well as the processes that will be used to execute and complete the work and accomplish the construction objectives and requirements including schedule. The construction management plan also includes the contingency plan and procedures to ensure a managed safe response to unplanned events such as flooding that could occur during construction. The contingency plan will be revised and tested as the construction proceeds from surface construction to shaft sinking to underground lateral development.

Health and Safety Management Plan

The Health and Safety Management Plan, DGR-PLAN-08962-1001, will be aligned with NWMO Health and Safety Policy, NWMO-POL-WM-0002 [40], and will be based on an assessment of health and safety risks. The Health and Safety Management Plan describes how all construction and commissioning activities will be conducted in a manner that ensures employee and contractor health and safety. The site emergency response plan will be included in the plan and it will be updated as the works and activities progress[77,78].

---

[76] *Clarifications on the management systems for DGR construction were provided in OPG response to IR-LPSC-04-66 (CEAA Registry Doc# 989).*

[77] *Clarification on the Fire Protection Program for site preparation and construction was provided in OPG response to IR-LPSC-01-36 (CEAA Registry Doc# 363).*

Environment Management Plan

The Environment Management Plan, DGR-PLAN-07002-1001, will be aligned with the NWMO Environment Policy, NWMO-POL-ES-0001 [41]. The plan describes how all construction and commissioning activities will be conducted in a manner that ensures that pollution is minimized and the environment is protected from adverse effects. The site spills and release response plan will be included in the Environment Management Plan. Section 4.15 provides additional information on environmental protection policies and procedures, including monitoring, that will apply to the DGR Project.

Design and Construction Project Quality Plan

The L&ILW DGR Design and Construction Project Quality Plan, DGR-PLAN-00120-0006 [42], describes the quality objectives for the DGR Project, the roles and responsibilities of DGR Project personnel and the minimum requirements necessary to ensure the DGR Project quality objectives are achieved. The document also describes the minimum requirements for construction contractor quality assurance plans as well as the minimum requirements for monitoring and audit of quality assurance and quality control activities.

Construction Quality Assurance Plan

The Construction Quality Assurance Plan, DGR-PLAN-01916-1001, defines the sequence, schedule and various systematic actions that will be taken in the field by NWMO staff and contractors to provide assurance that the DGR facility is being constructed to meet the design specifications. In particular, the plan defines the requirements for performance of field tests and inspections to confirm the DGR facility is being built in accordance with the approved engineering drawings and specifications. A key aspect of the construction quality assurance program during the site preparation and construction phase will be field test quality control. The plan will describe the use of a Field Quality Inspection Manual (DGR-MAN-01916-1002), which will provide detailed requirements for various in-the-field quality control activities.

4.7.8.8 Commissioning

Commissioning is the process of verifiying that all the subsystems achieve the project requirements as intended by the DGR owner (OPG), and as designed by the DGR engineers. The Commissioning Management Plan, DGR-PLAN-00920-1001, defines the commissioning process with detailed activities and schedule for the commissioning of the DGR. The Commissioning Change Control Procedure, DGR-PROC-00920-1001, is described in Section 4.10.

---

[78] *Clarification on the conventional safety requirements during site preparation and construction was provided in OPG response to IR-LPSC-01-37 (CEAA Registry Doc# 363).*

4.8 OPERATIONS PHASE

Emplacement operations are assumed to commence when construction is complete. A volume of approximately 200,000 m³ of waste (emplaced volume) will be stored in the DGR emplacement rooms. The majority (approximately 60%) of the total waste volume will be in storage at the WWMF before the assumed commencement of emplacement operations in 2018.

Once the packages in storage at the WWMF are cleared and transferred into their final disposal location in the repository, the DGR will only receive waste packages with new waste generated at the nuclear power stations. It should be noted that all waste materials will continue to be shipped to the WWMF for waste processing, sorting and packaging. Delivery of waste packages will be planned with the DGR Project controller to ensure that underground emplacement allocations are made available to suit the planned delivery schedule from the WWMF. Materials placed in the DGR are considered waste and the need for retrieval is not anticipated; however, retrieval can be achieved.

4.8.1 Workers, Payroll, and Purchasing

A workforce of approximately 40 people is required throughout the operations phase of the DGR Project. The operations phase workers required by skill and/or occupation are summarized in Table 4.8.1-1.

Table 4.8.1-1: Estimated Labour Requirement for Operations Phase

Operations Stage	Number of Workers
Management and Support	5
Hoisting and shafts	4
Mechanical/Technician	9
Waste Handling (forklift)	8
Technical Support	6
Planning	3
Operator	5

The facility will operate five days per week with a single 8-hour shift for emplacement activities. Limited maintenance and inspection will occur in off-shift hours. Similar to construction, it is assumed that each staff member will commute to work in their own vehicle.

4.8.1.1 Project Security

The surface structures of the DGR Project, including the main and ventilation shaft complex, and the site infrastructure, will be encompassed by a fence. Access to the DGR facility will be exclusively from within the Bruce nuclear site. Access to the Bruce nuclear site itself is strictly controlled by Bruce Power Security personnel. OPG contracts Bruce Power to provide security for its facilities on the Bruce nuclear site. A fence surrounds the perimeter of the Bruce nuclear site. The WWMF is surrounded by a separate fence. Access to the existing L&ILW facilities is restricted to qualified personnel and those escorted by qualified personnel. Visitors register with security, including providing photo identification, and their vehicles are subject to search prior to entering the Bruce nuclear site. Visitors who access zoned areas are escorted and must provide photo identification and pass monitoring ports before entering.

4.8.2 Above-ground Transfer of Waste and Receipt of Waste

4.8.2.1 Description of Waste Packages

Waste packages retrieved from the WWMF will be transferred in a DGR-ready state. The packages will be inspected to ensure that damage has not occurred in transfer and to confirm that WAC criteria are met (Table 4.5.1-3 outlines the WAC)[79]. Some packages will require overpacking and some will require special treatment. Both will occur before transferring to the DGR, as detailed in Table 4.8.2-1. Section 4.5 provides information on the design of the waste packages.

The DGR Project WAC (Table 4.5.1-3) require that each package meets the following two specific dose rate limits:

- 2 mSv/h on contact with external surface of waste package or shielding; and
- 0.1 mSv/h at 1 m from transportation package.

All waste packages are designed to meet the WAC limits, although some packages with high dose rates may require spot shielding or temporary shields to achieve this as part of a specific ALARA (As Low As Reasonably Achievable) plan to protect workers.

The maximum allowable mass for any waste package is 35 tonnes. However, an additional 9 tonnes is allocated for the rail cart, as well as any rigging and attachments in the design of the main shaft hoisting system. This gives a maximum cage payload of 44 tonnes.

[79] *Additional details on inspection and testing of waste containers were provided in OPG response to IR-EIS-11-508 (CEAA Registry Doc# 1157).*

Table 4.8.2-1: Summary of Waste Package Handling, Shielding and Repackaging

Waste Package Type	Waste Package Description
Low Level Waste	
LLW Bin-type Package	Most LLW bins will be transferred "as is" from WWMF storage. Shielded overpack containers will be used if the dose rates of packages exceed dose limits set out for the DGR WAC.
Shield Plug Containers	These containers will be retrieved last from WWMF trench storage, allowing reduction in dose rates and safe transfer into the DGR without excessive amounts of additional shielding. Additional shielding, if required, would be placed upon removal from storage at the WWMF.
Encapsulated Tile Hole	Encapsulated Tile Hole package comprises an outer cylindrical steel pipe (9.5 mm thick walls) that encapsulates the waste-filled tile hole that was once in the ground. The contents of the tile hole are stabilized with grout and the annular space between the steel pipe and the tile hole is also filled with grout. Concrete is used to seal the base of the steel pipe.
Heat Exchangers	Protuberances (e.g., nozzles, supports) from the heat exchangers will be cut off. Openings will be welded closed with a seal plate. Internal components will not be grouted prior to transfer into the DGR.
Steam Generators	Each steam generator will be filled with light-mass grout to stabilize the internal parts, then cut into sections using a diamond wire saw. Each segment will be sealed with a plate welded to each cut end. These plates will serve a dual purpose of increasing the shielding of the grouted segment and providing a flat surface to aid stacking in the emplacement rooms. Forklift pockets will be welded onto one seal plate on each segment to facilitate safe lifting and transfer.
Intermediate Level Waste	
Tile Hole Liner	The tile hole liners are a steel tube, which is filled with stabilizing and shielding grout. Overpacking is not required because of protection from shielding grout.
Resin Liners	Resin liners are stored in quadricells and In-Ground Containers (ICs) under existing conditions. The quadricells are assumed to be disposal-ready. The dose rates emitted by the resin liners vary. Various configurations of packaging will be employed to account for underground packing efficiencies while ensuring the waste package radiation emissions do not exceed the WAC dose rate limits.
T-H-E Wastes	Wastes from T-H-E liners will be retrieved into newly designed steel containers of similar dimensions to the resin liners. Shielding similar to that envisioned for resin liners will be employed as required to meet the WAC radiation dose rate limts.
ILW Shield	After 2018, the current method for storing all tile hole wastes in IC-18 T-H-E liners is assumed to be discontinued. These wastes will be disposed of in new, yet to be designed, shield containers.

Waste Package Type	Waste Package Description
Retube Waste Container	Specialized retube waste containers will be used for pressure tubes, calandria tubes, calandria tube inserts and uncut end-fittings. The containers will be of stackable steel-concrete-steel construction with a maximum loaded mass of 35 tonnes.

Waste conditioning methods employed at repositories in countries other than Canada are described in Section 3.4.10. For the purposes of the DGR Project, conditioning consists mainly of enclosing the waste in containers and overpacks, plus some additional methods described in Table 4.8.2-1, above, for specific waste package types.

4.8.2.2 DGR Waste Handling Equipment and Procedures

All packages being transferred to the DGR WPRB from the WWMF will be shipped in a DGR-ready state on flat-bed transporters, covered transporters, or forklifts[80]. The WPRB is described in Section 4.4.1.1. The packages will be transported across the abandoned rail bed crossing shown on Figure 4.4.1-2. At the WPRB, packages will be off-loaded by forklift or overhead crane and placed into the staging area, or loaded directly onto an empty rail cart prior to transfer into the shaft cage. A controller based at the main shaft control room will co-ordinate the process and ensure that all packages received are in accordance with planning manifests. Waste packages will be tracked regarding their location within the DGR.

All packages are loaded onto the rail carts in the WPRB (Table 4.8.2-2). The self-propelled and electric-tethered rail carts can only proceed towards the main shaft once the rail stop is removed. Once the main cage is in position at the station and chaired (chairing restricts vertical movement of the cage from loading and unloading), the rail stop is removed and the tether is connected to the rail cart. The cart traverses into the cage and the tether is disconnected, automatically locking the rail cart brakes. The rail cart is locked into position, the cage door is closed and the chairing mechanism is released.

DESCRIPTION UPDATE

Updated information regarding the use of electrical power reels to power the rail carts was provided in OPG letter dated Feb.10, 2012 (Item #3, CEAA Registry Doc# 336).

Electrical power reels will not be used to provide motive power to the rail carts on which waste packages are moved in the Waste Package Receiving Building, on/off the cage and underground. The festoon system is mechanically complicated. Rail carts will be powered from on-board batteries, with batteries recharged when rail carts are at surface in the well-ventilated Waste Package Receiving Building.

---

[80] *Additional information on handling of waste packages was provided in OPG response to IR-EIS-10-496 (CEAA Registry Doc# 990).*

Table 4.8.2-2: Summary of Equipment and Above-ground Handling Procedures

Waste Package Type	Package Handling Equipment	Above-ground Transfer Procedures
LLW bin-type waste packages	Rail Cart and Light Duty Forklift	Standard packages transported from the WWMF, off-loaded and stacked in a staging area by a light duty forklift. A forklift transfers the packages to awaiting rail carts for loading into the main shaft cage.
Heat exchangers and shield plug containers	Rail Cart and Crane	The containers are lifted on to a flat bed truck, and off-loaded by an overhead crane at the WPRB. An overhead crane places onto a railcar for transfer underground.
Unshielded resin liners, tile hole liners, ILW Shields	Rail Cart and Light Duty Forklift	Packages are off-loaded at the WPRB by light duty forklift and are placed in the staging area or directly onto an empty rail cart for transfer underground.
Encapsulated Tile Holes, resin liners in concrete shields, ATHEL waste packages in concrete shields, retube waste containers, steam generator segments	Rail Cart, Overhead Crane, and Heavy Duty Forklift	Heavy waste packages capable of being lifted by a forklift will be off-loaded at the WPRB using the heavy duty forklift or possibly overhead crane, and then placed on a rail cart for transfer underground.

4.8.3 Underground Transfer of Waste

The main shaft is used to transfer waste packages to the underground repository. Table 4.8.3-1 summarizes the equipment and handling procedures for the underground transfer of waste. The rail carts are moved from inside of the cage to the underground staging area. Depending on the mass of the waste package, either a light-duty or heavy-duty forklift pick up the waste packages and deliver them to an emplacement room. In the case of the large and heavy waste packages that cannot be transferred by forklift, the rail cart is used to deliver the waste package to an emplacement room equipped with rail. Once at the emplacement room, a gantry crane is used to move the waste package into its final location in the room[81].

[81] *Additional information on handling of waste packages was provided in OPG response to IR-EIS-10-496 (CEAA Registry Doc# 990).*

Table 4.8.3-1: Summary of Equipment and Below-ground Handling Procedures

Waste Package Type	Package Handling Equipment	Below-ground Transfer Procedures
LLW bin-type waste packages	Rail Cart and Light Duty Forklift	Bins are off-loaded from the rail cart in the underground staging area. Underground forklift places waste packages in final position within emplacement room.
Heat exchangers and shield plug containers	Rail Cart and Crane	Rail carts are off-loaded from the cage and traverse by rail to one of the rail-access emplacement rooms. Waste packages are lifted off the rail cart and stacked on the floor by gantry crane.
Unshielded resin liners, tile hole liners, ILW Shields	Rail Cart and Light Duty Forklift	Waste packages are off-loaded from the rail cart in the underground staging area. Underground forklift places waste packages in final position within emplacement room.
Encapsulated Tile Holes, resin liners in concrete shields, ATHEL waste packages in concrete shields retube waste containers, steam generator segments	Rail Cart and Heavy Duty Forklift	Waste packages are off-loaded from the rail carts in underground staging area by heavy-duty forklift. Heavy duty forklift will place package in final position in an emplacement room.

Typical emplacement room configurations for LLW and ILW are provided on Figures 4.8.3-1 and 4.8.3-2, respectively.

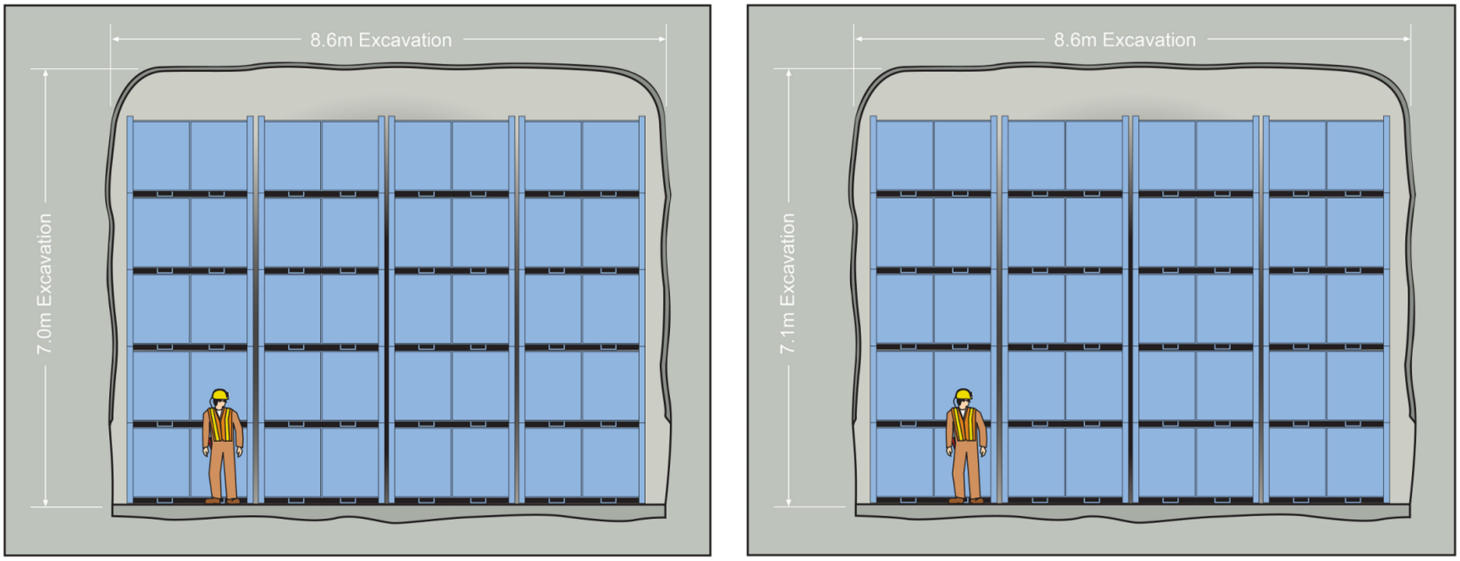
DESCRIPTION UPDATE

Updated dimensions of the emplacement rooms were provided in OPG letter dated Feb.10, 2012 (Item #2, CEAA Registry Doc# 336).

[...] room dimensions have been updated as follows:

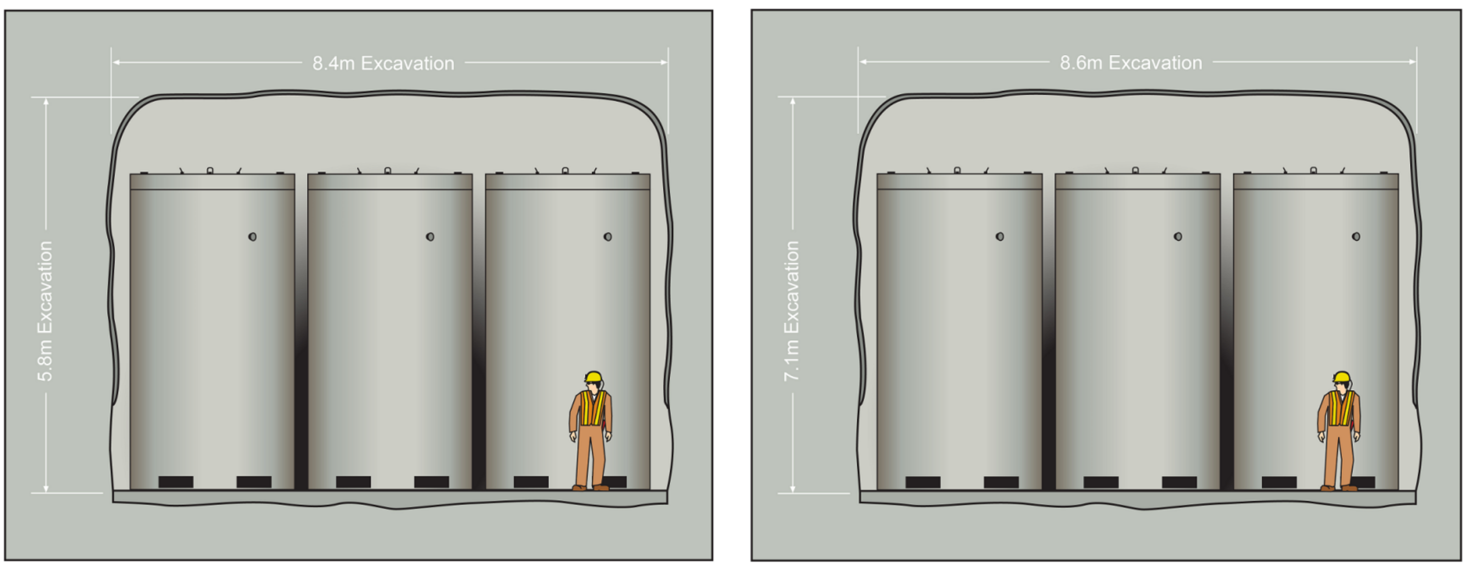
	Figure (PSR)	*PSR Dimensions (m)*	*Updated Dimensions (m)*
Emplacement Room Section View – Bin Type Waste Packages	*6-17*	*8.6W x 7.0H*	*8.6W x 7.1H*
Emplacement Room Section View – Resin Liner Type Waste Packages	*6-18*	*8.4W x 5.8H*	*8.6W x 7.1H*

These dimensions have been updated to provide greater room-size standardization and tunnel-size optimization with respect to traffic flow. [...]



(a) ***(b)***

Figure 4.8.3-1: Typical Emplacement Room Configuration for LLW



a) ***(b)***

Figure 4.8.3-2: Typical Emplacement Room Configuration for ILW

Note: For both figures above, (a) – as shown in March 2011 submission, (b) – updated dimensions as per OPG Letter Dated Feb. 10, 2012 [CEAA Registry Doc# 336])

4.8.3.1 End Walls and Room Closure[82]

Once an emplacement room is filled with waste, an end wall is installed to restrict access, and if required, reduce radiation fields in the adjacent access tunnel. The top of the wall is open to allow air to enter the room to maintain the continuous ventilation requirements.

After a group of rooms has been filled with waste packages, closure walls are constructed in the access and exhaust ventilation tunnels to fully isolate this group of rooms. The underground space behind the closure wall is not ventilated and all services are terminated. These closure walls are designed to limit the release of tritiated air, natural and waste-generated methane, and other off-gases from the waste packages (e.g., H_2 and CO_2). They also limit the release of potentially contaminated water. In the very unlikely event that explosive gases build up behind the closure walls and an explosion occurs, the air blast from the explosion would be contained by the closure walls.

The closure walls would consist of mass concrete within the access tunnel. Grout holes would be drilled through the concrete into the surrounding host rock for provision of high pressure consolidation/contact grouting. This closure wall would resist pressure through friction between the concrete plug and the rough surface of the access tunnel along the entire length of the seal.

4.8.4 Materials Handling System

Aside from the waste packages, the main materials that will be handled are oils, lubricants, and fuels. The handling and storage of these materials are described in the following section. Table 4.8.4-1 summarizes the substances present in larger quantities that will be used during DGR operations, and focuses on those that could have an effect on the environment. As discussed in Section 4.4.3.5, fuel for the operations phase of the DGR Project will be provided from the existing WWMF fuel station.

Table 4.8.4-1: Chemicals, Lubricants, and Oils Used at the DGR

Substance	State	Annual Consumption	Usage
Fuel (diesel)	Liquid	40,000 – 50,000 L/a	Vehicles, emergency generator
Lubrication oils	Liquid	750 – 1,000 L/a	Pumps, motors, hydraulics
Miscellaneous solvents and paints	Liquid	100 – 200 L/a	General maintenance
Batteries	Solid	90 – 135 kg/a	Equipment operation

[82] *Additional information on closure walls, concrete monolith, and shaft seals was provided in OPG's written submission (Sec. 6.0) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

Conventional industrial and office supplies will be shipped to the DGR by truck, and will generally be stored at the location they are used. Some items, such as small mechanical parts, may be kept in a centralized storage area until needed.

4.8.5 Operations Waste Management

This section identifies the types of wastes that can be expected to be generated during the operations phase of the DGR Project. It considers conventional, hazardous, and radioactive materials, and outlines the processes for collecting, handling, transporting, storing, and disposing of such materials. Note that operations-related releases (i.e., emissions and effluents) to the environment are discussed in Section 4.8.6.

4.8.5.1 Conventional Waste

The conventional waste produced by the DGR Project operations activities will include regular waste generated at an industrial site. Dry solid waste will be collected at regular intervals both at surface and the repository level. Any waste that comes into contact with radioactive material will be treated separately. Recyclable materials will be sent off-site to an appropriate facility. Hazardous materials will be dealt with separately, as described in the next section. The remaining conventional solids will be transported to a landfill for disposal. OPG operates a landfill at the Bruce nuclear site, and there are several other landfill options in the study areas (refer to the Socio-economic Environment TSD and Section 6.10).

Personnel working underground will be provided with potable water in either bottles or jugs for both drinking and hand washing. The underground hand washing stations use stands integrated with a small reservoir, pump, and water heater similar to those used at mines. The water from the hand washing stations will be collected in totes and brought to surface to be discharged into the surface sanitary system. Toilets will be provided at the two sanitary areas located at the repository level. These toilets are typical of underground mining operations, and use compressed air to function as simple, small-scale sewage treatment plants. The self-contained toilets function for approximately 18 months before a fluid clean-out is required. Using forklifts, the toilet units will be taken to surface for clean-out and replacement, and then returned underground for continued use. The cleaned-out material will be taken off-site for disposal.

The projected range of annual output of conventional waste is 3,000 to 5,000 kg of domestic waste and 1,000 to 1,500 kg of sanitary waste.

4.8.5.2 Hazardous Materials

Hazardous waste consists of chemicals and materials generated during the operations phase that are not radioactive, but cannot be discharged to the environment. This type of waste generally occurs in liquid form, and will be collected in containers (e.g., drums) that are suitable for segregating and storing it until it can be sent off-site for management at an appropriately licensed facility.

During operations, the underground fuelling area is the same as that utilized during the site preparation and construction phase and includes a diesel storage area and a refuelling/lubrication bay. The fuel storage arrangement is described in Section 4.4.3.5. As noted in the description of hazardous materials management during the site preparation and construction phase of the DGR Project (Section 4.7.5.2), no surface storage of fuel will be required other than the emergency generator tank, which is also described in Section 4.4.3.5.

To minimize potential contamination, the maintenance shop and the diesel fuel bay will each be equipped with an isolated containment sump. These sumps are suitable for containing any accidental fluid spills including fuel, oil, or engine coolant. Captured fluids would be pumped into a tote at the repository level, and then taken to the surface via the main shaft cage for appropriate treatment and/or disposal at a licensed facility.

Hazardous waste such as expired chemicals, cleaners, paints, aerosol cans, batteries, and electronic components will be managed in compliance with all federal and provincial requirements. It is estimated that approximately 400 to 600 L of used oils and greases will be generated on an annual basis over the course of the operations phase of the DGR Project. Approximately 25 to 50 L of waste solvents and paints are estimated to be generated annually. Between 90 and 135 kg of used batteries are estimated to be generated annually.

4.8.5.3 Radioactive Waste

Approximately 50 m^3 of LLW will generated each year over the course of the operations phase. This includes mostly maintenance waste consisting of rags, paper, protective clothing, and possibly some contaminated metal parts. This waste will be collected and returned to the WWMF for processing and packaging as part of the normal waste stream.

4.8.5.4 Water Management[83,84]

A series of sumps equipped with submersible pumps directs all water received at the repository level to the main dewatering sump and pump station during the operations phase of the DGR Project. Water inflow volumes are expected to be small, and a rate of 2 L/s has been assumed. However, it is important to note that during operations, it is anticipated that sumps installed in the panels will be dry since the rock is tight and no groundwater inflow is expected. Small amounts of groundwater inflow at the shafts and down into the shaft sumps may occur.

The dewatering sump is located at the repository level near the ventilation shaft, where water will be pumped to the surface via a positive displacement pump through the ventilation shaft discharge column. A back-up discharge column is provided in the main shaft. At surface, the pumped water will be discharged to the DGR Project stormwater management ditch network. The stormwater management system in place throughout the operations phase is the same as

---

[83] *Further clarification was provided in OPG response to IR-EIS-03-56 regarding the effect of stormwater management pond on groundwater quality, provision for prolonged retention and deployment of water treatment (CEAA Registry Doc# 608).*

[84] *Additional clarification on the provision for deployment of water treatment was provided in OPG response to IR-EIS-09-472 (CEAA Registry Doc# 949).*

that described for the site preparation and construction phase of the DGR Project. Refer to Section 4.7.5.4 for additional detail.

4.8.6 Operations Phase Emissions and Effluents

DGR Project emissions and effluents are identified and assessed in Section 7. These include assessment of liquid effluents (groundwater quality, Section 7.2; surface water quality, Section 7.3), radioactive releases (radiation and radioactivity, Section 7.6), gaseous emissions (air quality, Section 7.7) and noise emissions (noise levels, Section 7.8).

4.8.7 Operations Phase Program Requirements

For the DGR, operational programs and procedures will be developed to protect the environment, and health and safety of the public and the workers. These programs will be developed prior to the start of DGR operations to assure compliance with applicable provincial and federal legislation, and applicable regulations. Details of the programs including roles and responsibilities, training, reporting and records are described in Chapter 10 of the Preliminary Safety Report [26]. The following sections summarize this information. Each of the programs, procedures, policies and records acknowledged in the following sections is identified in Chapter 10 of the Preliminary Safety Report [26].

4.8.7.1 Radiation Protection Program

A radiation protection program for the DGR will be based on OPG's existing Radiation Protection Program N-PROG-RA-0013 [43] as required by Section 4 of the Radiation Protection Regulations (SOR/2000-203) [44]. The program will be used to manage radiological risks that could contribute to public and occupational radiation doses when the DGR becomes operational.

This program complies with the CNSC requirement that all licensees implement a radiation protection program, and establishes a quality program.

This program is designed to comply with the radiation protection program requirements of the following acts and regulations as applied to licensed OPG facilities and licensed OPG activities:

- Nuclear Safety and Control Act (NSCA, 1997, c.9);
- General Nuclear Safety and Control Regulations (SOR/2000-202) [45];
- Radiation Protection Regulations (SOR/2000-203) [44];
- Class I Nuclear Facilities Regulations (SOR/2000-204) [46]; and
- Nuclear Substances and Radiation Devices Regulations (SOR/2000-207) [32].

Further discussion of the proposed DGR radiation protection program is provided in Sections 4.15 and 4.16.

4.8.7.2 Keeping Doses As Low As Reasonably Achievable (ALARA)[85]

Exposure to radiation is managed through the following processes:

- limiting individual worker dose;
- establishing facility design optimized on the basis of ALARA considerations;
- assessing hazards for planning and to maintain knowledge of conditions; and
- planning and performing radioactive work to keep exposures ALARA and avoid unplanned exposures.

A key practice in maintaining control of radiation exposure and contamination is through the use of zoning as per OPG's procedure on Radiological Zoning, Personnel/Material Monitoring and Transfer Permits N-PROC-RA-0014 [47]. Further discussion on the control of radiation exposure and contamination is provided in Section 4.15.1.

4.8.7.3 Conventional Occupational Health and Safety Program

The operation of the DGR facility will be regulated under the OHSA. Worker health and safety aspects included under the Mines and Mining Plants Regulations (O. Reg. 854 [29]) will also be applicable.

An overall Occupational Health and Safety Program will be implemented for the DGR that will meet the requirements of OPG's Environmental, Health and Safety Management Program W-PROG-ES-0001 [48] applicable to its nuclear facilities. The program will also be consistent with the OPG Health and Safety Policy OPG-POL-0001 [49] and the OPG Nuclear Safety Policy N-POL-0001 [50]. Additionally, the program is consistent with OPG management systems, and British Standards Institution's Occupational Health and Safety Assessment Series (OHSAS) 18001, Management System Specification. The OPG management systems and OHSAS 18001 are based on a Plan→Do→Check→Review cycle.

The goal of OPG's Conventional Safety Program is to ensure workers work safely in a healthy and injury-free workplace by managing and mitigating risks associated with activities, products and services of OPG operations. Risk reduction is primarily achieved through compliance, by competent workers, to effective operational controls, developed through effective risk assessment and safe work planning. The Program is compliant with applicable legislative, corporate and nuclear business requirements.

4.8.7.4 Hazardous Materials Program

The DGR facility will contain a variety of non-radiological materials typically found in industrial buildings. The handling of hazardous materials will be controlled and will meet provincial regulations, in particular the OHSA and the Environmental Protection Act for non-radiological

[85] *Additional clarification on how ALARA is accounted for in the DGR was provided in OPG response to IR-LPSC-01-44 (CEAA Registry Doc# 363).*

hazards. Material Safety Data Sheets for hazardous materials will be readily available as required by Workplace Hazardous Materials Information System (WHMIS) legislation.

4.8.7.5 Personal Protective Equipment

The selection, use and maintenance of personal protective equipment for the above-ground portion of the DGR will be governed by OPG's existing Safety Management System Program OPG-HR-SFTY-PROG-0001 [51]. For radiological hazards above ground, OPG's procedure N-PROC-RA-0025 [52] will be applied. The requirements for personal protective equipment under the Mines and Mining Plants Regulations (O. Reg. 854 [29]) will be complied with for underground operations.

4.8.7.6 Environmental Protection Program

Environmental protection policies, programs and procedures will be established and will meet the requirements of the:

- OPG Environmental Policy OPG-POL-0021 [53];
- Biodiversity Policy OPG-POL-0002 [54];
- Land Assessment and Remediation Policy OPG-POL-0016 [55];
- Spills Management Policy OPG-POL-0020 [56]; and
- Policy for Use of Ozone Depleting Substances OPG-POL-0015 [57][86].

Execution of the program will be accomplished through an integrated set of documented activities, typical of an Environmental Management System. It will be consistent with the CNSC regulatory standard S-296 [58] and the International Organization for Standardization (ISO) standard 14001, and will meet the requirements of OPG's Environmental, Health and Safety Management Program W-PROG-ES-0001 [48]. Section 4.15 provides additional detail on environmental protection policies and procedures that will apply to the DGR Project.

4.8.7.7 Monitoring Program

As part of the Environmental Management System, an environmental monitoring program will be implemented for the DGR Project. The monitoring plan will address radiological contaminants, chemical contaminants and physical stressors that may present a risk to either human health or non-human biota[87].

The objectives of the monitoring program during the operations phase are as follows:

- to assess performance of various structures, systems, equipment and components relative to design specifications and baseline conditions;

---

[86] *This policy no longer exists. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447).*

[87] *Additional information on plans to monitor waste degradation within the repository was provided in OPG responses to IRs EIS-01-32 (CEAA Registry Doc# 363) and EIS-09-457 (CEAA Registry Doc# 957).*

- to monitor changes in underground rock/excavation conditions (e.g., rock movement, stress) over time;
- to assess preclosure safety and environmental performance relative to defined standards or limits, and baseline conditions; and
- to monitor for changes in groundwater quality as a result of the operation of the DGR facility.

Environmental monitoring programs are discussed further in Section 4.15.2 and Chapter 10 of the Preliminary Safety Report [26].

4.8.7.8 Staffing and Training Program

A Staffing and Training Program will be developed to ensure the presence of a sufficient number of qualified workers to carry out activities safely and in accordance with the Nuclear Safety and Control Act and its Regulations.

Where applicable, a minimum number of workers with specific qualifications, known as the minimum staff complement, will be identified by a systematic analysis to ensure that there are adequate staffing levels to successfully respond to all credible events.

Training meeting the requirements of OPG's Training Program N-PROG-TR-0005 [59] will be established and maintained. Only qualified staff will be assigned to work on tasks independently. All staff will be skilled and knowledgeable to perform the tasks to which they have been assigned.

4.8.7.9 Fire Protection Program[88]

The DGR will use OPG's Nuclear Waste Management Division (NWMD) Fire Protection Procedure W-PROC-ES-0011 [60] to ensure compliance with the applicable national codes and standards that will be specified in the operating licence issued by the CNSC.

4.8.7.10 Emergency Preparedness and Emergency Response Program

Emergency response at the DGR will be conducted in cooperation with Bruce Power, as described in NWMD Employee Emergency Response Procedure W-PROC-ES-0002 [61]. OPG will ensure that an effective response can be made to address an emergency affecting the health and safety of OPG employees, its business continuity and its property, contractors at the DGR, the environment, and the public[89].

---

[88] *Additional clarifications on the Fire Protection Program for the operational phase of the DGR were provided in OPG supplementary response to IR-LPSC-01-15 (CEAA Registry Doc# 606) and OPG response to IR-LPSC-01-43 (CEAA Registry Doc# 363).*

[89] *Additional clarification on emergency response and preparedness arrangements for the DGR project was provided in OPG response to IR-EIS-06-269 (CEAA Registry Doc# 823).*

The DGR is not considered to be a mine under the OHSA; however, trained and qualified mine rescue teams will be provided as required by the Mines and Mining Plants Regulations (Reg 854). As required by the Mine Rescue program, a second team is required at site before the first team can go underground and a third team must be on-route. Back-up will be provided by nearby mine rescue teams through mutual assistance agreements[90]. Further information is provided in Section 4.17.

4.8.7.11 Inspection and Maintenance Program

Implementation and control of maintenance activities are primarily achieved by instituting a maintenance program consistent with requirements specified in OPG's Conduct of Operations and Maintenance Program W-PROG-OM-0001 [62].

In compliance with Section 6(d) of Class I Nuclear Facilities Regulations [46], an Inspection and Maintenance Program consisting of polices, processes, and procedures will be developed with an objective to maintain the structures, systems and components of the DGR as per design specifications. The program will cover a range of inspection and maintenance activities including, but not limited to, monitoring, inspecting, testing, assessing, calibrating, servicing, repairing or replacing parts.

Further to the Class I Nuclear Facilities Regulations requirements [46], the DGR will also be required to comply with the Mines and Mining Plants Regulations (O. Reg. 854 [29]) for mining operations. Underground operations will require the development of inspection and maintenance plans that will include but are not limited to mobile equipment, ventilation systems, shaft and hoisting systems, and excavations.

4.8.7.12 Records and Document Control

All records for OPG's nuclear facilities are managed in accordance with OPG's Records and Document Control N-PROG-AS-0006 [63]. The following documents provide further detail regarding the management for records in the areas of quality assurance, radiation protection and dose, licensing, and training:

- records identified as controlled documents (including all licensing documents) will be managed as per OPG's Controlled Document Management Procedure N-PROC-AS-0003 [64];
- all dose records will be managed as per OPG's Creating and Maintaining Dose Records N-HPS-03413.1-0004 [65];
- records governed by the Radiation Protection Program will follow OPG's Radiation Protection Requirements N-RPP-03415.1-10001 [66]; and
- training records will be managed as per OPG's Records and Documentation Procedure N-PROC-TR-0012 [67].

---

[90] *Additional clarification on mine rescue support during operation was provided in OPG response to IR-LPSC-03-61 (CEAA Registry Doc# 608).*

4.9 RISK MANAGEMENT

Workers will be exposed to typical risks associated with working in a nuclear environment, an industrial setting, an underground environment, and, at times, a construction site. The risks are identified and evaluated in the Preliminary Conventional Safety Report [68] and the Preliminary Safety Report [26]. The construction-related risks will be typical of those at any construction site and are associated mainly with being in close proximity to heavy equipment and carrying out excavations to depth. The operations risks will be similar to those at the WWMF and typical of underground mine activities.

The Malfunctions, Accidents and Malevolent Acts TSD (summarized in Section 8) identifies potential risks to workers, the public and the environment in various accident and malfunction scenarios. A summary of the risks attributable to malfunctions and accidents is provided in Section 4.13 and Section 8. These sections also consider the risks associated with malevolent acts.

Environmental protection measures will be established to prevent the uncontrolled release of soil materials, chemicals or wastes into the environment at, or near, the source. As described in Section 4.7.8.7, the site spills and release response plan will be included in the Environment Management Plan DGR-PLAN-07002-1001 established for the site preparation and construction phase. During operations, contingency plans for uncontrolled release of substances will be consistent with the requirements of the Spills Management Policy OPG-POL-0020 [56]. Dust abatement measures associated with the construction and use of roadways will be implemented during the construction period. Training will be a key component of the plan to increase environmental awareness and to develop contingencies for emergency response (e.g., spills response plans and procedures). A monitoring plan will assess the effectiveness of these environmental protection measures during construction.

A Construction Quality Assurance Plan DGR-PLAN-01916-1001, described in Section 4.7.8.7, will verify the construction of the DGR to ensure that the DGR has been constructed according to the DGR Project design and meets design requirements. As per NWMO's governance, the Construction Management Plan DGR-PLAN-00180-1001 applies to the activities ahead of the site preparation and construction phase.

The Geoscientific Verification Plan [69] will be implemented during the site preparation and construction phase and will verify geoscientific parameters that influence repository safety.

Emergency response is currently supplied to the WWMF by the Bruce Power emergency response team (ERT). It is expected that this service will be extended to the DGR construction and operations. Further details are provided in Section 4.17.1.

4.10 MODIFICATIONS TO THE PROJECT

The EA considers the effects of site preparation, construction, operations, decommissioning, abandonment and long-term performance of the DGR. As the EA process is carried out in the planning stages of DGR Project development, a number of decisions regarding some specific elements of DGR infrastructure will be made during the development of the detailed design.

The following sections provide a brief description of the potential design changes that may occur, and discuss the possibility of future expansion. Finally, the process that would be followed by NWMO and/or OPG in the unlikely event that the DGR Project was to be largely altered at any stage is outlined.

Carrying out the EA is a key step in deciding to implement the DGR Project. It is logical to assume that once the EA is satisfactorily completed, and the many other necessary approvals and licences are obtained to proceed with the DGR Project, it is highly improbable that a decision to discontinue or significantly alter the DGR Project would be made. An attempt to identify such circumstances that may necessitate or lead to decisions of this nature would be highly speculative.

4.10.1 Design Changes

The following design elements have the potential to change during the development of the detailed design for the DGR Project. These potential modifications are not expected to result in environmental effects that are substantially different or increased from those identified in the EIS:

- changing the ventilation shaft hoist from a ground mounted double drum hoist to a tower mounted Koepe hoist;
- changing the ventilation shaft headframe material from steel to concrete;
- adding refrigeration and bulk air coolers for the ventilation system;
- changing the layout of the underground facility to better align with the measured principle stress;
- changing the location of some ancillary facilities from those shown in the EA preliminary design to refine the layout; and
- changing the underground rock support system.

The DGR Project change control procedure will describe the management process for control of project change. It will include prompt identification of DGR Project Change Notices (PCNs) and an approval process that results in appropriate review and authorized changes to scope, budget, and/or schedule. Changes to the DGR Project design will be managed in accordance with NWMO Design Management, NWMO-PROC-EN-0001 [34]. The Commissioning Change Control Procedure, DGR-PROC-00920-1001, describes the process by which change can be made to the design or operation of the DGR during commissioning. No change will be implemented unless it is determined to be necessary (e.g., a flaw that renders equipment or process inoperable or endangers health or safety), and the change receives independent review and approval, design verification, and appropriate validation testing during commissioning.

4.10.2 Additional Emplacement Rooms[91,92]

The DGR is designed based on volume estimates and assumptions about volume reduction efficiency. If these assumptions are not realized, there may be a need to increase the number of emplacement rooms. If additional storage is required, waste transfer operations will be discontinued and construction activities resumed. The waste rock handling facilities would be commissioned and a similar sequence of works and activities as those described in Section 4.7.4 would occur. Waste could be stored at the WWMF during the development of additional emplacement rooms, as necessary.

It is expected that there will only be five emplacement rooms active in Panel 1 at the end of the planned DGR Project life. Three of these rooms have rail access and are designed to include some additional capacity for future large waste packages. It is likely that the access to Panel 1 will be controlled and would not be accessible to the construction activities undertaken for the creation of additional emplacement rooms, but would be monitored and ventilated.

The process that would be undertaken should a decision be made to expand the DGR at some future point in time is similar to that described, above, for design changes.

4.10.3 Discontinuation of the Project

In the event the DGR Project was cancelled, for any reason, during the site preparation and construction phase or prior to waste emplacement operations having begun, the DGR Project site would be decommissioned as described in Section 4.11. The main difference would be the absence of any radioactive materials in the emplacement rooms, and decommissioning would not involve any radiological considerations. Chapter 13 of the Preliminary Safety Report [26] provides additional information on this scenario, including a schedule for decommissioning activities that would be required at the end of construction.

OPG, which will hold the licence for the site preparation and construction phase of the DGR Project, has the financial capacity to ensure the plan could be carried out. Reasons for halting site preparation prior to completion, or making a decision to not complete construction activities are speculative, and could be associated with policy, business, technical considerations or other developments.

Should the DGR Project be cancelled for any purpose during the operations phase, the DGR facility would be decommissioned as described in the Preliminary Decommissioning Plan [70], which has been submitted as part of the permitting application. Section 4.11 outlines a conceptual plan for decommissioning the facility, and demonstrates there is sufficient technical knowledge and expertise to ensure decommissioning is effective. OPG, as licensee, will be required to financially guarantee the safe shutdown of the DGR.

---

[91] *Additional clarifications of expansion potential were provided in OPG responses to IRs EIS-04-145 (CEAA Registry Doc# 725), EIS-10-494 (CEAA Registry Doc# 990).*

[92] *Additional clarifications on DGR conceptual expansion plans were provided in OPG responses to IRs EIS-04-120 (CEAA Registry Doc# 725), EIS-12-512 (CEAA Registry Doc# 1788), and EIS-12a-512 (CEAA Registry Doc # 1837).*

4.10.4 Public Communications

NWMO will continue to implement a public information program following the submission of the EIS. Additional targeted communications would be initiated in the event of a proposal to modify the DGR Project in ways which would result in a meaningful change. These include, but are not limited to changes to the:

- layout of the DGR facility;
- characteristics or sources of waste to be emplaced in the DGR;
- capacity of the DGR;
- life cycle schedule for the DGR Project;
- monitoring program for the DGR Project; and
- socio-economic considerations (e.g., employment or spending).

Notification of these DGR Project modifications would be made, at a minimum, to members of the public residing in the Bruce municipalities as well as other interested stakeholders. The Saugeen Ojibway Nation as well as the Historic Saugeen Métis Community and the Métis Nation of Ontario would also be contacted.

A detailed communication plan including objectives, strategy, spokespeople, target audiences, key messages and communication activities would be prepared to govern how the information would be relayed for each proposed modification to the DGR Project. The communication plan would provide a targeted approach for communicating the specific proposed modification and may include briefings and interviews with key stakeholders, updated website, media briefings and press releases, advertising, notification letters, newsletters, workshops, open houses and community information sessions.

A comment database would be maintained to record and monitor all comments, correspondence and communications with stakeholders and Aboriginal peoples interested in the proposed modifications to the DGR Project. Concerns or issues identified through this communication process would be considered in a manner similar to that employed for addressing issues raised throughout the EA process.

4.11 DECOMMISSIONING PHASE

A summary of the decommissioning activities is provided in the sections below. Decommissioning planning is summarized in Chapter 13 of the Preliminary Safety Report [26]. As noted in Section 4.10.3, a Preliminary Decommissioning Plan [70] has been prepared, and submitted as part of the lincensing application, for the DGR Project. This plan meets:

- CNSC Regulatory Guide G-219 Decommissiong Planning for Licensed Activities [71]; and
- CSA N294-09 Decommissioning of Facilities Containing Nuclear Substances [72].

Planning for decommissioning is an on-going process, and planning assumptions are expected to change over time. The Preliminary Decommissioning Plan [70] will be reviewed and revised periodically to incorporate changes in the planning assumptions.

As indicated in Section 4.6, decommissioning is expected to take approximately five years to complete. Chapter 13 of the Preliminary Safety Report [26] includes an outline schedule for completing the decommissioning work program. At the time of writing, the projected workforce averages 115 persons over the course of the decommissioning phase including NWMO and OPG staff plus contractors.

4.11.1 End-state Objectives

The objective of decommissioning is to permanently retire the DGR facility from service in a manner that ensures the health and safety of the public and the workers, and protection of the environment. Decommissioning involves closing the DGR and restoring it to an agreed end-state. Upon completion of decommissioning and obtaining a licence to abandon the site, the site would be in a condition that will make it available for other uses while under institutional controls.

4.11.2 Decommissioning Strategy

The decommissioning strategy for the DGR is based upon the fundamental assumption that no radioactive wastes emplaced in the DGR will be removed as part of the decommissioning. The decommissioning strategy is based on a combination of prompt decommissioning and in situ confinement as defined in CSA N294-09 [72]. Decommissioning will be followed by a period of institutional controls.

The DGR is unique in that it combines aspects of mining with a nuclear facility. Even though the DGR does not meet the legal definition of a mine, Mine Development and Closure Regulations (O. Reg. 240/00) under Part VII of the Mining Act [73] provides useful information on the installation of concrete caps atop decommissioned mine shafts. In general, a reinforced concrete cap, certified by a qualified professional engineer is placed atop decommissioned mine shafts. The caps installed atop the main and ventilation shafts will be consistent with the requirements given in O. Reg. 240/00 [73].

An overview of the principal hazards and protection strategies envisioned for decommissioning is provided in Section 4.11.6.

4.11.3 Decommissioning of Facilities

Decommissioning will begin following a period of monitoring after all of the waste has been emplaced and a Decommissioning Licence has been obtained.

Decommissioning at the repository level will largely consist of preparing the underground services area for the construction of a concrete monolith. Decommissioning of the underground facilities will include the assessment of equipment to determine whether or not it should be removed and salvaged, or remain in the repository for closure. Particular attention will be given to areas where potentially hazardous materials, such as waste fluids from mobile equipment, may exist. At the time of writing, it is assumed that most permanent equipment and materials will remain within the repository and that only mobile equipment, which has been tested and does not contain residual radioactive contamination, will be removed to surface. As described in Section 4.11.4, the ventilation shaft steel-work and services will be placed in the repository for closure. All repository services will be disconnected and the underground shaft and services area will be prepared to construct the concrete monolith. The monolith will be located at the base of both shafts and extend into the shaft and services area of the repository level.

The majority of surface facilities will be decommissioned following completion of the shaft seals, as the infrastructure will be required to maintain service to the shafts during the installation of the sealing materials. Some of the surface facilities components and equipment, which are determined to be contaminated (e.g., main surface exhaust fans and associated equipment) can be removed and placed in the repository prior to sealing the shaft.

Following removal of all surface facilities, the DGR Project site will be graded and vegetated. The location of the shafts will be appropriately secured. The construction of the shaft sealing system is further explained in Section 4.11.4.

The stormwater management pond and the drainage ditches established for the DGR Project will be decommissioned during site restoration activities.

The waste rock remaining in the WRMA will be covered by a soil cap and vegetation. The waste rock pile will be capped with a minimum of 150 mm of soil and topsoil that is suited to the requirements of the local flora[93,94]. Surface materials will be stabilized and the surface will be contoured to promote drainage and to minimize erosion. Wind breaks will be established, if necessary, for erosion control until such time that the vegetation is sufficiently established. Waste materials anticipated to be generated during the decommissioning phase are discussed and quantified in Section 4.11.5.

4.11.4 Decommissioning of the Shafts

Decommissioning of the shafts will consist of sequential removal of shaft infrastructure and installation of the shaft sealing materials. As noted, all internal shaft support structures (e.g., steel sets) and infrastructure connections (power, ventilation, water) will be disconnected and removed before sealing work begins in a shaft. A new ventilation system will be established in each shaft to allow the workers to safely decommission the shafts.

Prior to placing shaft sealing materials, the concrete monolith will have been constructed at the base of each shaft (Figure 4.11.4-1). The concrete monolith would be then overlain by a column of compacted bentonite/sand. An asphalt column would be placed above the first

[93] *Additional clarification was provided in OPG response to undertaking TIS-9 on the rationale for the planned top soil cover of 150 mm on the waste rock pile at closure (CEAA Registry Doc# 692).*

[94] *Additional information regarding the WRMA decommissioning vegetation plans was provided in OPG response to IR-EIS-05-171 (CEAA Registry Doc# 793).*

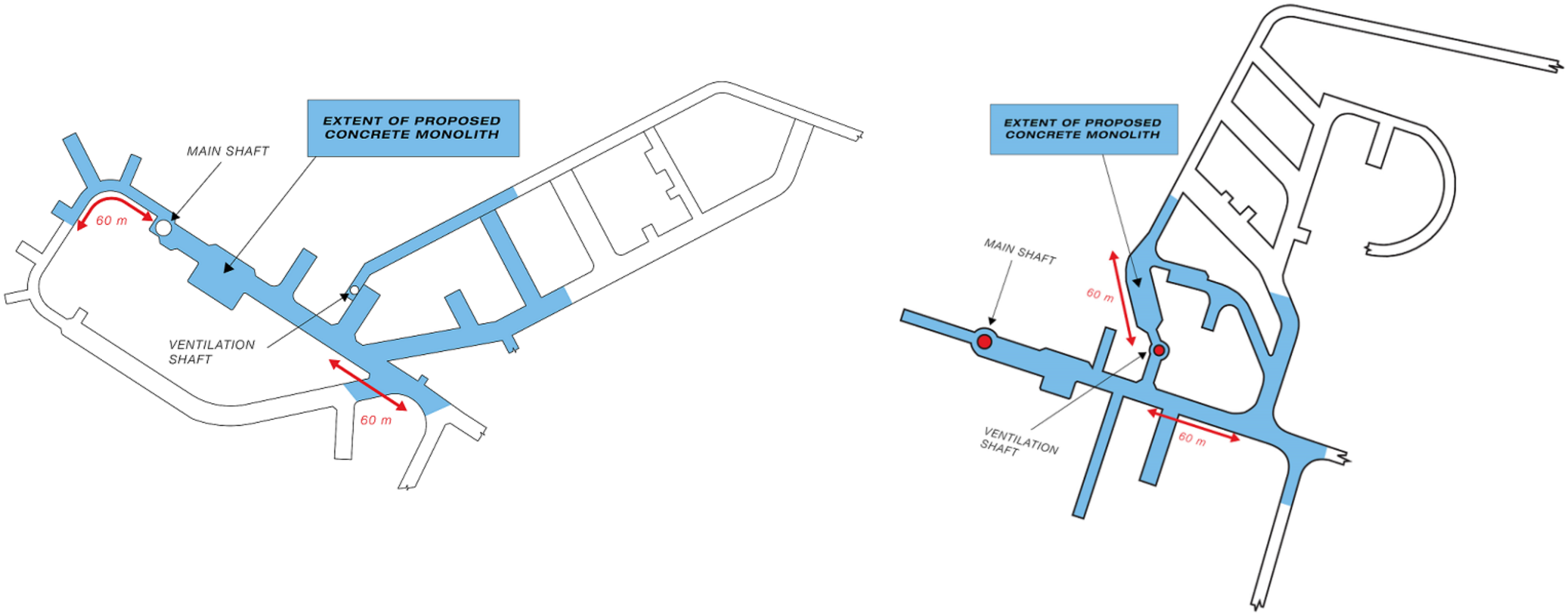
bentonite/sand layer to provide a redundant low permeability sealing material against upward or downward fluid flow.

A series of bentonite/sand columns are separated by concrete bulkheads to provide structural components to the column and provide additional sealing capability. These design features contribute towards isolation and containment of the waste.

The preferred design approach for the shaft seal focuses on the use of simple, proven materials and methods for emplacement, using currently available technology[95,96]. Since the shaft seal will not be implemented for several decades, there is time to incorporate new information learned during operation of the DGR as well as long-term sealing tests at the DGR and internationally. Therefore, the design described here is intended to provide reasonable assurance that a competent shaft seal can be constructed.

[95] *Additional information on shaft seal performance was provided in OPG response to IR-EIS-03-64 (CEAA Registry Doc# 608).*

[96] *Additional information on natural analogs for seal material durability was provided in OPG response to IR-EIS-10-492 (CEAA Registry Doc# 1048).*



(a) *(b)*

Figure 4.11.4-1: Extent of the Proposed Concrete Monolith

Note: (a) – as shown in March 2011 submission, (b) – updated as per OPG Letter dated Feb. 10, 2012 [CEAA Registry Doc# 336])

4.11.4.1 Seal Materials

The approach for the shaft seal design and construction has focused on the use of simple, relatively well understood and durable materials, and use of proven methodologies for emplacement. Concrete, bentonite/sand mixture and asphalt will be the sealing materials used in each shaft. An engineered fill material based on rock excavated during shaft sinking or some other suitable material will be used in the upper portion of each shaft as shown on Figure 4.11.4-2. Additional information on the seal materials is provided in the following section.

4.11.4.2 Construction of Shaft Seal

As noted, a concrete monolith will be placed at the base of the seal system (Figure 4.11.4-1). Concrete will provide a stable foundation for the overlying seal materials. The monolith will be constructed in two stages, one for the ventilation shaft, followed by another for the main shaft. They will form a contiguous mass concrete structure with no structural reinforcement within the concrete. All services and utilities will be stripped out of the excavations to be filled by the monolith.

Throughout all seal sections up to the top bulkhead, shown on Figure 4.11.4-2, shaft support structures and concrete liners will be removed to ensure a complete seal of the shaft column to the surrounding low permeability host rock. Also, it is assumed that an additional 500 mm of host rock will be excavated beyond the initial shaft diameter to remove any damaged rock that may have formed during shaft sinking and the operations phase of the DGR Project[97].

The column of sealing materials in each shaft is largely composed of a compacted bentonite/sand mixture (Figure 4.11.4-2). Once saturated, the compacted bentonite/sand materials will act as a low permeability barrier to retard the movement of radionuclides out of the repository and minimize the potential for groundwater flow down into the repository. Compacted clays or clay/sand mixtures are the most commonly proposed sealing materials for nuclear waste repositories.

Sand will be added to the bentonite to act as a filler without compromising the hydraulic conductivity and swelling potential of the bentonite dominant material. The use of sand will improve workability during placement, ease compaction and dust control.

As the compacted bentonite/sand materials saturate with groundwater from the surrounding rock, they will generate swelling pressures, which will aid in the development of a tight seal against the shaft wall and provide a confining pressure to the rock surface.

A 60 m thick asphalt column will be placed above the lowermost bentonite/sand column[98]. The asphalt column extends over a length of the Georgian Bay Formation to just above the

---

[97] *Additional clarification on removal of shaft infrastructure prior to seal installation was provided in OPG response to IR-LPSC-03-58 (CEAA Registry Doc# 608).*

[98] *Additional clarifications of the basis for the asphalt seal, including potential for chemicals of concern from the asphalt seal, were provided in OPG response to IR-EIS-03-63 (CEAA Registry Doc# 608).*

Queenston/Georgian Bay contact. Asphalt was selected because it has the ability to flow and make good contact with host rock. Immediately upon emplacement, the asphalt will create an effective barrier to water flow. Furthermore, the use of another low permeability sealing material provides an additional level of redundancy to the sealing system against upward or downward fluid flow.

Asphalt will be pumped to the shaft and placed through the use of a slickline and header. The slickline will require heating to maintain the asphalt's viscous state. Asphalt will be placed in controlled lifts. Following placement of an asphalt lift, placement operations will cease to allow for cooling of the asphalt and to ensure a safe environment for workers starting the subsequent placement of sealing materials. Ventilation into the shaft will be maintained during this period to promote cooling and to remove any hazardous fumes. Air temperature and quality will be remotely monitored to establish when it would be safe to resume shaft sealing activities. Leading up to the top bulkhead, there are two higher permeability units within the surrounding geosphere: the Guelph Formation and the upper 4 m of the Salina A1 carbonate unit (see Section 6.2.7). As a result of the expected lateral flow along this unit, a concrete cylinder will be placed along the full extent (approximately 6 m) of this unit. To ensure structural stability, the underlying concrete structure will be constructed to a height slightly larger than the diameter of the excavated shaft, and the concrete bulkhead will be keyed into the surrounding host. The concrete mix will be similar to that selected for the concrete monolith. The concrete/rock interface will also be pressure-grouted to minimize groundwater flow along the interface.

A concrete bulkhead will be installed at the upper 4 m of the Salina A1 carbonate unit and the design will be the same as that proposed for the Guelph Formation.

Salina Unit F represents a lower (at least one order of magnitude) permeability zone within the dolostones (an aquitard) between a fresh water aquifer above and more saline water-bearing formations below. To prevent movement of the poor quality, saline groundwater from the lower Salina Formation upwards through the shaft cross-section into the upper fresh water aquifer, a concrete bulkhead will be constructed at this location.

As with the monolith, concrete for the bulkheads will be placed in mass and with no reinforcing steel, and using measures to control heat build-up. Contact/seal grouting will be applied around the bulkheads to minimize the potential impacts of shrinkage at the interface with the host rock formation. Concrete will be poured directly onto the bentonite/sand columns located below each bulkhead.

The uppermost portion of each shaft will be filled with an engineered fill (e.g., 'Granular A' material). The engineered fill will be topped by a surficial concrete cap, which is the final element of the seal system. The cap will serve the following functions:

- further reduce the potential for subsidence, as concrete is stronger than compacted fill;
- provide a marker for the shaft locations; and
- reduce the potential for inadvertent human entry by providing a restrictive barrier at the surface.

The surficial cap will be constructed using concrete. Air entrainment within the concrete is required to minimize adverse effects of freeze/thaw action on the concrete cap.

4.11.5 Decommissioning Waste Management

This section identifies the types of wastes that are anticipated to be generated during the decommissioning phase of the DGR Project. It considers conventional, hazardous and radioactive materials. Wherever appropriate, mechanisms and materials decommissioned from surface and underground facilities will be recycled or reused elsewhere to reduce requirements for disposal. Those materials that are not recyclable will be disposed of in a licensed facility. Any materials or equipment in surface facilities that would be considered radioactive waste will be removed near the start of decommissioning and placed in the repository prior to the start of shaft sealing.

4.11.5.1 Conventional and Hazardous Wastes

Conventional and hazardous waste will be produced during the decommissioning phase of the DGR Project. These wastes will consist of consumable materials such as rags and coveralls used for maintenance and clean-up, solids generated from underground sanitary facilities, and other miscellaneous wastes. All waste materials will be collected in waste bins or totes, sent to treatment as necessary, and disposed of at licensed facilities.

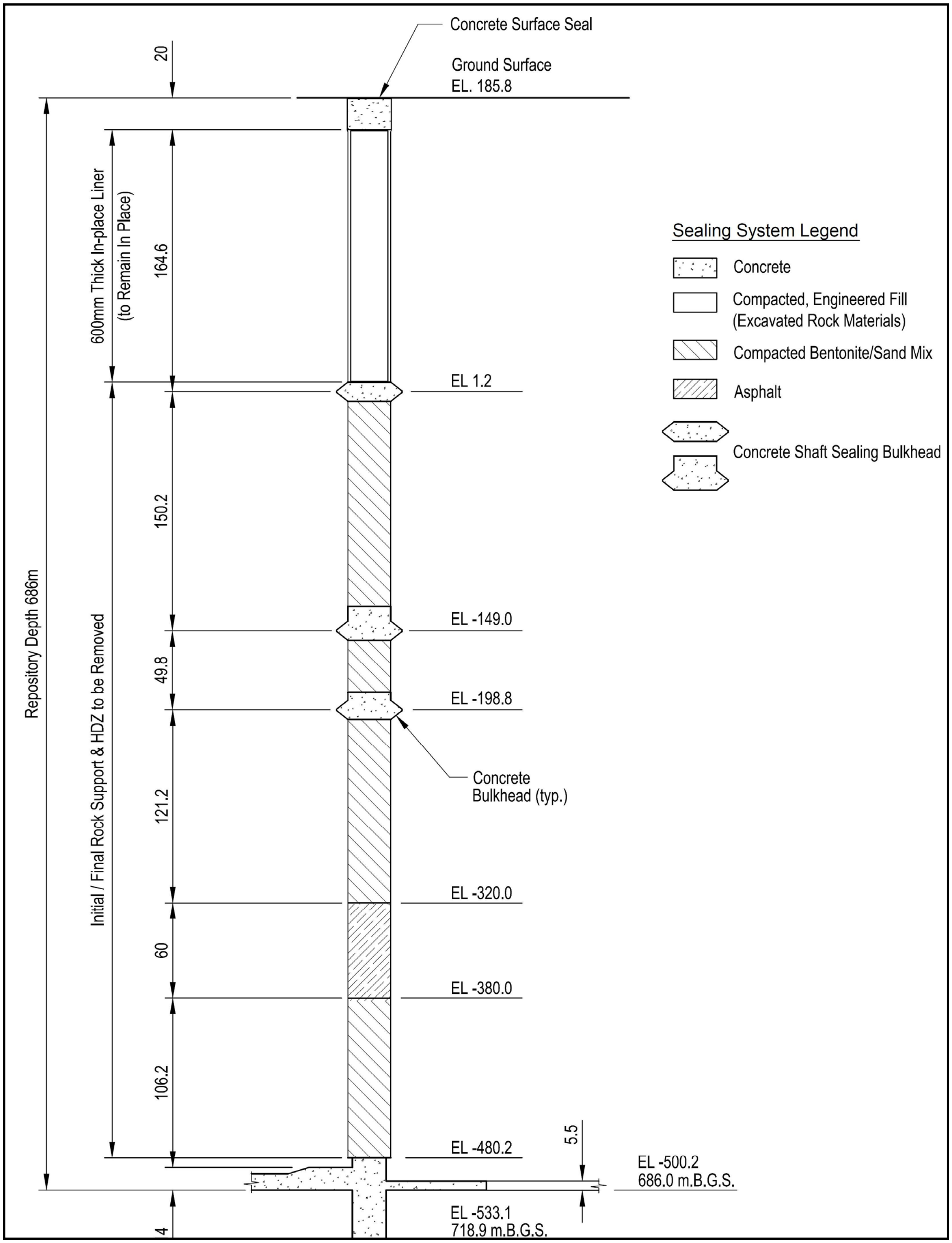


Figure 4.11.4-2: Arrangement of Shaft Seal Components

As described in Section 4.11.3, it is assumed that underground mobile equipment will be removed to the surface. Once at surface, it is possible that some of the equipment could be salvaged for reuse or for its scrap metal. Alternatively, if the equipment has no value and space is available and approval is received to do so, then the mobile equipment could remain underground. All fluids (e.g., fuel, lubricants, and hydraulic fluids) and any other hazardous materials (e.g., batteries) would be removed prior to leaving any equipment underground.

Waste materials resulting from the removal of ventilation shaft and main shaft infrastructure (such as shaft steelwork and concrete lining) will be brought to the surface and reused/recycled wherever possible. Similarly waste rock resulting from excavation of any damaged rock in the shafts will be reused on site wherever possible (e.g., as engineered fill in upper portion of shafts as described in Section 4.11.4) or could be placed in the WRMA. Materials from decommissioning of the ventilation shaft and main shaft that cannot be reused or recycled will be sent to a licensed disposal facility.

Table 4.11.5-1 presents the estimated quantity of waste materials that would arise from the decommissioning of the DGR facility. The projected range of conventional and hazardous waste materials that would be produced during decommissioning is shown in Table 4.11.5-2.

Table 4.11.5-1: Waste Materials Arising from Decommissioning[99]

Structure	Material Type	Quantity[a]
Ventilation shaft	Steel	490 tonnes
	Concrete	5,600 m^3 [b]
	Waste rock (HDZ)[c]	7,000 m^3
Ventilation shaft headframe	Steel	520 tonnes
	Concrete	260 m^3
Main shaft	Steel	780 tonnes
	Concrete	9,100 m^3
	Waste rock (HDZ)[c]	8,800 m^3
Main shaft headframe and WPRB	Steel	380 tonnes
	Concrete	8,700 m^3
Other items such as miscellaneous cabling, panels, and other equipment		

Notes:
a Volumes (in m^3) of material are bulked volumes.
b It is assumed that less than 10% of the ventilation shaft concrete could be contaminated; however, it would be impractical to separate the contaminated concrete from the remainder of the concrete liner.
c Highly Damaged Zone (HDZ)

[99] *Additional clarification was provided in OPG response to IR-LPSC-01-46 on waste materials to be removed as part of decommissioning, and further details on waste materials arising from decommissioning following construction (CEAA Registry Doc# 363).*

Table 4.11.5-2: Projected Range of Conventional and Hazardous Wastes Arising from Decommissioning[100]

Waste Material	Projected Range of Output
Oils and grease	15,000 – 18,000 L per year
Batteries	60 – 80 kg per year
Solvents	1,500 – 2,500 L per year
Domestic waste	25,000 – 35,000 kg per year
Sanitary waste	8,000 – 12,000 kg per year

4.11.5.2 Radioactive Waste

During operations, all waste packages will be checked for contamination, and decontaminated if necessary, before they are emplaced in the DGR. Abnormal operating occurrences may result in some contamination events during the course of operations; however, it is anticipated that any such contamination would be removed whenever it is discovered. It is expected that there will be little or no radioactive contamination on facility structures, systems and equipment. Consequently, the volume of radioactive waste generated during the decommissioning will be limited to 10 m^3, in addition to the waste identified in Section 4.11.5-1. Operational experience and radiological surveys will be used to prepare a revised estimate.

4.11.6 Decommissioning Hazards and Protection Strategies

As previously noted, a Preliminary Decommissioning Plan [70] has been prepared in support of the licence application to prepare the site and construct the DGR facility. It describes planning work that has been completed to comply with CSA Standard N294-09, Decommissioning of Facilities Containing Nuclear Substances [72] and CNSC Regulatory Guide G-219, Decommissioning Planning for Licensed Activities [71]. This plan describes the intended approach based on current information that would be taken to decommission all structures, systems and components found within the DGR Project site. It is intended to demonstrate that decommissioning can be completed, with existing technology, in a manner that ensures the protection and safety of workers, members of the general public and the environment. More specifically, the Preliminary Decommissioning Plan [70] identifies the following:

- the types of activities that could pose a significant hazard to workers, the public or the environment;
- the role of existing procedures for managing hazards; and
- the specific activities for which additional protection/mitigation procedures will be required at the detailed planning stage.

---

[100] *Additional clarification was provided in OPG response to IR-LPSC-01-46 on waste materials estimated to be generated during decommissioning on yearly basis (CEAA Registry Doc# 363).*

4.12 ABANDONMENT AND LONG-TERM PERFORMANCE PHASE

An application for a Licence to Abandon the facility will be submitted to the CNSC following decommissioning. An abandonment plan will be developed in support of the application for a Licence to Abandon[101]. The application will include:

- the results of the decommissioning; and
- the results of the environmental monitoring programs.

The results of the environmental monitoring will include the information collected during the course of the decommissioning and during any other monitoring period. This report will describe the decommissioning work that has been performed, the outcome of that work, the results of the final surveys that were performed and the interpretation of those results. Other information required by the applicable regulations will also be included.

A period of institutional control, currently assumed to last up to 300 years, will follow the decommissioning. A Licence to Abandon issued by the CNSC may include conditions that would apply throughout the period of institutional control. Institutional controls will help prevent or reduce the likelihood of human actions inadvertently interfering with the waste or causing degradation of the safety features of the repository[102]. More information on institutional controls can be found in CNSC G-219, Decommissioning Planning for Licensed Activities [71], CNSC Guide G-320, Assessing the Long Term Safety of Radioactive Waste Management [74] and IAEA Safety Standard WS-R-4, Geological Disposal of Radioactive Waste [75].

Given the type of facility and the nature of the hazards present, it is assumed that:

- a period of passive institutional control will be applied to the L&ILW DGR which may include local land use controls; local, national and international records; and the use of durable surface and/or subsurface markers;
- the site will be available for other purposes that are consistent with any applicable land use restrictions; and
- the period of institutional controls would be up to 300 years.

This is consistent with national guidance and international practice. Additional details of the nature of institutional controls will be included in the detailed decommissioning plan. Section 9 of this report provides additional details demonstrating the long-term safety of the DGR.

---

[101] *Additional clarifications on abandonment were provided in OPG responses to IRs EIS-05-181 (CEAA Registry Doc# 776) and EIS-08-364 (CEAA Registry Doc# 886).*

[102] *Additional clarifications on institutional controls were provided in OPG responses to IRs EIS-03-50 (CEAA Registry Doc# 608), EIS-05-181 and EIS-05-194 (CEAA Registry Doc# 776), and EIS-08-363 (CEAA Registry Doc# 886).*

4.13 MALFUNCTIONS, ACCIDENTS AND MALEVOLENT ACTS

This section describes the identification of the potential malfunctions or accidents associated with the DGR Project[103]. The identification and screening of credible malfunctions and accidents was carried out in the Malfunctions, Accidents and Malevolent Acts TSD. That TSD also addresses malevolent acts. Section 8 of this EIS summarizes the assessment related to malfunctions, accidents and malevolent acts.

Malfunctions or accidents could occur throughout all phases of the DGR Project. They could take place as internally-initiated events (such as equipment failures) and externally-initiated events (including human activity such as traffic accidents, and natural hazards such as tornados or earthquakes). For the EA, malfunctions and accidents associated with the DGR Project are grouped into two categories:

- radiological accidents; and
- non-radiological (i.e., conventional) accidents.

Radiological accidents refer to those which could result in the acute release of radioactivity to the environment and potentially affect all or part of the subcomponents of the radiation and radioactivity environment (atmosphere, surface water, groundwater, aquatic biota, terrestrial biota, members of the public and workers). Conventional accidents refer to those which involve only non-radiological substances and will not result in adverse radiological effects on the environment or human beings.

4.13.1 Radiological Malfunctions and Accidents

4.13.1.1 Site Preparation and Construction Phase

No radiological accidents are postulated for the site preparation and construction phase of the DGR Project since the associated works and activities do not involve any radioactive materials.

4.13.1.2 Operations Phase

Potential radiological accidents were considered to occur both above-ground or at various locations below-ground. Potential accident scenarios involving a source of hazards, initiating event, and potential hazardous events/consequence were considered. The result of this analysis was a list of specific accident scenarios. Based on the frequency of the initiating events and the likelihood of the events/consequence, accident scenarios which are considered non-credible are screened out as the risk associated with these scenarios is deemed to be acceptable.

Potential sources of hazards which could affect waste packages are grouped into the following:

---

[103] *An assessment of impact of potential events on the Bruce site that could affect the DGR was provided in OPG response to IR-LPSC-01-41 (CEAA Registry Doc# 363).*

- geology;
- radioactive waste packages;
- non-radioactive combustible materials;
- heavy equipment; and
- utilities.

A list of credible initiating events that are applicable to the Bruce nuclear site and the DGR facility design was developed (Table 3.2-1 in the Malfunctions, Accidents and Malevolent Acts TSD).

The frequency of the initiating events was then estimated by considering three classes:

- possible events: annual frequency of $>10^{-2}$;
- unlikely events: annual frequency between 10^{-2} and 10^{-7}; and
- non-credible events: annual frequency of $\leq 10^{-7}$.

The assessment identified the following hazardous events for further consequence analyses:

- Fire:
    - ILW Packages (with combustible material);
    - LLW Packages (with combustible material);
    - steam and volatile species release from shielded ILW packages;
- Breach:
    - ILW Packages;
    - LLW Packages;
- inadequate ILW package shielding; and
- ventilation system failure.

After the initial screening of the accident scenarios, a list of bounding accident scenarios was developed. The bounding accident scenarios were selected for each type of hazardous event identified (e.g., waste package fire, waste package breach). The criteria for selection of the bounding accident scenarios were based on the qualitative estimation of the magnitude of the consequences which, in turn, is a function of the type and number of waste packages affected and the location of the hazardous event. The lists of bounding accidents for above-ground and underground operations of the DGR are provided in Tables 4.13.1-1 and 4.13.1-2, respectively. The detailed assessment of the bounding scenarios is provided in Section 8.3 and the Malfunctions, Accidents and Malevolent Acts TSD.

Table 4.13.1-1: List of Potential Accidents in the DGR Above-ground Operations

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Fire	Outdoor Unshielded Waste Package Fire	Box Compacted	8
		Non-Processible Boxed	8
		Non-Processible Drummed	8
		Moderator Resin (Unshielded)	1
	Indoor Unshielded Waste Package Fire	Box Compacted	24
		Non-Processible Boxed	24
		Non-Processible Drummed	24
		Moderator Resin (Unshielded)	1
Fire (continued)	Indoor Unshielded Waste Package Fire (continued)	Combined LLW and ILW Packages	24 Non-processible drummed + 2 moderator resin (unshielded)
	Shielded ILW Package Steam Release	Moderator Resin (Outdoors)	1
		Moderator Resin (Indoors)	1
Low Energy Container Breach	Outdoor Waste Package Breach	Bottom Ash	8
		Box Compacted	8
		Non-Processible Boxed	8
		Non-Processible Drummed	8
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1
	Indoor Waste Package Breach	Bottom Ash	24
		Box Compacted	24
		Non-Processible Boxed	24
		Non-Processible Drummed	24
		Bottom Ash	1
		Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
		Combined LLW and ILW Packages	24 Non-processible drummed + 2 moderator resin (unshielded)
		Moderator Resin (Shielded)	1
Other	Inadequate Shielding	Moderator Resin	1

Table 4.13.1-2: List of Potential Accidents in the DGR Underground Operations

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Fire	Unshielded Waste Package Fire During Transfer	Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
	In Room Unshielded Waste Package Fire	Box Compacted	2,400
		Non-Processible Boxed	2,400
		Non-Processible Drummed	2,400
		Moderator Resin (Unshielded)	1,200
	Shielded ILW Package Steam Release	Moderator Resin (Transfer)	1
		Moderator Resin (In Room)	1
Low Energy Container Breach	Waste Package Breach During Transfer	Bottom Ash	1
		Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1
	In Room Waste Package Breach	Bottom Ash (Old)	3
		Box Compacted	4
		Non-Processible Boxed	5
		Non-Processible Drummed	5
		Moderator Resin (Unshielded)	4
		Moderator Resin (Shielded)	3
High Energy Container Breach	Cage Fall	Bottom Ash	2
		Box Compacted	2
		Non-Processible Boxed	3
		Non-Processible Drummed	3
		Moderator Resin (Unshielded)	2
		Moderator Resin (Shielded)	1
		Retube-End Fittings	1

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Loss of Ventilation	Ventilation System Failure	All Waste	—

Note:
— Not applicable

4.13.1.3 Decommissioning Phase

No radiological accidents are postulated for the decommissioning phase of the DGR Project since the associated works and activities are associated with sealing the shafts, removing surface facilities, and regrading and vegetating the site. As described in Section 4.11.5.2, it is expected that there will be little or no radioactive contamination on facility structures, systems and equipment.

4.13.1.4 Abandonment and Long-term Performance Phase

Malfunctions and accidents could occur during the abandonment and long term performance phase that would result in radiological consequences. The Postclosure Safety Assessment [27] identifies four disruptive scenarios, shown in Table 4.13.1-3[104]. All of these scenarios are assessed in Section 8.3 and the Malfunctions, Accidents and Malevolent Acts TSD.

Table 4.13.1-3: Disruptive Scenarios during Abandonment and Long-term Performance Phase

Scenario	Brief Description
Human intrusion	Inadvertent intrusion into the DGR via an exploration borehole
Severe shaft seal failure	Very poor performance of the shaft seals
Poorly sealed borehole	Site investigation borehole not properly sealed
Vertical fault	A transmissive vertical fault in the vicinity of the DGR

4.13.2 Conventional Malfunctions and Accidents

Non-radiological accidents were considered to occur both above-ground or at various locations underground during the site preparation and construction, operations, and decommissioning phases of the DGR Project. Conventional accidents during the abandonment and long-term performance phase are not considered since the repository and shafts will be sealed, surface facilities removed, and the site returned to an agreed-to end state, as described in Section 4.11.1. The list of credible conventional accidents during the DGR Project includes:

[104] *Analysis of additional disruptive scenarios was provided in OPG response to IR-EIS-09-460 (CEAA Registry Doc# 989).*

- electrical accident;
- loss of ventilation;
- spill of fuel, chemicals, lubricants or oils;
- exposure to substances hazardous to health;
- entrapment;
- structural instability;
- material handling accidents;
- shaft damage;
- fire/smoke;
- explosion/detonation;
- asphyxiation or severe reduction in air quality;
- vehicle accident; and
- occupational accidents.

Each credible malfunction and accident was screened to determine if it could reasonably result in an adverse environmental consequence and warrant further consideration, as documented in Section 8.3.1 and the Malfunctions, Accidents and Malevolent Acts TSD. Similarly, each credible malfunction and accident was screened to determine if it could reasonably be expected to result in an adverse consequence to members of the public. Based on this screening, bounding non-radiological accident scenarios were identified. The two bounding accidents advanced for further consideration are: (1) explosion/detonation, and (2) spill of fuel, chemicals, lubricants or oils.

Occupational hazards to workers were identified in the Preliminary Conventional Safety Assessment [68]. The assessment of hazards to workers was conducted systematically using a screening process hazard analysis method combined with a job hazard analysis approach. The list of credible hazards to workers is presented in the Malfunctions, Accidents and Malevolent Acts TSD.

The assessment of conventional malfunctions and accidents is presented in Section 8.3.

4.13.3 Malevolent Acts

There are four broad categories of potential malevolent acts: threats of violence; sabotage; theft; and attack. Threats and theft are not considered in this assessment[105].

The DGR is entirely contained within the Bruce nuclear site and will remain well protected by the Bruce nuclear site security forces from the start of site preparation and construction through decommissioning of the facility. A suite of security measures will be in place at the DGR facility, as described in the Malfunctions, Accidents and Malevolent Acts TSD.

---

[105] *Additional clarification on threats and theft as potential malevolent acts were provided in OPG response to IR-EIS-05-195 (CEAA Registry Doc# 793).*

Potential malevolent acts are considered for each DGR Project phase: site preparation and construction; operations; decommissioning; and abandonment and long-term performance. Malevolent acts are described and assessed in Section 8.4.

4.14 ORGANIZATION AND MANAGEMENT

4.14.1 Site Preparation and Construction Phase

During the regulatory approvals and site preparation and construction phases, OPG, as the proponent of the DGR Project, will maintain overall responsibility for its development, although its primary role will be in overseeing and monitoring the performance of its contractor, the NWMO. The OPG management system applicable to the DGR is described in OPG's Deep Geologic Repository Management System [76]. Figure 1.3-1 shows OPG's organization and management structure for the site preparation and construction phase. The NWMO, under contract to OPG, is managing regulatory approvals and the design and construction[106] of the DGR Project on behalf of OPG. The operational responsibility for the DGR Project will reside with OPG's Nuclear Waste Management Division. Figure 4.14.1-1 shows the NWMO organization and management structure for the site preparation and construction phase.

The NWMO will manage the engineering, site preparation and construction work for the DGR Project. The Project Quality Plan for the site preparation and construction phase will be compliant with CAN/CSA N286-05 [77] and ISO 9001:2008 quality management standards, include project specific quality objectives, and describe the quality requirements for all the functional areas of site preparation and construction for the DGR. The Project Quality Plan will ensure that quality continues to be integrated into final design decisions so that component configurations, materials specifications, functional performance, safety and constructability are optimized. During construction, the Project Quality Plan will be focused on providing assurance that there is strict conformance to these final design and planning decisions. The Project Quality Plan will include the specification of quality requirements in engineering design deliverables, contract documentation, materials and equipment acceptance, construction documentation and the required level of quality assurance for validation testing, inspections and commissioning.

The project design consultant will also develop a Project Quality Plan that achieves the following:

- meets the minimum NWMO requirements;
- identifies responsibilities for quality assurance and control;
- specifies auditing and corrective actions requirements; and
- maintains a register of quality compliance relating to reviews, and checks of designs.

The quality program includes provisions for systematic planned audits and assessments designed to provide a comprehensive, critical and independent evaluation of project activities. These audits and assessments cover the overall quality program, sub-tier programs, and

[106] The NWMO will also be the constructor for the DGR Project.

interfaces between programs. The audits and assessments monitor compliance with governing procedures, standards and technical requirements, and confirm that quality program requirements are being effectively implemented. Audit and assessment results are documented, reported to and evaluated by a level of management having sufficient breadth of responsibility to assure actions are taken to address the findings.

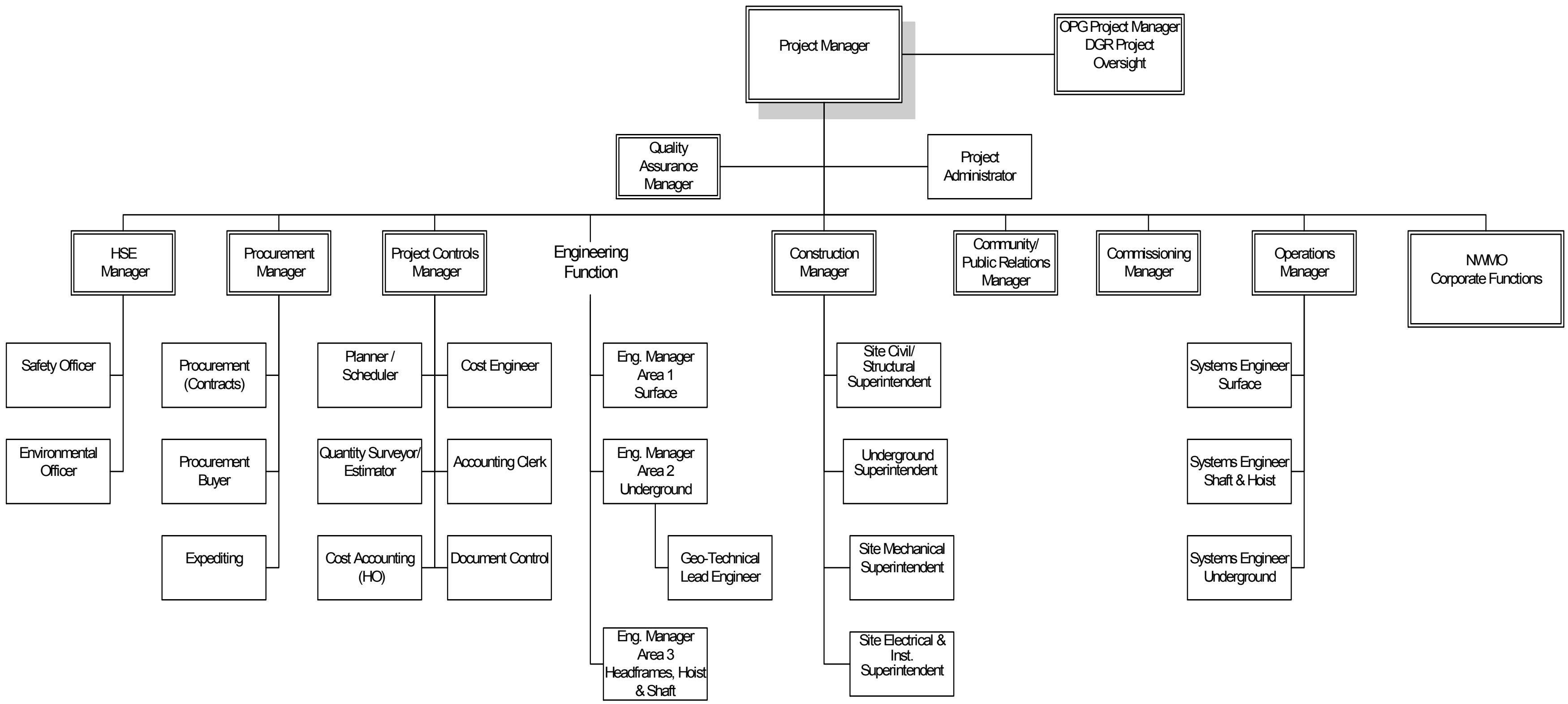


Figure 4.14.1-1: NWMO's Site Preparation and Construction Phase Organization

(a) – as shown in March 2011 submission

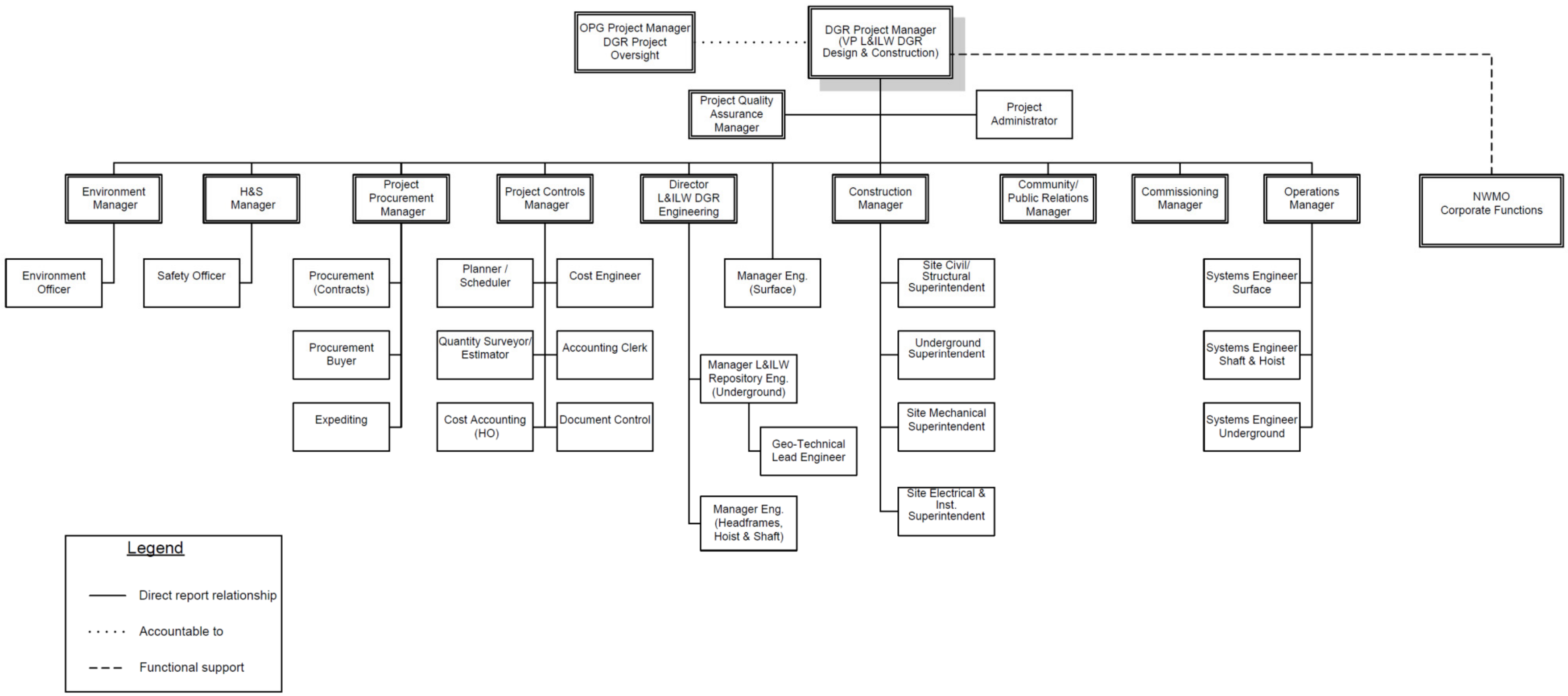


Figure 4.14.1-1: NWMO's Site Preparation and Construction Phase Organization

(b) – as shown in updated NWMO Management System Document, DGR-PD-EN-0001 R001

Additional oversight of activities is provided through self-assessment and the non-conformance and corrective action program. In particular, the corrective action program assures that non-conformance conditions are identified, documented, reported, evaluated and corrected in a timely manner.

The Project Quality Plan is supported by NWMO governance that establishes expectations for engineering and design, safety assessment, procurement, occupational health and safety, environmental protection, product and services approval, document control and records keeping. Additional information on these requirements is provided in Section 4.7.8.

4.14.2 Operations Phase

OPG will have accountability for operation of the DGR in accordance with nuclear safety, health and safety, economic, environmental, security and quality requirements, including the implementation of environmental mitigation measures, environmental monitoring and management of potential adverse effects[107].

Operation of the DGR will fall within the responsibility of OPG's NWMD. It is expected that the DGR will operate using governance and an organizational structure appropriate for a nuclear waste management facility and consistent with those currently in place at the WWMF, including the Nuclear Waste Management Program, which describes the organizational responsibilities, interfaces and key program elements for the management of nuclear waste. Governing documents provide the means to ensure that only specified and accepted processes and practices are used, are carried out by qualified staff, and meet the requirements of applicable standards. The program establishes the overall system for the NWMD and incorporates, directly or by reference, the controls necessary to meet the requirements of CSA N286-05, ISO 14001, and OHSAS 18001, and others as appropriate to the DGR, its related facilities and activities.

The Vice President of Nuclear Waste Management holds overall responsibility for the operation of the DGR facility. Managers within the organization are responsible for ensuring implementation of their individual assigned area. Figure 4.14.2-1 shows the current management structure within OPG's NWMD and identifies the anticipated placement of DGR Manager within the overall organizational structure.

[107] *Additional clarification was provided in OPG response to IR-EIS-05-213 on where Health, Safety and the Environment (HSE) as well as Communications fits within the organization chart (CEAA Registry Doc# 776).*

DESCRIPTION UPDATE

Revised organization description and chart were provided in OPG response to IR-EIS-09-456 (CEAA Registry Doc# 957).

OPG's and its Nuclear Waste Management Division's (NWMD) organization charts have changed since Figure 4.14.2-1 in the Environmental Impact Statement was submitted. The organization is no longer structured with the same ten management functions displayed in this figure. In 2012 for example, the Engineering organization was transferred to report directly to OPG's Chief Nuclear Engineer and continues to provide support to NWMD through a dotted-line reporting relationship.

OPG is currently undergoing a Business Transformation which involves further reorganization into centre-led business functions. Under this model, the support functions of Health, Safety and Environment (HSE) and Communications are provided through centre-led groups to the Nuclear Waste Management Division operating organization. Below is an organization chart which indicates that the support functions have a dotted-line reporting relationship to the NWMD organization.

However, it is critical to note that ensuring that the DGR facility will operate in accordance with the Nuclear Safety and Control Act and its regulations is not accomplished through a specific organizational chart but rather through its governance structure.

The NWMD Vice-President reports directly to the Chief Nuclear Officer of OPG. As such, NWMD is governed by the Nuclear Management System Charter, N-CHAR-AS-0002. That charter then provides authority to the Nuclear Waste Management system contained within W-PROG-WM-0001 "Nuclear Waste Management" which provides the framework for the nuclear waste program within OPG. This program document "establishes the overall system for NWMD and incorporates, directly or by reference, the controls necessary" for compliance with several standards.

Within that program document, the controls and measures in place to manage Health, Safety and the Environment are fully documented. The program document also provides a link to N-STD-AS-0013, External Communications for a managed system with respect to Communications.

As NWMD and OPG move towards the operational phase of the DGR, it is conceivable that organizational structures may change again. However, a governance structure will always be in place, regardless of the organization layout, that will ensure that the facility is operating under the requirements of the Nuclear Safety and Control Act.

4.14.3 Decommissioning Phase

Organization and management of the decommissioning phase will be the responsibility of OPG and will follow OPG governance in place at the time.

4.15 ENVIRONMENTAL PROTECTION POLICIES AND PROCEDURES

The OPG Environmental Policy OPG-POL-0021 [53] has been adopted by the NWMD as its environmental policy. The policy provides the guiding principles for environmental management and environmental performance within the division. The four key principles of the environmental policy are:

- practice pollution prevention;
- meet or exceed regulations;
- continual improvement in environmental performance; and
- monitor and report on environmental performance.

The guiding policy statement is: "OPG will strive to continually improve its environmental performance by committing to the following seven requirements:

- **Meet or Exceed Legal Requirements**: Meet all legal requirements and OPG's voluntary commitments, with the objective of exceeding those standards where appropriate and feasible.
- **Advance Environmental Stewardship**: Contribute to environmental protection, pollution prevention and energy and resource use efficiency.
- **Maintain ISO 14001 System**: Maintain registrations to the International Organization for Standardization (ISO) 14001: 2004 Environmental Management System.
- **Integrate Environment in Decision-Making**: Integrate environmental factors and stakeholder considerations into our planning, decision-making and business practices.
- **Engage Employees**: Engage and educate employees to conduct their activities in a manner that respects and protects the environment.
- **Contribute to Our Communities**: Contribute to and enhance the environmental well-being of the communities in which we operate and the broader public who grant us our licence to operate.
- **Communicate**: Measure and publicly communicate our environmental performance with employees, governments, local communities, contractors and other stakeholders."

Environmental procedures for construction are under development and will be finalized once the detailed DGR Project design has been established. A detailed Environmental Management Plan DGR-PLAN-07002-0001 will be developed and implemented by the contractor for the site preparation and construction of the DGR Project, and will be consistent with accepted practices and standards.

OPG's existing Environmental Management System (EMS) is ISO 14001 certified, and will serve as the governing document during the operations phase of the DGR Project. The ISO 14001 EMS system helps OPG to make certain that its environmental policies are managed, implemented, checked and reviewed within an overall context of continuous improvement. Within operations, the EMS is instrumental in assisting the business units to manage their potential environmental effects.

All OPG employees have accountability for protecting the environment and for complying with applicable policies and procedures.

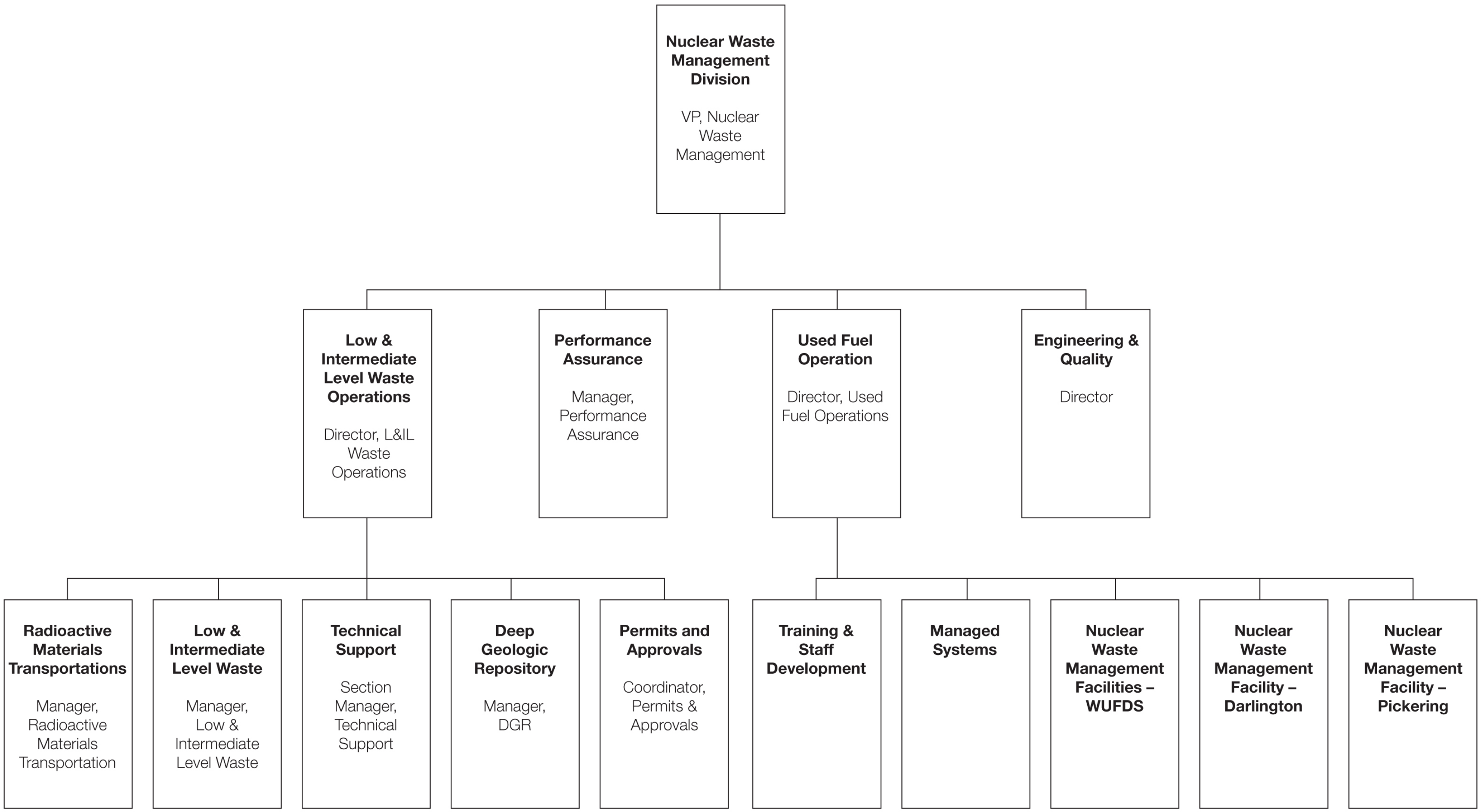


Figure 4.14.2-1: Operations Phase Organization

(a) – as shown in March 2011 submission

Nuclear Waste Organization (with Centre-Led Business Unit Support)

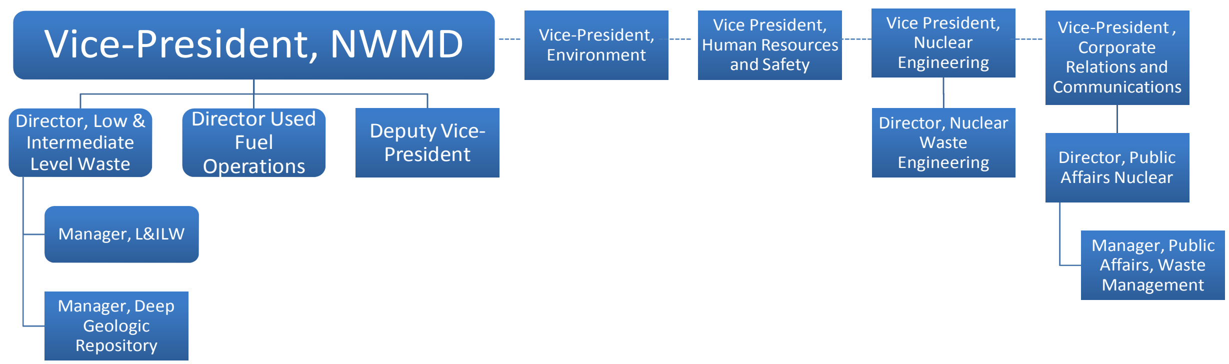


Figure 4.14.2-1: Operations Phase Organization

(b) – updated as per OPG response to IR-EIS-09-456 [CEAA Registry Doc# 957])

4.15.1 Environmental Protection

Environmental protection policies, programs and procedures will be established as described in Section 4.7.8 (site preparation and construction phase) and Section 4.8.7 (operations phase).

Execution of the programs will be accomplished through an integrated set of documented activities, typical of an EMS and it will also integrate the documentation activities related to the DGR EA Follow-up Monitoring Program [78]. A conceptual EA follow-up monitoring plan is described in Section 12 of this report. The results of the follow-up monitoring carried out during the site preparation and construction, and operations phases of the DGR Project will contribute to the overall EMS.

4.15.1.1 Control of Radiation Exposure and Contamination

A key practice in maintaining control of radiation exposure and contamination is through the use of zoning. The two radiological zones to be used for the DGR Project are defined as follows:

- Zone 1 is a clean area which is not a radiological zone and may be considered the equivalent of a normal public access area.
    - Zone 1 shall not contain radioactive sources other than those found in normal industrial establishments, or those specifically approved for use in applications such as training and demonstrations.
    - Fixed contamination levels in Zone 1 shall not exceed the established contamination limit for Zone 1 surfaces. No detectable loose contamination shall be permitted in Zone 1.
    - Zone 1 shall have a very low probability of cross-contamination from adjacent areas and shall have a low general radiation background, not exceeding the established limit.
- Zone 2 is a radiological zone that is normally free of contamination but is subject to infrequent cross-contamination due to the movement of personnel and equipment from contaminated areas.
    - Zone 2 is normally free of radioactive sources other than those found in normal industrial establishments, or those specifically approved (e.g., waste containers in the case of the DGR).
    - Zone 2 shall have a low general radiation background.
    - Where appropriate, local containment systems shall be used when radioactive systems in Zone 2 are opened or leaking.
    - If local containment systems are not used, a rubber area shall be established when radioactive systems in Zone 2 are opened or leaking, and it shall be removed promptly when work on the system is complete.

Generally accessible areas outside the DGR will be maintained at Zone 1 within the dose rate constraint ≤0.5 μSv/h. All spaces within the DGR facility perimeter will be classified in accordance with the potential for contamination. All areas of the DGR associated with the handling of radioactive waste will be designated as Zone 2. These include the crossing from the WWMF to the WPRB, the WPRB, shafts and the underground areas. Office and amenities areas at the DGR will be designated Zone 1. A Zone 1 and Zone 2 boundary is located within the amenities area for the movement and tracking of personnel. As all areas underground (i.e. below the shaft collars) will be Zone 2, access to the lunchroom underground will require the use of the whole body and small article monitors.

DESCRIPTION UPDATE
Information on updated radiological zoning was provided in OPG letter dated Feb.10, 2012 (Item #6, CEAA Registry Doc# 336).
The radiological zoning has been updated to include the ventilation shaft headframe and the ventilation exhaust area within Zone 2 in recognition that the ventilation exhaust may contain contaminated air.

Minimizing the spread of radioactive contamination relies on the skills and knowledge of workers and their diligence in exercising good contamination control practices. These good practices may entail the use of additional effort in detecting and controlling contamination. Furthermore, inter-zonal monitoring will provide the final barrier to the spread of radioactive contamination to the public domain.

Safety measures at the DGR for visitors will be similar to current safety measures for visitors at the WWMF. The safety of members of the public who take part in tours of OPG's WWMF is accomplished by following strict conventional and radiological safety practices. First of all, visitors are required to wear the appropriate general PPE consisting of a hard hat, safety glasses, and safety shoes and to use hearing protection when required. As it relates to radiation protection, visitors are taken on approved tour routes limited to areas with radiation hazards well below limits that require posting per the CNSC requirements. Secondly, all visitors participating in facility tours in radiologically zoned areas are required to wear a dosimeter (thermoluminescent dosimetry badge, which is used to measure radiation exposure) and be subjected to comprehensive whole body monitoring for contamination upon exiting from that area. Finally, the WWMF Routine Radiological Survey program continuously monitors, assesses and reports on the radiological conditions of the facility to ensure it meets the stringent requirements of the OPG Corporate Radiation Protection Program and applicable CNSC regulations.

4.15.2 Environmental Monitoring Programs

Environmental monitoring of the DGR Project will be comprehensive in terms of substances, media and locations, and will include, at the minimum, the following:

- sampling and analyzing run-off leaving the DGR Project site;
- groundwater monitoring[108];
- monitoring airborne emissions from the WPRB;

[108] *Additional information was provided in OPG response to IR-EIS-08-383 regarding the existing near-surface groundwater monitoring activities and long-term monitoring strategy (including measurement parameters) (CEAA Registry Doc# 886).*

- measuring average ambient radiation dose rates at the perimeter of the DGR Project site;
- storage structure integrity checks; and
- contamination checks and radiation surveys within the DGR Project site.

OPG and Bruce Power have established comprehensive environmental monitoring programs that apply to the Bruce nuclear site and will apply to the DGR Project. The purpose of these programs is to ensure compliance with the Nuclear Safety and Control Regulations, applicable federal and provincial legislation, and corporate requirements[109].

Non-radioactive releases to the environment are regulated by the Ontario Ministry of the Environment (MOE). Certificates of Approval will be obtained as required for the DGR Project. OPG will monitor environmental releases in accordance with these Certificates of Approval and report the results as required. OPG will comply with other regulatory requirements as well, such as reporting requirements under the National Pollutants Release Inventory [79] and O. Reg.127/01 [80].

Overviews of the programs are provided in the following sections. DGR Project monitoring programs are expected to be similar to the existing WWMF monitoring programs. Additional information on monitoring programs is available in Chapter 10 of the Preliminary Safety Report [26].

4.15.2.1 Facility Controls and Monitoring

Control and monitoring systems will perform several functions:

- monitoring and alarming any detection of fire, noxious or explosive gases;
- monitoring radioactivity and other contaminants in underground water (in the shaft sumps) and air (at the exhaust fan intakes);
- monitoring the status of equipment and installations;
- tracking the location of vehicles underground;
- monitoring the status of the shaft hoists and positions of conveyances;
- tracking waste package locations;
- providing input to the planning system for control of waste package movement and transfer schedule; and
- monitoring changes in underground rock/excavation conditions (e.g., rock movement, stress).

As well as providing real time data for daily management and safety control, the monitoring system will capture and save data over time to establish the DGR facility and environmental baseline conditions, and assess the performance of various DGR structures, systems and components relative to design specifications and baseline conditions.

---

[109] *Additional information was provided in OPG response to IR-EIS-03-67 regarding the adequacy of the radiological environmental monitoring program in light of the DGR radionuclide inventory (CEAA Registry Doc# 608).*

Underground rock and shaft concrete structures will be monitored using rock mass and pillar convergence instrumentation, embedded and surface-mounted concrete load cells in the shaft linings, and rock dowel load cells. Real-time data will be transmitted to the surface control room for collection and analysis as stated above.

The quality of air delivered to access tunnels and rooms will be monitored to ensure concentration of potential contaminants is below acceptable limits for worker safety. Similarly, the quality of air that is exhausted to atmosphere via the ventilation shaft will be monitored to ensure the concentrations of potential contaminants comply with Certification of Approval limits.

Once all of the emplacement rooms have been filled and closed, the DGR will be monitored to ensure that it is performing as expected prior to decommissioning. This period of monitoring prior to the start of decommissioning is included in the operations phase, as described in Section 4.6. The length of the monitoring period will be decided at some future time in consultation with the regulator.

In the longer term, the borehole monitoring systems will be dismantled and permanently sealed. Regulatory approval processes at that time may require implementation of continuing institutional controls to prevent the public from accessing the site for some period of time. Further monitoring could be required, but at a reduced level. Any remaining facilities would ultimately be dismantled.

4.15.2.2 Effluent Monitoring

A follow-up monitoring program is recommended to ensure that the concerns identified in the EIS are carried forward. This program is discussed in Section 12, and outlines the effluent monitoring program elements that will be carried. Where possible, effluent monitoring will be integrated with existing WWMF monitoring programs.

4.15.2.3 Bruce Nuclear Site Radiological Environmental Monitoring Program

The WWMF radiological monitoring program is a component of the Bruce nuclear site Radiological Environmental Monitoring Program (REMP) administered by Bruce Power. The REMP is designed to measure environmental radioactivity in the vicinity of the Bruce nuclear site from all site sources. Data from the REMP are used to assess off-site public dose consequences resulting from the operation of nuclear facilities at the Bruce nuclear site, including the WWMF.

The REMP is conducted at fixed locations within the Bruce nuclear site and at control areas 10 to 20 km from the Bruce nuclear site. Monitoring is carried out for radioactivity in the atmosphere, water, aquatic biota, sediments and terrestrial foodstuffs. In all environmental monitoring programs, the media sampled, locations, frequency of sampling and the analyses performed are in accordance with four primary objectives:

- to confirm that discharges of radioactive materials are under control;
- to verify that site-specific release limits (Derived Release Limits or DRLs) assumptions remain valid;
- to permit an estimate of doses to the public resulting from emissions; and
- to provide data to aid development and/or evaluation of models that describe the movement of radionuclides through the environment.

WWMF operations are carried out such that radiological exposures to workers and the public, and effects on the environment, are maintained within regulatory limits and kept as low as reasonably achievable (ALARA). Normal WWMF process operations do not have any significant radiological off-site consequences to members of the public or detectable radiological effects on the environment, as described in Section 6.6. WWMF emissions are typically only a small fraction of emissions from the Bruce nuclear site.

The REMP will continue to assess the off-site consequences of all Bruce nuclear site operations, including those of the DGR Project, and will continue to report environmental monitoring data and trends. For public dose purposes, it is impossible to distinguish between contributions from Bruce Power operated facilities and the WWMF, hence reporting is done on a Bruce nuclear site-wide basis.

4.16 OCCUPATIONAL HEALTH AND SAFETY PROGRAMS

Occupational Health and Safety programs will be implemented as part of the DGR Project. Section 4.7.8.7 outlines the Health and Safety Management Plan DGR-PLAN-08962-1001 for the site preparation and construction phase, and Section 4.8.7 outlines several occupational health and safety programs that will be implemented for the operations phase of the DGR Project. OPG believes that healthy employees working safely in an injury-free and healthy workplace is good business, and OPG integrates public safety considerations into business practices and decisions[110].

OPG and its contractors will meet all applicable health and safety legislative requirements. OPG will also meet other associated standards to which it subscribes with the objective of moving beyond compliance. OPG will require that contractors and their subcontractors maintain a level of safety equivalent to that of OPG employees while at OPG workplaces.

The safety program elements in place at the WWMF that are applicable to the DGR Project include the following:

- Occupational Radiation Protection Program;
- Occupational Radiological Risks; and
- Occupational Non-radiological (Conventional) Safety Management.

---

[110] *Clarifications on the Health and Safety Safety Management Plan for DGR construction were provided in OPG response to IR-LPSC-04-66 (CEAA Registry Doc# 989).*

These programs are described further, below. In addition, as previously noted in Section 4.7.2.1, the DGR does not fall under the definition of a mine in the OHSA and the Ontario Mining Regulations [29]; however, there are many aspects of the facility (hoists and shafts) that are not covered adequately in any regulations other than the Mining Regulations. OPG intends to apply the OMR, as appropriate, to the DGR Project to ensure protection of workers.

4.16.1 Occupational Radiation Protection Program

As described in Section 4.8.7.1, an Occupational Radiation Protection Program is currently in place for the WWMF, and is expected to form the basis for the DGR radiation protection program. The program identifies operations and materials that have the potential to contribute to occupational dose. The program provides guidelines and procedures to monitor and minimize occupational dose and reduce the potential for contamination at the WWMF, and these guidelines and procedures will also be applicable to the DGR.

The occupational radiation safety practices implemented under the program are consistent with OPG Radiation Protection Requirements for nuclear facilities and radiography operations,the Nuclear Safety and Control Regulations, and the ALARA (As Low As Reasonably Achievable) principle. Existing and proposed structures within the WWMF have been designed with consideration for these requirements, as has the DGR.

4.16.1.1 Occupational Dose Control

The doses arising from routine waste management operations are monitored and assessed against dose targets. Thermoluminescent Dosimeter (TLD) badges will be worn as a minimum external dosimetry requirement for personnel involved in the operation of the DGR Project.

Consistent with current WWMF procedures, access to the buildings/structures associated with the DGR Project will be limited to designated personnel and those escorted by qualified personnel. The WWMF is designated as a Radiological Controlled Area. As described in Section 4.15.1.1, the DGR and portions of the associated surface infrastructure (e.g., the WPRB) will also be designated as a Radiological Controlled Area.

4.16.1.2 Contamination Control

During storage, the containers are monitored for loose contamination. Any occurrence of loose contamination is removed by manually wiping with a cloth, or by wet methods if necessary, taking appropriate measures for containment of contamination at the source and personnel protection.

The presence of detectable loose contamination is considered an abnormal operating condition. Personnel are trained to respond to such events according to procedures. Follow-up would also be undertaken, including appropriate communications and actions by WWMF and waste generator personnel to reasonably prevent reoccurrence. Contamination controls are in place to prevent the spread of contamination throughout the WWMF, and it is expected such controls would extend to the DGR.

4.16.1.3 Radiological Hazard Monitoring

Existing Radiation Protection Program requirements include area gamma radiation monitoring and routine radiological surveys, as well as contamination monitoring. The main objective of monitoring is the timely detection of changes in radiological hazard levels so that appropriate remedial actions can be taken and radiation exposures avoided. Routine gamma radiation surveys are performed to cover the entire sequence of WWMF operations including:

- monitoring for overall changes in radiation levels; and
- initiating corrective action, if needed, as per approved radiation protection procedures to maintain occupational safety standards.

4.16.1.4 Occupational Radiological Risks

Potential occupational radiological hazards associated with the DGR Project operations can be categorized as:

- chronic radiological hazards associated with normal operations; and
- acute radiological hazards associated with malfunctions and accidents.

A discussion of chronic radiological hazards is provided in Section 7.6. Malfunctions and accidents are discussed in the Malfunctions, Accidents and Malevolent Acts TSD and are summarized in Section 8.

4.16.2 Predicted Worker Doses

The radiological doses predicted for the workers involved with the associated operations activities during the operations phase are presented in Section 7.6. Details of the prediction methods are provided in Chapter 7 of the Preliminary Safety Report [26].

4.16.3 Occupational Non-Radiological (Conventional) Safety Management

The goal of the Conventional Safety Program will be to ensure workers work safely in a healthy and injury-free workplace by managing and mitigating risks associated with activities, products and services of OPG operations. Risk reduction will be primarily achieved through compliance, by competent workers, to effective operational controls, developed through effective risk assessment and safe work planning.

Occupation conventional safety as it applies to the DGR Project is documented in detail in the Preliminary Conventional Safety Assessment [68]. Section 4.7.8.7 provides a summary of the Health and Safety Management Plan that will apply during site preparation and construction. As noted in Section 4.8.7.3, an overall Occupational Health and Safety Program will be implemented for the operations phase of the DGR Project. This program will be consistent with the requirements of OPG's Conventional Safety Program that is applicable to its nuclear facilities.

4.17 FIRE PROTECTION AND EMERGENCY RESPONSE

The Bruce nuclear site is served by its own internal Emergency Response Team, medical aid and fire prevention facilities. In addition, a comprehensive on- and off-site emergency response plan is in place[111]. Response teams have been trained and are equipped to respond to potential emergencies such as personal injury, fire or non-routine releases of radioactivity. The municipal fire department, the Regional Medical Officer of Health and Kincardine's health and safety service providers work co-operatively with Bruce Power, which coordinates site-wide fire protection and emergency response, to ensure that additional support and response capability is in place.

As stated in Section 4.8.7.10, trained and qualified mine rescue teams will be provided as required by the Mines and Mining Plants Regulations (O. Reg. 854 [29])[112,113].

4.17.1 Emergency Response

Three types of events could occur at the DGR that will require a planned emergency response[114]:

- **Fire:** Immediately following a fire alarm, all workers would report to a refuge station. Workers in the vicinity of the fire will assess the situation and use the nearest fire extinguisher. If the fire is not extinguished promptly, the nearest mine rescue team will be called. A second team will be called to the site, as back-up to the first team. The mine rescue team will evacuate the workers after a fresh air passage can be guaranteed to the surface.
- **Rock fall:** In the unlikely event of a rock fall, the mine rescue team will be used to assess the situation and initiate a recovery strategy depending on the circumstances.
- **Radiological contamination release:** For a container failure in an emplacement room, the ventilation system will pull any contamination in the air stream away from the workers. Workers will evacuate to a refuge station. Management will initiate a pre-developed plan for rescue of the personnel, similar to that described by procedures implemented by a fire alarm.

---

[111] *Additional clarification on emergency response and preparedness arrangements were provided in OPG responses to IRs LPSC-01-45 (CEAA Registry Doc# 363), EIS-06-269 (CEAA Registry Doc# 823).*

[112] *Additional clarification on mine rescue support during construction and operation phases was provided in OPG response to IR-LPSC-03-61 (CEAA Registry Doc# 608).*

[113] *Additional information on mine safety was provided in OPG's written submission (Sec. 5.0) and presentation to JRP TIS #1 (CEAA Registry Doc# 636).*

[114] *Additional clarification on ventilation in the event of release of significant volatile radionuclides/hazardous substances was provided in OPG response to IR-LPSC-01-15 (CEAA Registry Doc# 363).*

Malfunctions and accidents are further discussed in Sections 4.13 and 8.

4.17.2 Fire Protection Systems

Fire safety is an important consideration for the design and operation of the DGR. The wastes for emplacement in the DGR are all in non-combustible containers and pallets, and the DGR and its associated infrastructure are designed to avoid or minimize combustible materials. Additionally, as described previously, only small quantities of diesel fuel and no explosives will be stored on the DGR Project site during the operations phase. The following sections describe the fire protection systems design.

4.17.2.1 Surface Facilities

All DGR surface facilities will be equipped with fire detection and protection systems in accordance with the National Building Code of Canada [81] and the National Fire Code of Canada [82] requirements. In the event of power failure, the system will be powered by the emergency generator power supply, as described in Section 4.4.3.2. Smoke detectors and heat detectors will be located throughout the buildings to provide means for early detection of fire.

A number of fire hydrants will be located near main entrances to the buildings. Office, maintenance and locker room areas will be protected with large volume Class ABC fire extinguishers consistent with National Fire Code requirements.

4.17.2.2 Underground Facilities

There are multiple independent communication systems that will alert workers in the unlikely event of a fire underground. During construction and operations a "stench gas" system will be employed as the prime notification system for fire. A distinct and foul smelling but safe gas is introduced to the intake air and distributed through the ventilation system. This type of system is widely used in Ontario mines effectively as a warning agent to workers.

An underground fire detection system will consist of smoke and carbon monoxide detectors located throughout the underground workings (i.e., intake plenum, underground working areas and emplacement rooms through all stages and the main exhaust ventilation ducts). This system will alarm to the control panel and will also be audible underground. This system is intended for the operations phase of the DGR Project.

Underground fire suppression systems will be chemical-based as opposed to water-based[115]. The following suppression methods are included:

- handheld foam-based extinguishers located at clearly marked locations in high traffic areas (i.e., diesel fuel bay, mechanical shop) as well as on mobile equipment;

[115] *Additional clarifications on fire suppression methods were provided in OPG responses to IRs LPSC-01-16, LPSC-01-22 (CEAA Registry Doc# 363).*

- a mobile foam generator will be based underground for use in open emplacement rooms; and
- diesel equipment will be equipped with on-board foam suppression systems that are heat triggered (i.e., automatic system), and could also be manually activated by the operator in the event of a fire.

4.18 BASIS FOR THE EA

The Basis for the EA is a summary of the specific works and activities for the DGR Project. These works and activities are assembled into groups, allowing the potential interactions of the DGR Project with the environment to be evaluated in a logical, replicable and concise manner. Most of the DGR Project works and activities fall under one of the specific DGR Project phases identified in Section 4.6, though some works and activities span multiple DGR Project phases (e.g., waste management). There are no specific works and activities associated with the abandonment and long-term performance phase, and the abandonment of the DGR facility work and activity is considered to occur at the close of the decommissioning phase for the purposes of this EA. Table 4.18-1 presents the works and activities used to assess the likely effects of the DGR Project on the environment.

Although site preparation, construction, and operations activities will generally be implemented in a sequential development approach as shown on Figure 4.2-1, some activities may also apply to one or more phases.

Table 4.18-1: Basis for the EA of the DGR Project

Project Works and Activities	Description
Site Preparation	Site preparation would begin after receipt of a Site Preparation Licence and would include clearing approximately 30 ha of the DGR Project site and preparing the construction laydown areas. Activities would include: • Removal of brush and trees and transfer by truck to on-site storage; • Excavation for removal and stockpiling of topsoil and truck transfer of soil to stockpile on-site; • Grading of sites, including roads, construction laydown areas, stormwater management area, ditches; • Receipt of materials including gravel, concrete, and steel; • Installation of construction roads and fencing; • Receipt and installation of construction trailers and associated temporary services; and • Install and operate fuel depot for construction equipment.

Project Works and Activities	Description
Construction of Surface Facilities	Construction of surface facilities will include the construction of the waste transfer, material handling, shaft headframes and all other temporary and permanent facilities at the site. Activities would include: • establish a concrete batch plant; • receipt of construction materials, including supplies for concrete, gravel, and steel by road transportation; • excavation for and construction of footings for permanent buildings, and for site services such as domestic water, sewage, electrical; • construction of permanent buildings, including headframe buildings associated with main and ventilation shafts; • receipt and set up of equipment for shaft sinking; • construction of abandoned rail bed crossing between WWMF and the DGR site; • fuelling of vehicles; and • construction of electrical substation and receipt and installation of standby generators.
Excavation and Construction of Underground Facilities	Excavation and construction of underground facilities will include excavation of the shafts, installation of the shaft and underground infrastructure (e.g., ventilation system) and the underground excavation of the emplacement and non-storage rooms. Activities will include: • drilling and blasting (use of explosives) for construction of main and ventilation shafts, and access tunnels and emplacement rooms; • receipt and placement of grout and concrete, steel and equipment; • dewatering of the shaft construction area by pumping and transfer to the above-ground stormwater management facility; • temporary storage of explosives underground for construction of emplacement rooms and tunnels; • receipt and installation of rock bolts and services; and • installation of shotcrete.
Above-ground Transfer and Receipt of Waste	Above-ground handling of wastes will occur during the operations phase of the DGR Project and will include receipt of L&ILW from the WWMF at the staging area in the DGR Waste Package Receiving Building (WPRB) and on-site transfer to shaft. Above-ground handling of wastes includes: • receipt of disposal-ready waste packages from the WWMF by forklift or truck • offloading of waste packages at the WPRB; • transfer of waste packages within the WPRB by forklift or rail cart; • temporary storage of waste packages inside the WPRB.

Project Works and Activities	**Description**
Underground Transfer of Waste	Underground handling of wastes will take place during the operations phase of the DGR Project and will include: • receipt of waste packages at the the main shaft station; • offloading from cage and transfer of waste packages by forklift to emplacement rooms; • rail cart transfer of some large packages (Heat Exchangers/Shield Plug Containers) to emplacement rooms; • installation of end walls on full emplacement rooms; • remedial rock bolting and rock wall scaling; • fuelling and maintenance of underground vehicles and equipment; • receipt and storage of fuel for underground vehicles. Emplacement activities will be followed by a period of monitoring to ensure that the DGR facility is performing as expected prior to decommissioning.
Decommissioning of the DGR Project	Decommissioning of the DGR Project will require a separate environmental assessment before any activities can begin. Decommissioning of the DGR Project will include all activities required to seal shafts and remove surface facilities including: • removal of fuels from underground equipment; • removal of surface buildings, including foundations and equipment; • receipt and placement of materials, including concrete, asphalt, sand, bentonite for sealing the shaft; • construction of concrete monolith at base of two shafts, removal of shaft infrastructure and concrete liners, and reaming of some rock from the shafts and shaft stations; • sealing the shaft; and • grading of the site. The waste rock pile (limestones) will be covered and remain on-site.
Abandonment of the DGR Facility	Timing of abandonment of the DGR facility will be based on discussion with the regulator. Activities may include removal of access controls.
Presence of the DGR Project	Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security over the life cycle of the DGR Project. This includes the aesthetics and vista of the DGR facility.

Project Works and Activities	Description
Waste Management	Waste management represents all activities required to manage waste during the DGR Project. During construction waste management will include managing the waste rock along with conventional waste management. During operations, waste management would include managing conventional and radiological wastes from the underground and above-ground operations. Decommissioning waste management may include management of conventional and construction wastes. Activities include: • transfer of waste rock, by truck to the WRMA; • placement of waste rock on the storage pile; • collection and transfer of construction waste to on-site or licensed off-site facility; • collection and transfer of domestic waste to licensed facility; • collection, processing and management of any radioactive waste produced at the DGR facility; and • collection, temporary storage and transfer of toxic/hazardous waste to licensed facility.
Support and Monitoring of DGR Life Cycle	Support and monitoring of DGR life cycle will include all activities to support the safe construction, operation, and decommissioning of the DGR Project. This includes: • operation and maintenance of the ventilation fans, heating system, electrical systems, fire protection system, communications services, sewage and potable water system and the standby generator; • collection, storage, and disposal of water from underground sumps, and of wastewater from above-and below ground facilities; • management of surface drainage in a stormwater management facility; • monitoring of air quality in the facility, exhaust from the facility, water quality of run-off from the developed area around the shafts and Waste Rock Management Area, water quality from underground shaft sumps and geotechnical monitoring of various underground openings; • maintenance and operation of fuel depots above-ground (construction only) and below-ground; and • administrative activities above- and below-ground involving office space, lunch room and amenities space.
Workers, Payroll and Purchasing	Workers, payroll and purchasing will include all workers required during each phase to implement the DGR Project. Activities include: • spending in commercial and industrial sectors; • transport of materials purchased to the site; and • workers travelling to and from site.

References

[26] Ontario Power Generation (OPG). 2011. *Deep Geologic Repository for Low and Intermediate Level Waste - Preliminary Safety Report.* 00216-SR-01320-00001 R000.

[27] Quintessa Ltd., Geofirma Engineering Ltd., and SENES Consultants Ltd. 2011. *Postclosure Safety Assessment .* NWMO DGR-TR-2011-25.

[28] Nuclear Waste Management Organization (NWMO). 2011. *Geosynthesis.* NWMO DGR-TR-2011-11 R000.

[29] Government of Ontario. 1990. *Occupational Health and Safety Act - Mines and Mining Plants Regulations R.R.O 1990.*

[30] Ontario Power Generation (OPG). 2010. *Reference Low and Intermediate Waste Inventory for the Deep Geologic Repository.* 00216-REP-03902-00003 R003.

[31] Canadian Standards Association (CSA). 2008. *Management of Low and Intermediate Level Radioactive Waste.* CSA N292.3.

[32] Canadian Nuclear Safety Commission (CNSC). 2000. *Nuclear Substances and Radiation Devices Regulations.* SOR/2000-207.

[33] Nuclear Waste Management Organization (NWMO). 2011. *Design and Construction Phase Management System (OPG's L&ILW DGR).* DGR-PD-EN-0001 R000.

[34] Nuclear Waste Management Organization (NWMO). 2011. *Design Management.* NWMO-PROC-EN-0001.

[35] Nuclear Waste Management Organization (NWMO). 2011. *Community Engagement Plan.* DGR-PLAN-06020-1001.

[36] Nuclear Waste Management Organization (NWMO). 2011. *Records Management.* NWMO-PROC-AD-0002.

[37] Nuclear Waste Management Organization (NWMO). 2011. *Standards for Controlled Documents.* NWMO-STD-AD-0001.

[38] Nuclear Waste Management Organization (NWMO). 2011. *Document Management Plan.* DGR-PLAN-00121-1002.

[39] Nuclear Waste Management Organization (NWMO). 2011. *Procurement Procedure.* NWMO-PROC-FN-0006.

[40] Nuclear Waste Management Organization (NWMO). 2011. *Health and Safety Policy.* NWMO-POL-WM-0002.

[41] Nuclear Waste Management Organization (NWMO). 2011. *Environment Policy.* NWMO-POL-ES-0001.

[42] Nuclear Waste Management Organization (NWMO). 2011. *Design and Construction Phase Project Quality Plan for OPG's DGR for L&ILW.* DGR-PLAN-00120-0006.

[43] Ontario Power Generation (OPG). 2011. *Radiation Protection Program.* OPG Program Document N-PROG-RA-0013.

[44] Canadian Nuclear Safety Commission (CNSC). 2000. *Radiation Protection Regulations.* SOR/2000-203.

[45] Canadian Nuclear Safety Commission (CNSC). 2000. *General Nuclear Safety and Control Regulations.* SOR/2000-202.

[46] Canadian Nuclear Safety Commission (CNSC). 2000. *Class I Nucear Facilities Regulations.* SOR/2000-204.

[47] Ontario Power Generation (OPG). 2011. *Radiological Zoning, Personnel/Material Monitoring and Transfer Permits.* OPG Procedure N-PROC-RA-0014.

[48] Ontario Power Generation (OPG). 2011. *Environmental, Health and Safety Management Program.* OPG Program Document W-PROG-ES-0001.

[49] Ontario Power Generation (OPG). 2011. *Health and Safety Policy.* OPG Policy OPG-POL-0001.

[50] Ontario Power Generation (OPG). 2011. *Nuclear Safety Policy.* OPG Policy N-POL-0001.

[51] Ontario Power Generation (OPG). 2011. *Safety Management System Program.* OPG Program Document OPG-HR-SFTY-PROG-0001.

[52] Ontario Power Generation (OPG). 2011. *Selection of Radiation Personal Protective Equipment.* OPG Procedure N-PROC-RA-0025.

[53] Ontario Power Generation (OPG). 2011. *Environmental Policy.* OPG Policy OPG-POL-0021.

[54] Ontario Power Generation (OPG). 2011. *Biodiversity Policy.* OPG Policy OPG-POL-0002.

[55] Ontario Power Generation (OPG). 2011. *Land Assessment ad Remediation Policy.* OPG Policy OPG-POL-0016.

[56] Ontario Power Generation (OPG). 2011. *Spills Management Policy.* OPG Policy OPG-POL-0020.

[57] Ontario Power Generation (OPG). 2011. *Policy for Use of Ozone Depleting Substances.* OPG Policy OPG-POL-0015.

[58] Canadian Nuclear Safety Commission (CNSC). 2006. *Regulatory Standard S-296: Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills.*

[59] Ontario Power Generation (OPG). 2011. *Training Program.* OPG Program Document N-PROG-TR-0005.

[60] Ontario Power Generation (OPG). 2011. *Fire Protection Procedure.* OPG Procedure W-PROC-ES-0011.

[61] Ontario Power Generation (OPG). 2011. *Employee Emergency Response Procedure.* OPG Procedure W-PROC-ES-0002.

[62] Ontario Power Generation (OPG). 2011. *Conduct of Operations and Maintenance Program.* OPG Program Document W-PROG-OM-0001.

[63] Ontario Power Generation (OPG). 2011. *Records and Document Control.* OPG Program Document N-PROG-AS-0006.

[64] Ontario Power Generation (OPG). 2011. *Controlled Document Management.* OPG

Procedure N-PROC-AS-0003.

[65] Ontario Power Generation (OPG). 2011. *Creating and Maintaining Dose Records.* OPG Document N-HPS-03413.1-0004.

[66] Ontario Power Generation (OPG). 2001. *Radiation Protection Requirements - Nuclear Facilities.* OPG Document N-RPP-03415.1-10001-R07.

[67] Ontario Power Generation (OPG). 2011. *Records and Documentation.* OPG Procedure N-PROC-TR-0012.

[68] MARCH Consulting Associates Inc. 2011. *Preliminary Conventional Safety Assessment.* NWMO DGR-TR-2011-37 R000.

[69] Nuclear Waste Management Organization (NWMO). 2011. *Geoscientific Verification Plan.* NWMO-DGR-2011-38 R000.

[70] Nuclear Waste Management Organization (NWMO) and Cadesco. 2011. *Preliminary Decommissioning Plan.* NWMO DGR-TR-2011-39 R000.

[71] Canadian Nuclear Safety Commission (CNSC). 2000. *Regulatory Guide G-219: Decommissioning Planning for Licensed Activities.*

[72] Canadian Standards Association (CSA). 2009. *Decommissioning of Facilities Containing Nuclear Substances.* CSA N294-09.

[73] Government of Ontario. 2007. *Mining Act - Mine Development and Closure Regulations under Part VII of the Mining Act.* O.Reg. 240/00.

[74] Canadian Nuclear Safety Commission (CNSC). 2006. *Regulatory Guide G-320: Assessing the Long Term Safety of Radioactive Waste Management.*

[75] International Atomic Energy Agency (IAEA). 2011. *IAEA Safety Requirements: Geological Disposal of Radioactive Waste.* IAEA Safety Standard WS-R-4.

[76] Ontario Power Generation (OPG). 2011. *Deep Geologic Repository Management System.* 00216-CHAR-0001 R000.

[77] Canadian Standards Association (CSA). 2005. *Management System Requirements for Nuclear Power Plants.* CAN/CSA/ N286-05.

[78] Nuclear Waste Management Organization (NWMO). 2011. *DGR EA Follow-up Monitoring Program.* NWMO DGR-TR-2011-10 R000.

[79] Government of Canada. 1999. *Canadian Environmental Protection Act - National Pollutants Release Inventory Under CEPA 1999, Part 3, Section 48.*

[80] Government of Ontario. 2001. *Environmental Protection Act - Airborne Contaminant Discharge Monitoring and Reporting, O. Reg. 127/01.*

[81] Government of Canada. 2005. *National Building Code of Canada.*

[82] Government of Canada. 2005. *National Fire Code of Canada.*

DESCRIPTION UPDATE

The following references have been updated:

[33] Nuclear Waste Management Organization (NWMO). 2013. Design and Construction Phase Management System (OPG's L&ILW DGR Project). DGR-PD-EN-0001 R001

[53] Ontario Power Generation (OPG). 2012. Environment Policy. OPG Policy OPG-POL-0021. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447)

[54] Ontario Power Generation (OPG). 2012. Biodiversity Policy. OPG Policy OPG-POL-0002. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447)

[55] Ontario Power Generation (OPG). 2012. Land Assessment ad Remediation Policy. OPG Policy OPG-POL-0016. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447)

[56] Ontario Power Generation (OPG). 2012. Spills Management Policy. OPG Policy OPG-POL-0020. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447)

[57] This policy no longer exists. (OPG response to IR-EIS-02-41, CEAA Registry Doc# 447)

[69] Nuclear Waste Management Organization (NWMO). 2014. Geoscientific Verification Plan. NWMO-DGR-2011-38 R001. (OPG response to IR-EIS-12-511, CEAA Registry Doc# 1792)

[76] Ontario Power Generation (OPG). 2013. Deep Geologic Repository Project, Management System. 00216-CHAR-0001 R001.

[81] Government of Canada. 2010. National Building Code of Canada. (OPG response to IR-LPSC-01-01, CEAA Registry Doc# 363)

[82] Government of Canada. 2010. National Fire Code of Canada. (OPG response to IR-LPSC-01-01, CEAA Registry Doc# 363)