ONTARIO POWER GENERATION

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OPG Proprietary

February 28, 2023

CD# NK054-CORR-00531-10751

MR. DENIS SAUMURE
Commission Registrar

Canadian Nuclear Safety Commission
280 Slater Street
Ottawa, ON
K1P 5S9

Dear Mr. Saumure:

DNNP – Submission of Package #5(a) Core Control Processes and Operations Aspects Deliverable in Support of the Licence to Construct Application for the CNSC Review

Reference:

1. OPG Letter, M. Knutson to D. Saumure, "Darlington New Nuclear Project – Application for a Licence to Construct a Reactor Facility", October 31, 2022, CD# NK054-CORR-00531-10738
2. OPG Letter, M. Knutson to S. Eaton, "DNNP - Submission of the Licence to Construct Application Plan Revision R01", June 1, 2022, CD# NK054-CORR-00531-10667
3. CNSC Letter, B. Rzentkowski to M. Knutson, "Canadian Nuclear Safety Commission (CNSC) staff response to Darlington New Nuclear Project (DNNP) Licence to Construct (LTC) Application Plan Revision R01", July 15, 2022, CD# NK054-CORR-00531-10706
4. OPG Letter, M. Knutson to D. Saumure, "DNNP – Submission of Package #5(b) - Core Control Processes & Operations Aspects Confidential Deliverables in Support of the Licence to Construct Application for the CNSC Review", February 28, 2023, CD# NK054-CORR-00531-10766

The purpose of this letter is to submit the Package #5(a) Core Control Processes and Operations Aspects deliverable in support of the Licence to Construct (LTC) Application (Reference 1) to the CNSC for review as stated in the LTC Application Plan (References 2 and 3).

The following document is enclosed in the Package #5(a) submission (see Table 1).

Table 1: List of Package #5(a) Core Control Processes & Operations Aspects Deliverable

Enclosure #	Document Title	Document Number	Revision #
1	DNNP – Solid Radioactive Waste Management Strategy	NK054-PLAN-03460-00001	R000

The confidential documents of Package #5 are submitted to the CNSC as part of a separate Package #5(b) submission (Reference 4).

Should you have any questions or require additional information, please contact Ms. Sevana Bedrossian, Manager, Regulatory Affairs – DNNP Licensing at (416)-716-3879 or by email at sevana.bedrossian@opg.com.

Sincerely,

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Enc.

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S. Eaton - CNSC (Ottawa)
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Enclosure 1

DNNP – Solid Radioactive Waste Management Strategy

NK054-PLAN-03460-00001 R000

December 23, 2022

SNC · LAVALIN

	Document Number **DWM-03011-ASD-002**	Revision **0**
Nuclear Project Number **691687**	Contract Number **438600006**	Page **1**
Customer Document Number	Customer Name **Ontario Power Generation**	

Title:
DNNP - SOLID RADIOACTIVE WASTE MANAGEMENT STRATEGY

Project: **Decommissioning Waste Management**

691687	438600006		APPROVED FOR USE	2022/12/23
FINANCIAL PROJECT NO	CONTRACT NO	CHANGE ORDER	DESCRIPTION	RELEASE DATE

ONTARIO POWER GENERATION

OPG Document Number	
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OPG Security Classification	
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ACCEPTED AS NOTED	
REVISE AND RESUBMIT	

JWooland — 23-Dec-2022

Signature **Date**

Name: Jason Wooland

Dept: NSS Eastern Operations

This acceptance does not relieve the contractor from responsibility for errors or omissions or from any obligations or liability under this contract.

Notes:

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	Document Number	Revision
	DWM-03011-ASD-002	0
Nuclear Project Number	Contract Number	Page
691687	438600006	2
Customer Document Number	Customer Name	
	Ontario Power Generation	

Title:
DNNP - SOLID RADIOACTIVE WASTE MANAGEMENT STRATEGY

Project: **Decommissioning Waste Management**

Prepared by

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Revision History

Ref. Procedure NU-907020-PRO-001

For Release Information, refer to the Document Transmittal Sheet accompanying this document.

Revision History

Revision		Details of Rev.	Prepared By	Reviewed By	Approved By
No	Date (yyyy/mm/dd)				
D1	2022/11/25	Issued for “Review and Comments”.	S. Julien D. Cuthbert	Z. Walker (DR) R. Khaloo (DL) P. Tume H. Hughes	
D2	2022/11/30	Issued for Client Review	S. Julien D. Cuthbert	R. Khaloo J. Matilainen	P. Tume
0	2022/12/21	Issued as “Approved for Use”, Revision 0 for Client release	S. Julien D. Cuthbert	K. Tsang	P. Tume

TERMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
APM	Adaptive Phase Management
BWR	Boiling Water Reactor
CANDU	Canada Deuterium Uranium
CFD	Condensate Filters and Demineralizer
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
DGR	Deep Geological Repository
DWMF (NSS-D)	Darlington Waste Management Facility (Nuclear Sustainability Services-Darlington)
DNGS	Darlington Nuclear Generating Station
DNNP	Darlington New Nuclear Project
EA	Environmental Assessment
FPC	Fuel Pool Cooling and Cleanup
GE	General Electric
GNF	Global Nuclear Fuel
HEPA	High Efficiency Particulate Air
HIC	High Integrity Container
IAEA	International Atomic Energy Agency
ICC	Isolation Condenser Pool Cooling and Cleanup System
ILW	Intermediate-Level Waste
LLW	Low-Level Waste
LPRM	Local Power Range Monitors
LTC	Licence to Construct
LWM	Liquid Waste Management
MPCa	Maximum Permissible Concentration for air
NSCA	Nuclear Safety and Control Act
NSS	Nuclear Sustainability Services
NWMO	Nuclear Waste Management Organization
OPEX	Operating Experience
OPG	Ontario Power Generation
PSAR	Preliminary Safety Analysis Report
RWB	Radioactive Waste Building
RW	Radioactive Waste
SB	Storage Building
SCC	Stress Corrosion Cracking
SRNM	Start-Up Range Neutron Monitors
SRWMS	Solid Radioactive Waste Management Strategy
SSC	Structures, Systems, and Components
SWM	Solid Waste Management
VCT	Vertical Cask transporter

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APPENDICES

1. INTRODUCTION

For more than 50 years, OPG has been a world leader and innovator in nuclear material management. Our proven programs and resources will be leveraged to safely manage the nuclear by-products for the Darlington New Nuclear Project (DNNP), just as we have done for decades with our existing nuclear fleet.

Nuclear by-products are managed by OPG's Nuclear Sustainability Services (NSS) division which is a leader in safe and environmentally-sound management of nuclear by-products for OPG and the Canadian nuclear industry. OPG's NSS team has three key pillars that govern their operations:

- Stewardship: We (NSS) accept, transport, process and store nuclear by-products carefully and thoughtfully. It is a job done with pride and purpose. Above all else, the safety of our employees and the public is our highest priority.
- Lasting solutions: OPG remains focused on achieving permanent and safe solutions for nuclear by-products, to protect people, the Great Lakes and the environment.
- Peace of mind: Sound methods are used to reduce nuclear by-products from our facilities and secure its safe storage. By earning the confidence and trust of regulators and the public, we maintain our social licence to operate.

Like all industries and energy-producing technologies, the use of nuclear results in some by-products. Unlike other industries, the nuclear sector takes full responsibility for all its materials, all of it accounted for, monitored, and safely stored.

OPG also embraces the environmental "three Rs" – reduce, re-use and recycle – to minimize volumes of stored materials, and to divert clean materials to re-use and recycle. In this context, such nuclear by-products are not waste as they have economic value, therefore this document recognizes "nuclear by-products" as radioactive material that are within the implementation of the waste hierarchy as a process. Where there is industry recognized term, or specific system labeled as "waste", the terminology "waste" is retained in the document.

OPG has a mature and effective waste management program that meets all applicable regulatory requirements and related objectives. These programs are fully developed, implemented, and audited to control and minimize the volume of nuclear by-products generated by licensed activities.

OPG currently holds a Nuclear Power Reactor Site Preparation Licence PRSL 18.00/2031 for the DNNP. OPG has developed this Solid Radioactive Waste Management Strategy (SRWMS) to support the Licence to Construct (LTC) Application that was submitted to Canadian Nuclear Safety Commission (CNSC) in October 2022 [1]. This supporting document provides the strategy for the management of low and intermediate level solid nuclear by-products that are managed as waste, used fuel and irradiated in-core components and addresses D-C-9.1 Radioactive Waste Management Plan commitments as stated in NK054-REP-01210-00078 R008 [4].

Activities to be licenced under the DNNP LTC will not involve the generation of radioactive nuclear by-products as the reactor is not operational (i.e., generating power). However, the information provided in this document is to inform how the radioactive nuclear by-products will be managed through the lifecycle of the DNNP.

The SRWMS is developed and structured in alignment with CNSC's Regulatory Document REGDOC-2.11.1, Waste Management, Volume I: Management of Radioactive Waste [13] and according to steps in the life-cycle management of solid radioactive nuclear by-products, from production in the nuclear facility, through decommissioning and disposal. It builds on information provided in Chapter 11 of the DNNP Preliminary Safety Analysis Report (PSAR) [5]. The SRWMS minimizes nuclear by-products generation through a waste-led design approach in the development of the DNNP. By minimizing the nuclear by-products generated, the radiation exposure to workers and the public is reduced to align with the As Low as Reasonably Achievable (ALARA) principles.

Section 2 lists the CNSC's Regulatory Documents, Canadian Standards Association (CSA) standards and OPG Documents used as guidance in the development of the SRWMS. Section 3 describes the Solid Waste Management (SWM) systems for the DNNP [5] and classification of Low-Level Waste (LLW), Intermediate-Level Waste (ILW) and high-level nuclear by-product waste (i.e., used fuel). Section 4 describes the pertinent physical nature and radioactive source terms of LLW, ILW, and used fuel generated during normal operations of a single-unit BWRX-300[1].

Section 5 describes the nuclear by-products handling, minimization through design and operational nuclear by-products management, and segregation program for the DNNP. The SRWMS factors in the OPG waste management practices at Darlington Nuclear Generating Station (DNGS). This approach and most components of OPG's waste management practices can be applied to the management of routine operational nuclear by-products with the objective of minimizing, as far as practicable, the nuclear by-products for storage and/or disposal. The waste hierarchy in the management of radioactive nuclear by-products is a requirement of REGDOC-2.11.1, which re-enforces a waste-led design approach, including preventing generation, reducing volume and radioactivity content, reusing and recycling of radioactive material and are incorporated into the strategy, where practicable and effective to do so.

Section 6 describes the packaging, transferring and storage of LLW, ILW and used fuel. Section 7 describes the methods and facility that will be used for the disposal of LLW, ILW and used fuel. Section 8 describes the strategy for the safe management of decommissioning nuclear by-products.

1.1 Scope and Objectives

The SRWMS for the DNNP ensures all solid Radioactive Waste (RW) produced throughout the plant's lifetime from operations to decommissioning are safely controlled, collected, handled, processed, stored, and disposed of, and radiation exposure to the plant operating staff and public meets dose and regulatory limits and is ALARA.

The SRWMS is developed based on the current BWRX-300 design and operational experience (OPEX) in existing nuclear generating stations. The SRWMS will evolve with the development of the BWRX-300 design and incorporate best management practices in nuclear generating stations.

An estimate of the quantities and activity levels of solid radioactive nuclear by-products generated during normal operations and maintenance at this stage of the design process are provided in Appendix A . This strategy, the volumes, and activity levels of the nuclear by-products will be updated at a future licensing phase.

Radioactive liquid and gaseous waste management systems are outside the scope of the SRWMS and are detailed in Chapter 11 of the PSAR [5].

1.2 Indigenous Engagement

OPG acknowledges the Aboriginal and treaty rights of Indigenous communities as recognized in the *Constitution Act, 1982* and is committed to engaging with Indigenous Nations and communities regarding its nuclear operations and future projects, including the DNNP. OPG's Indigenous Relations policy provides a framework for engaging with Indigenous peoples and supporting community programs and initiatives.

[1] If more units are to be sited at Darlington, this strategy may need to be updated but the general approach is expected to be similar to what is presented here.

In general, the purpose of OPG's Indigenous Engagements is to:

- Keep local Indigenous communities informed of nuclear station operations, emerging projects, and environmental performance reporting and monitoring.
- Take appropriate steps to fulfill OPG commitment to meaningful engagement and consultation.
- Facilitate opportunities to participate in the development, implementation, and review of mitigation measures related to activities that may adversely impact the established Indigenous communities.
- Address and resolve concerns raised by local Indigenous communities as appropriate.

The Indigenous communities for inclusion in OPG Indigenous engagement program related to DNNP and the existing DNGS have been identified. The list is divided between those Indigenous communities that have Aboriginal and treaty rights in the area and those with interests. OPG invites these communities to engage regularly to share nuclear environmental reporting, operational updates, and project developments. OPG has also engaged on past licensing renewals, e.g., Pickering Waste Management licence renewal, Pickering Station license renewal, Darlington Refurbishment Project, and the DNNP.

1.3 Public Information and Disclosure

OPG's principles and processes for external communications are governed by the nuclear standard N-STD-AS-0013, *Nuclear Public Information and Disclosure* which applies to the DNNP as discussed in Section 5.3 of the LTC application [1]. OPG has continued to inform the stakeholders and public about the status of DNNP as part of the existing Darlington Nuclear public information program through various methods and forums, and will continue to do so throughout the construction period under the requested LTC application.

1.4 Nuclear By-Products Management Principles

The following principles are considered in the development of this strategy:

- **Protection of human health** – RW shall be managed in such a way as to secure an acceptable level of protection for human health.
- **Protection of the environment** –RW shall be managed in such a way as to provide an acceptable level of protection of the environment consistent with the DNNP Environmental Assessment (EA) and the Environmental Monitoring and Environmental Assessment Follow-up program for DNNP [29].
- **Protection of future generations** –RW shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
- **Burdens on future generations** – RW shall be managed in such a way that will not impose undue burdens on future generations. In this context, OPG sustainability goals and a waste-led design approach support this strategy.
- **National legal framework** –RW shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions. This framework includes future learnings and modernization of Canada's RW management policy and the Canadian Nuclear Safety and Control Act (NSCA).

- **Control of radioactive nuclear by-product generation and waste-led design** – Generation of radioactive nuclear by-products shall be kept to the minimum practicable.

  Using a waste-led design approach, systems that either contain or are affected by radioactivity will be assessed to identify nuclear by-products. The nuclear by-products will be assessed to prevent, reduce, re-use or recycle the materials relative to the system/component design, material selection, field activities, operations and maintenance, and decommissioning activity. Figure 1 shows the waste hierarchy principles applied by OPG in the waste-led design approach. Where materials are determined to be nuclear by-products that have no economic value, the processes will:

  - Ensure RW minimization, and where practical at the plant, the nuclear by-products will be sorted and segregated so that likely clean waste can be diverted from RW streams.
  - Contamination control will be diligently exercised to avoid cross contamination.
  - Only essential items will be brought into radioactive working areas.
  - Proper identification and characterizations of the nuclear by-products is done upfront to ensure its' proper management.
- **Radioactive nuclear by-products generation and management interdependencies** – Interdependencies among all steps in RW generation and management shall be appropriately considered.
- **Safety of facilities** – The safety of facilities for RW management shall be appropriately assured during their lifetime.

The following sections speak to the strategy for implementation of these principles for nuclear by-products that are determined to have no economic value (i.e., waste).

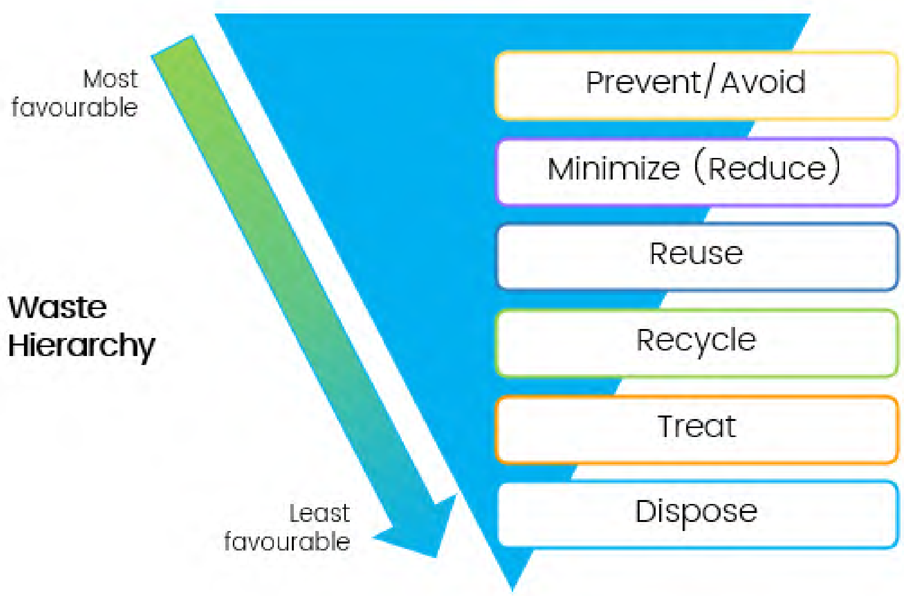

Figure 1: Waste Hierarchy

1.5 Basis

This is the proposed strategy based on currently available information. Informed by ongoing stakeholder engagement and communications, the strategy will be further defined and optimized to support a future application for an operating licence.

LLW and ILW:

1. Consistent with the waste hierarchy, nuclear by-products will be sorted, segregated, and processed to have a minimal disposal footprint.
2. The LLW and ILW will be transported to an appropriate licensed radioactive waste management facility[2] for interim storage until a disposal facility becomes available [27].
3. The licensed radioactive waste management facility will have sufficient storage capacity for the interim storage of LLW and ILW volumes generated throughout the lifetime of the DNNP.
4. The nuclear by-products will meet the waste acceptance criteria for the interim storage at the waste management facility. When applicable, these nuclear by-products may be further conditioned, sorted, and segregated.

Used Fuel:

5. Used fuel will be stored on the Darlington site where they will remain until a disposal facility becomes available [4].
6. The used fuel will eventually be disposed in a Deep Geological Repository (DGR) which is the responsibility of Nuclear Waste Management Organization (NWMO).
7. A DGR will have sufficient storage capacity for the disposal of used fuel volumes generated throughout the DNNP lifetime and will accommodate the criteria of DNNP used fuel.

The licensed radioactive waste management facility and DGR will factor in future improvements from the modernization of Canada's radiation waste management policy and recommendations [27].

2. REGULATIONS, STANDARDS AND OPG DOCUMENTS

The following documents have been used for guidance in developing the strategy with the expectation that they may be applicable for a future application.

2.1 Regulatory Documents

- The Nuclear Safety and Control Act [7]
- REGDOC-1.1.2, Licence Application Guide: Guide to Construct A Reactor Facility, Version 2 (Published October 2022) [8]
- REGDOC-2.4.3, Nuclear Criticality Safety [9]
- REGDOC-2.7.1, Radiation Protection (ALARA) [10]
- REGDOC-2.9.1, Environmental Principles, Assessments and Protection Measures [11]
- REGDOC-2.11, Framework for Radioactive Waste Management and Decommissioning in Canada [12]
- REGDOC-2.11.1, Waste Management, Volume I: Management of Radioactive Waste [13]

[2] The licensed radioactive waste management facility is a facility for the interim storage of LLW and ILW.

- REGDOC-2.11.2, Decommissioning [16]
- REGDOC-2.13.1, Safeguards and Nuclear Material Accountancy [15]
- SOR/2015-145, Packaging and Transport of Nuclear Substances Regulations [14]
- REGDOC-3.2.2, Indigenous Engagement [17]

2.2 CSA Standards

- CSA N292.0, General Principles for the Management of Radioactive Waste and Irradiated Fuel [18]
- CSA N292.1, Wet Storage of Irradiated Fuel and Other Radioactive Materials [19]
- CSA N292.2, Interim Dry Storage of Irradiated Fuel [20]
- CSA N292.3, Management of Low- and Intermediate-Level Radioactive Waste [21]
- CSA N292.5, Guideline for the Exemption or Clearance From Regulatory Control of Materials That Contain, or Potentially Contain, Nuclear Substances [22]
- CSA N294, Decommissioning of Facilities Containing Nuclear Substances [23]

2.3 OPG Documents

- Management of Waste and Other Environmentally Regulated Materials [2]
- Waste Acceptance Criteria for Low and Intermediate Level Radioactive Waste [3]

3. OPERATIONAL SOLID RADIOACTIVE NUCLEAR BY-PRODUCT MANAGEMENT

Radioactive solid nuclear by-products produced by DNNP is grouped into the following categories based on their physical-chemical properties and radiological characteristics:

1. Low-Level Waste (LLW)
2. Intermediate-Level Waste (ILW) and irradiated in-core components
3. High-Level Waste is used fuel

3.1 LLW and ILW

The SWM system controls, collects, handles, processes, facilitates packaging, and temporarily stores LLW and ILW [5] (see Section 4.2) generated throughout the life of the plant during normal operation (including maintenance and outage) and decommissioning prior to shipping the nuclear by-products to the licensed waste management facility. The design includes adequate provisions for the safe on-site handling, monitoring, sorting, packaging, transferring and storage of radioactive nuclear by-products consistent with options for off-site management or disposal that complies with the requirements (See Section 2.1) of the NSCA [7].

The SWM system will manage:

- filter backwash sludges,
- reverse osmosis concentrates,
- charcoal media,

- bead resins generated by the Liquid Waste Management (LWM) system, Fuel Pool Cooling and Cleanup (FPC), Isolation Condenser Pool Cooling and Cleanup system (ICC), and Condensate Filters and Demineralizer (CFD) system,
- contaminated solids such as High Efficiency Particulate Air (HEPA) filters, cartridge filters, rags, boxes, plastic, paper, gloves, protective clothing, tools, and equipment, and
- lab waste, chemicals and oily sump waste[3],

The SWM system is primarily located in the Radioactive Waste Building (RWB) with individual collection locations around the plant, and consists of:

- Spent Resin Processing
- Sludge Processing
- Operational Dry Solid Nuclear By-Products Processing

3.1.1 Spent Resin Processing

Spent bead resin slurry from the LWM system, ICC system, FPC system and CFD system are sent to dedicated spent resin tanks for collection and decay. When sufficient bead resins have been collected in the spent resin tank, resin is transferred to High Integrity Containers (HICs) for dewatering and eventual storage and/or disposal.

3.1.2 Sludge Processing

Filter backwash from the CFD, FPC and LWM systems is collected in sludge tanks to allow the solids to settle out. Backwash water from the high flow fine filtration filters can also be routed to the sludge tanks for processing and liquid removal. Once enough sludge has been collected, the sludge is transferred by the sludge tank transfer pumps to the HICs for dewatering, storage, and eventual disposal.

3.1.3 Operational Dry Solid Nuclear By-Products

Operational dry solid nuclear by-products consist of HEPA filters, air filters, miscellaneous paper, protective clothing, rags, etc., from contaminated areas; containment clothing, tools, and equipment parts that cannot be effectively decontaminated; and solid laboratory LLW. These nuclear by-product will be collected in containers located in appropriate areas throughout the plant, as dictated by volume of by-products generated during operation and maintenance. The containers will be sealed and moved to the nuclear by-products handling area for monitoring, sorting and temporary storage.

Provisions are made for remote operation of many routine radioactive waste management system functions. This feature reduces the worker dose from these activities.

3.1.4 In-Core Components

ILW includes in-core reactor components. The current concept is decay storage in the fuel pool followed by storage in appropriately shielded containers and subsequent disposal to a DGR.

3.2 Used Fuel

Used fuel is the high-level waste generated by DNNP.

[3] Oily sump wastes may be contaminated with some radionuclides creating mixed wastes.

4. SOURCE TERMS, CHARACTERIZATION AND ACCEPTANCE CRITERIA

4.1 Source Terms

4.1.1 LLW and ILW

The radionuclides present in reactor water and steam within the reactor pressure vessel fall into three distinct categories based on their production mechanism within the reactor core:

1) Fission products and Actinide products
2) Corrosion products
3) Activation products

The LLW and ILW produced by the DNNP consist of materials that have been contaminated with fission and activation products or have become radioactive as a result of neutron activation.

DNNP operating estimates of the volume and activity of LLW and ILW nuclear by-products is presented in Appendix A .

4.1.2 ILW In-Core Components

ILW in-core components arise solely from the periodic removal of various in-core components from the reactor. The nuclear by-products stream to be managed comprises of control rods and other ILW items (see Section 4.2.3).

All the ILW in-core components are neutron activated. These will be stored in the fuel pool for decay followed by storage in appropriately shielded containers and subsequent disposal to a DGR. The DNNP operating estimates of the volume and activity of ILW in-core components is presented in Appendix A .

4.1.3 Used Fuel

The used fuel generates heat via radioactive decay. The used fuel requires shielding from gamma radiation and neutrons, and contains long-lived radionuclides necessitating long-term isolation.

4.2 Nuclear By-Product Characterization

4.2.1 LLW

Low-level wastes are grouped into the following categories:

1. Compactible nuclear by-products: compactible nuclear by-products consists of pliable materials such as HEPA filters, cartridge filters (from Reactor Building, RWB, Turbine Building, Control Building), plastic, gloves, protective clothing, glass, empty nuclear by-product drums etc.
2. Non-processible: non-processible nuclear by-products includes concrete, contaminated equipment and tools, metal, etc.
3. Incinerable nuclear by-products: incinerable nuclear by-products consists of combustible materials such as paper, plastic, cloth, and some filter media that meets the waste acceptance criteria for incineration.

4.2.2 ILW

Intermediate-level wastes are grouped into the following categories:

1. Spent Resin: spent bead resin slurry from the LWM, ICC, FPC and CFD systems.
2. Contaminated Sludges: filter and demineralizer backwash from the CFD and LWM systems.
3. Spent Filters: FPC and CFD systems.

4.2.3 ILW In-Core Components

Irradiated in-core components are considered ILW such as reactor internals, hafnium cruciform control rods (used for neutron flux control in the reactor on a day-to-day basis), Start-up Range Neutron Monitors (SRNM) and Local Power Range Monitors (LPRM), fuel channel zirconium boxes and other reactor components which may originate from periodic removal during normal operations and decommissioning.

4.2.4 Used Fuel

The BWRX-300 core design uses a 240-bundle core configuration and utilizes low-enriched UO_2 fuel in the Global Nuclear Fuel's GNF2 fuel bundle assembly. Approximately 30-32 fuel assemblies will be removed from the reactor core every 12 to 24 months during the refuelling process. The radioactive fission products are contained in the fuel pellets within the fuel assemblies. Some degree of surface deposits will be accumulated on the fuel bundles, as well as activation products within the cladding.

4.3 Waste Acceptance Criteria

The OPG Waste Acceptance Criteria are used as guides for the conditioning, sorting, segregation, and minimization of LLW and in accordance with operational needs. The nuclide inventory of the nuclear by-products will be identified as part of the plant waste management systems.

4.3.1 LLW

LLW at OPG is categorized based on the types and processing equipment that OPG currently uses [3]. These types are:

1. Processible compactible.
2. Incinerable combustible.
3. Non-processible that is not incinerable or compactable.

4.3.2 ILW

Types of ILW are:

1. all radioactive nuclear by-products above a specified unshielded dose rate.
2. all alpha emitting nuclear by-products that is not used fuel, LLW or high thermal spent cobalt waste.
3. all filters and ion exchange (IX) columns with long half-life radionuclides, and
4. bulk IX resins.

The ILW are packaged and transported for interim storage at the licensed waste management facility.

4.3.3 ILW In-Core Components

The ILW in-core components will be placed in appropriately shielded containers until eventual disposal.

4.3.4 Used Fuel

The acceptance criteria for fuel handling, packaging and storage are described in Section 5.5 and 6.4.

5. NUCLEAR BY-PRODUCT HANDLING, MINIMIZATION AND SEGREGATION

5.1 Design Features

BWRX-300 design features that help reduce radioactive contamination and minimize nuclear by-products include:

1. Containment provided in areas where leaks and spills are most likely to occur.
2. Leak detection capability is provided for prompt detection of leakage from Structures, Systems, and Components (SSC).
3. Leak detection uses methods (e.g., instrumentation, automated samplers) capable of early detection of leaks in areas where it is difficult (inaccessible) to conduct regular inspections (such as the fuel pool and buried, embedded, or subterranean piping) to avoid release of contamination.
4. Decommissioning is facilitated by minimizing embedded piping, sumps, or buried equipment.
5. The plant is designed to facilitate the removal or replacement of equipment or components during facility operation or decommissioning.
6. The generation of radioactive contamination and nuclear by-products during operation and decommissioning is minimized by reducing the volume of components and structures that become contaminated during plant operation.
7. Material selection minimizes the creation of activated corrosion products.
8. Zinc injection minimizes dose rate from Co-60 deposition.

5.2 LLW

Methods such as good housekeeping, nuclear by-products analysis, segregation and minimization will be implemented into the DNNP waste management operating procedures and design. Material handling procedures will include provisions to separate products from their packages before the product is used in a potentially contaminated area. Tools that are brought into the active area are to remain there, to be reused to the maximum extent possible. As a standard for any waste management facility, a database system to track nuclear by-products is to be provided.

Typical best practices consistent with the plant design are described below:

1. The use of containers (to the extent possible) to collect the nuclear by-products in collection areas, which are provided at several locations on the boundary between the active and inactive zones.
2. These containers are subsequently sealed and checked externally for radioactivity level with a beta-gamma monitor at the sorting and segregation facilities located in the RWB.
3. The containers will be segregated into inactive and radioactive nuclear by-products based on prescribed criteria. The contamination criteria for determining the nuclear by-products as inactive and thereby allowing it to be disposed of as ordinary non-active solid nuclear by-products are based on Nuclear Substances and Radiation Devices Regulations [24].

4. Inactive and radioactive nuclear by-products will be placed into the appropriate stream for processing.
5. Inactive nuclear by-products (Likely Clean Waste) will be either recycled (if recyclable) or sent offsite to a landfill.
6. RW will be segregated into compactible, non-processible, and incinerable nuclear by-products, placed into appropriate containers and will subsequently be sent to the licensed waste management facility.
7. Contaminated materials such as tools, personal protection equipment, metal scaffolding, bins and metal skids and shielded flasks for transporting radioactive materials will be monitored, decontaminated (if required), and will be reused based on current best practices for LLW management in nuclear stations.

Figure 2 shows a simplified diagram for the segregation of the LLW. The solid LLW handling procedures and working practices ensure that the doses received by the worker/public and production of nuclear by-products are kept ALARA.

5.3 ILW

5.3.1 ILW Minimization

The BWRX-300 design contains a range of features that contribute to minimizing the radiation source term which reduces the radioactivity levels in the ILW:

1. The design, manufacture, and management of nuclear fuel to minimise the potential for a release of fission products from the fuel into the steam circuit or fuel pool water.
2. Minimize the use of and the impurity level of materials which may become activated due to exposure to the neutron flux of the reactor, including products of corrosion or wear (e.g., cobalt, antimony).
3. Reduction of the generation of used fuel and higher activity nuclear by-products for a given energy output.
4. Reduction of the generation of lower activity nuclear by-products for a given energy output.
5. Prompt detection and management of failed fuel.
6. Introduction of techniques to be used during commissioning, start-up, and shutdown to minimize the incidence of Stress Corrosion Cracking (SCC) of key reactor components.

5.3.2 Resins and Sludges

For the purpose of nuclear by-products segregation and minimization, the baseline design incorporates a number of stainless-steel tanks to store the resins and sludges separately. The resins contain higher levels of fission and corrosion products than the sludges generated from the LWM and CFD systems. The nuclear by-products segregation minimizes the total waste stream and storage.

The design of the sludge and resin treatment systems in the plant as described in the PSAR Chapter 11 is consistent with common practice for nuclear by-products treatment. However, this design can be developed for site specific requirements if necessary.

5.3.3 Spent Filters

The filters at each location are prepared for removal by dewatering and drying. On-site transfer of spent filters is accommodated by shielded flasks. The filters are picked up at the filter housing at the specified locations within the plant. The flasks are placed on top of the housing and the winch hoists the filter cartridge into the flask while keeping it shielded. Each filter flask has its own hoisting and winch mechanism to allow handling of the filter. The spent filter flask is temporarily stored on site, and then transported to the licensed waste management facility.

The design of the spent filter handling system incorporates many features (e.g., dewatering, drying, shielding) to ensure doses received by the worker/public and production of nuclear by-products are kept ALARA.

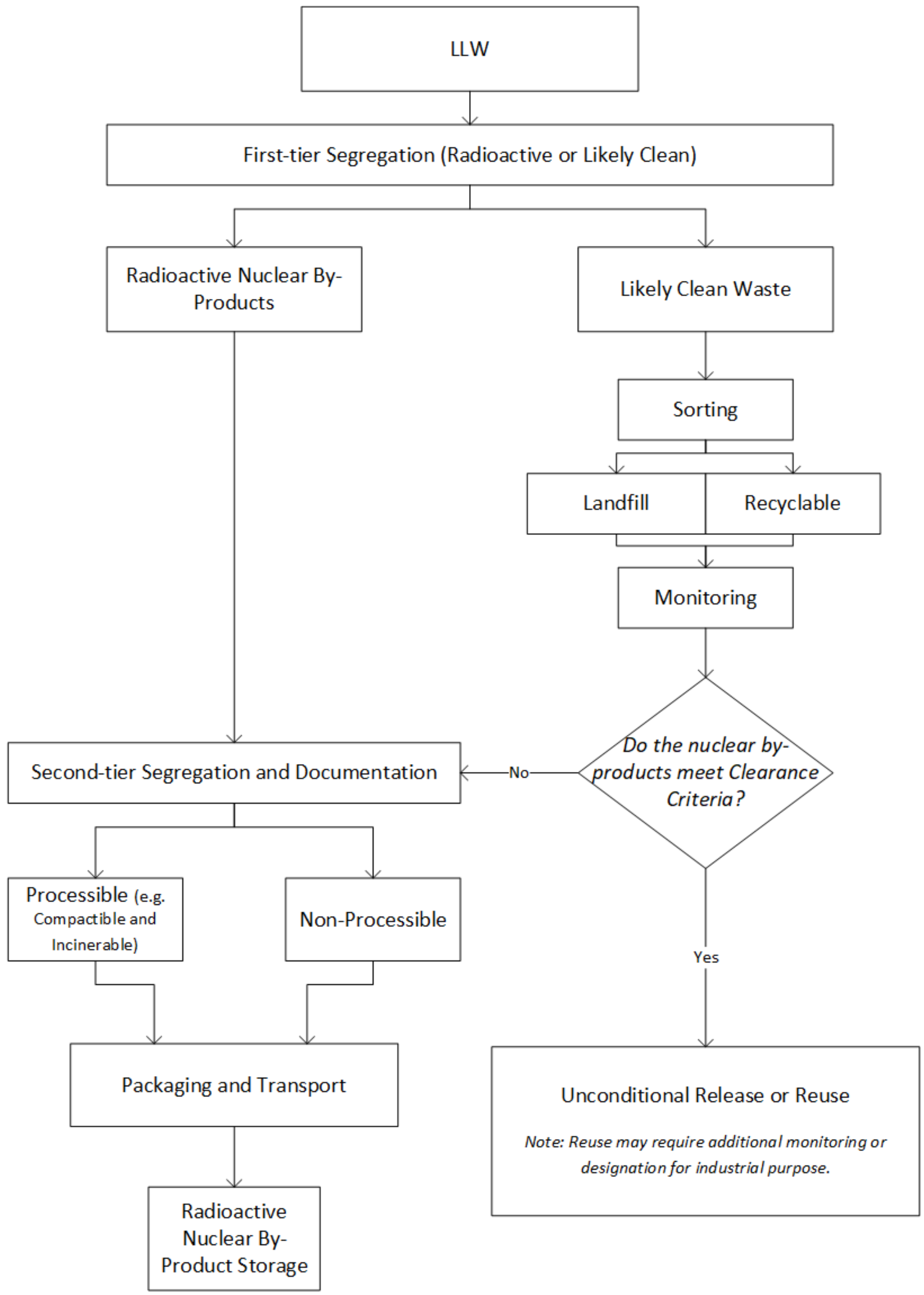

Figure 2: Simplified Diagram for Segregation and Minimization Approach for LLW

5.4 ILW In-Core Components

Reactor internals such as hafnium cruciform control rods (used for neutron flux control in the reactor on a day-to-day basis), SRNM and LPRM, fuel channel zirconium boxes and other reactor components will be transferred to the fuel pool for decay followed by storage in appropriately shielded containers subsequent disposal to a DGR.

5.5 Used Fuel

The BWRX-300 fuel handling process is based on well established Boiling Water Reactor (BWR) practices [6].

The reactor building will be supplied with a refueling machine which can be used for loading the fuel into the reactor as well as removing the used fuel [6]. Using a position indicating system, the refuelling machine removes the used fuel from the reactor vessel and transfers to the storage racks within the fuel pool where it will be stored until the used fuel is ready to be transferred to the on-site interim storage facility.

Before being transferred to the interim storage facility, the used fuel bundles are repackaged to ensure dose rates to the workers as well as the public are ALARA while being transferred. The typical process for handling the used fuel is laid out below and is consistent with the PSAR:

1) An empty canister which holds the fuel assemblies is placed into a heavily shielded transfer cask.
2) The transfer cask and empty canister are placed into the fuel pool.
3) The used fuel is placed into the empty canister and the canister lid is installed under water.
4) The transfer cask and canister are removed from the pool and placed on the cask transfer pad.
5) The canister lid is remotely seal welded, drained, dried, and backfilled with helium and the transfer cask lid is installed.
6) The transfer cask is moved out of the welding station and onto a transporter.
7) The transfer cask is lifted off the low-profile transporter and aligned with the overpack.
8) The canister is inserted into the overpack.
9) A lid is placed onto the overpack and the overpack is moved to the on-site interim storage facility.

The used fuel, once inside the overpacks and moved to the interim storage facility will remain there until it is ready to be repackaged and transported to a DGR by the NWMO.

The advanced design of the GNF2 fuel bundles and improved manufacturing process greatly reduces corrosion as well as improves debris resistance [6]. Thus, the probability of clad failure is decreased reducing radioactive nuclear by-products from fission products escaping the fuel bundle. The GNF2 fuel is currently in-use in many BWRs around the world and will provide valuable OPEX in the handling, storage, and disposal of the used fuel.

Using heavily shielded flasks, remote operated machinery, and by gaining OPEX, the dose rates to workers and the public at all stages of the used fuel handling process are kept as low as reasonably achievable to align with the ALARA principle.

6. NUCLEAR BY-PRODUCT PACKAGING, TRANSFER AND STORAGE

The detailed design for the packaging, transfer, and storage of LLW and ILW will be optimized in accordance with best available technology for the DNNP; the types of technologies being considered at this stage of the design process are based on OPG Waste Management Program.

6.1 LLW

LLWs are packed, transferred and stored using current technologies such as:

1. Compactible nuclear by-products: The volume of the nuclear by-products will be reduced by compaction. The compactible nuclear by-products are packed in steel containers (e.g., B25 or B1000 Compactor Boxes or equivalent) for storage at the licensed waste management facility.
2. Non-processible nuclear by-products: The nuclear by-products will be stored temporally in approved containers on-site without any physical processing but may be decontaminated when required. The non-processible nuclear by-products are packed in steel containers (e.g., low and high capacity non-processible containers) for the transportation to the licensed waste management facility.
3. Incinerable nuclear by-products: The incinerable nuclear by-products generated from the DNNP will be shipped to the licensed waste management facility for incineration. The ashes are stored at the licensed waste management facility.

6.2 ILW

ILWs are packed using current technologies described below:

Dewatered IX spent resin and sludges will be stored in HICs and temporarily packed and stored in reusable in-station shielded flasks. Spent filters will be packed in shielded flasks. The flasks are shipped in appropriate transport packages to the licensed waste management facility where their contents are stored either in an above ground storage in shielded packages, or in in-ground facilities using unshielded packages.

6.3 ILW In-Core Components

ILW in-core components will be transferred to the fuel pool for decay followed by storage in appropriately shielded containers and subsequent disposal to a DGR.

6.4 Used Fuel

A separate procedure for the handling, packaging, transfer, and storage of the used fuel has been described in this document. The packaging and transfer of the used fuel waste is discussed in Section 6.4.1 and 6.4.2, respectively. The preferred storage option where the used fuel will be stored is discussed in Section 6.4.3.

6.4.1 Used Fuel Packaging

All packaging of used nuclear fuel must be chosen appropriately and take into account considerations set out by OPG. The considerations for used fuel packaging include Fit, Form and Function, Licensing and Regulations, and Safety. These considerations are further detailed below.

6.4.1.1 Fuel Dimensionality

There is no intention to reduce the size of used fuel assemblies for packaging and storage. Therefore, the design solution for the casks must be capable of fitting entire fuel assemblies while staying within the mass limit of the container.

6.4.1.2 Compatibility with Existing Infrastructure

The packaging, transferring, and storage solution will be compatible with the site and infrastructure restrictions such as road load, width height overhead and underground services.

6.4.1.3 Fuel Pool Design

The used fuel will be loaded into the canister within the transfer cask and lifted out for sealing, dewatering, and into a transfer configuration. The canisters and casks will be compatible with the physical dimensions and load rating for the crane in the fuel pool area.

6.4.1.4 Heat and Dose Management

The casks will transfer heat efficiently from the fuel to prevent deterioration of the fuel. The cask will also be of sufficient thickness and density to attenuate the radiation from the used fuel to reduce dose rates to the workers.

6.4.1.5 IAEA Non-proliferation Safeguards

Used fuel casks will have several features specified by the International Atomic Energy Agency (IAEA) to ensure the cask has not been opened, as per the nuclear non-proliferation treaty. All design solutions must demonstrate compliance with this requirement of the IAEA.

6.4.1.6 Nuclear Safety and Criticality Prevention

The storage solution will prevent criticality excursion in normal and accident conditions as well as manage heat from the used fuel to prevent any deformation that could result in the unlikely event of a nuclear accident.

6.4.1.7 Worker and Public Dose Limits

Dose rates from the casks will not exceed 2 mSv/h (200 mrem/h) on contact (gamma and neutron). The casks will also comply with public dose limits at the site fence as well as public walkways, which must be on average 0.5 µSv/h (50 µrem/h) at the facility fence. Emissions monitoring during the transfer and storage of radioactive nuclear by-products on the DNNP site will be undertaken and reported in accordance with the license requirements. This emissions monitoring will be part of the DNNP CNSC commitments which will be developed and submitted to the CNSC before fueling commissioning.

6.4.2 Used Fuel Transfer

Used fuel is to be loaded from the reactor core into the storage racks located in the fuel pool within the reactor building using the refuelling machine. After sufficient time spent in the fuel pool, the used fuel is loaded into a canister and placed in a shielded transfer cask. The reactor building crane transfers the casks onto a transporter and is transferred from the reactor building to the interim storage facility.

The design chosen for the storage facility will determine how the casks are transferred from the transporter. If a vertical above ground overpack is chosen, a Vertical Cask Transporter (VCT) is needed to raise the cask above the overpack and lower the canister containing the fuel into the concrete/metal overpack. If a horizontal configuration of storage modules is used, then the casks will be placed from the reactor building onto a cask support skid in the horizontal position. Once the casks are safely secured to the support skid, they will be transferred to the interim storage facility using a trailer where a hydraulic ram will transfer the canisters into the storage module.

Many specifications and details must be considered depending on which packaging and storage system is utilized. These considerations include maximum lifting height and openings to allow passage into the reactor building, crane capacity, height clearances between the reactor building and the interim storage facility, availability of storage location for the transporter, and infrastructure weight limits and slope.

6.4.3 Used Fuel Storage

As discussed in the previous sections, after the used fuel is removed from the reactor core and packaged into the appropriate canisters and transfer casks, it is transferred to an interim storage facility within the Darlington site where it will remain until it is eventually repackaged and transferred to a DGR. The storage system lifetime is greater than 100 years, giving sufficient time to safely store the used fuel until it is disposed of at a DGR. The DNNP site is located on the eastern edge of the Darlington site east of the Darlington Waste Management Facility, now known as Nuclear Sustainability Services-Darlington (NSS-D) buildings. Manufacturing the interim storage facility as close as possible to the DNNP site is beneficial in reducing the risks with transferring the used fuel.

The location and design of the interim storage facility depends on several considerations such as ground water table level, seismic efficiency, foundation and soil profile, security, as well as other environmental conditions. The facility must also be designed to ensure sub-criticality of the used fuel is maintained and that radiation shielding is provided to ensure dose limits to both the workers and the public are maintained ALARA.

Currently at the DNGS, the used CANDU fuel is stored in the existing NSS-D storage buildings (SB). It was determined that there is not enough available space within the SBs to store the DNNP used fuel along with the CANDU fuel. Other options exist for the interim storage facility including storage of the used fuel casks:

1) On a used fuel storage concrete pad.
2) Inside another/new storage building or structure.

Each storage option has their own unique advantages and disadvantages, and further analysis must be conducted to evaluate which option is ideal for the DNNP.

7. NUCLEAR BY-PRODUCT DISPOSAL

7.1 LLW and ILW

OPG is responsible for the management of LLW and ILW from OPG owned and/or operated nuclear reactors and has been safely managing the nuclear by-products as part of operating nuclear plants for many years. An Integrated Strategy for Radioactive Waste (ISRW) [25] is being developed to address the long-term management strategy for all of Canada's radioactive nuclear by-products, in particular LLW and ILW, as part of the government's radioactive waste management policy review. LLW and ILW will remain at a licensed interim waste management facility until a long-term management facility becomes available.

7.2 Used Fuel

NWMO is the organization that is responsible for the long-term management of used nuclear fuel in Canada as described in the Adaptive Phased Management Report (APM) [26]. NWMO is also responsible for the transportation, repackaging, and emplacement of the used fuel in a DGR. OPG, in collaboration with NWMO will ensure interfaces for the cask and storage system designs chosen are accounted for.

The conceptual design for a DGR [26] can be seen in Figure 3 which includes surface facilities, a services area, placement rooms and an excavated rock management area.

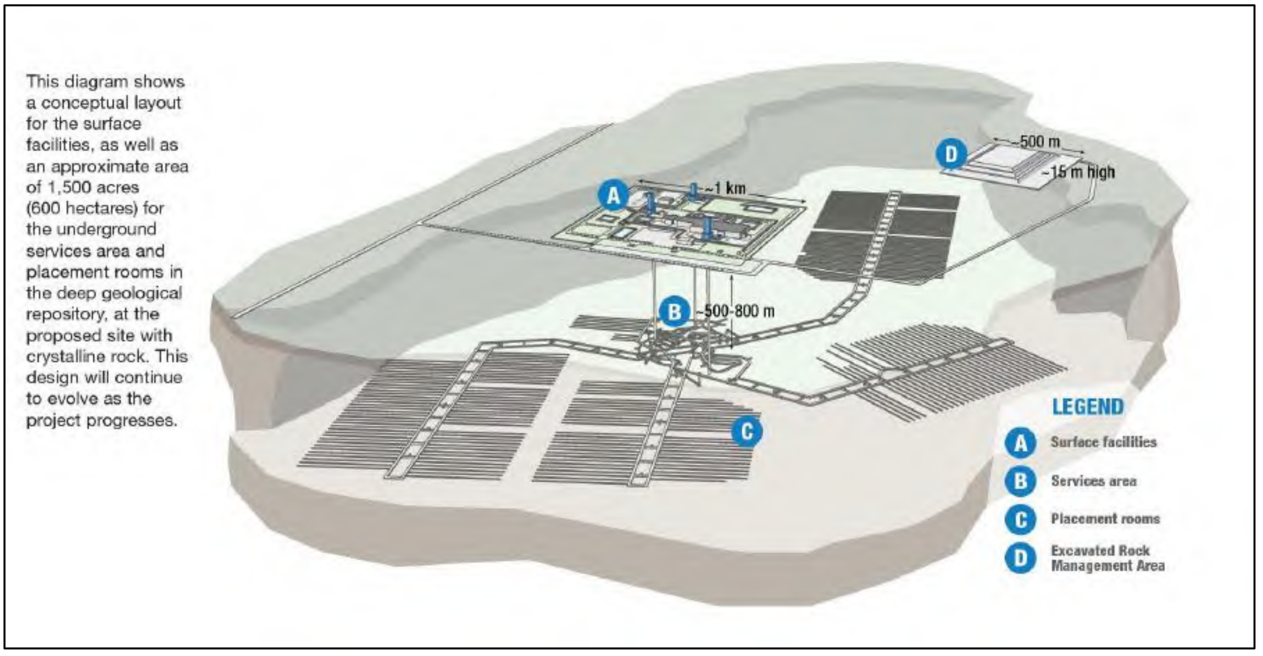

Figure 3: DGR Conceptual Layout

8. MANAGEMENT OF DECOMMISSIONING NUCLEAR BY-PRODUCTS

The management of decommissioning nuclear by-products will be incorporated in the DNNP Preliminary Decommissioning Plan [30]. This plan will also describe the preferred decommissioning strategy and solid nuclear by-product volumes for the DNNP to ensure the protection of health, safety, and security of workers, the public and the environment.

The PSAR [5] gives an overview of a preliminary decommissioning strategy options and the design features that will facilitate the decommissioning and dismantling of the DNNP plant.

The planning for decommissioning is a living process and will take place throughout the life cycle of the plant.

8.1 Decommissioning Strategy

The following strategy options are under consideration for selection individually or in combination:

1. Immediate (prompt) decommissioning:
    a. To decontaminate, dismantle, or clean-up without any planned delays.
2. Deferred decommissioning
    a. To place the facility, location, or site in a period of Storage with Surveillance (sometimes referred to as care and maintenance), followed by decontamination, dismantling, or clean-up

b. To conduct activities directed at placing certain buildings or facilities, locations, or sites in a safe and secure interim end-state, followed by a period of Storage with Surveillance, and ultimately, decontamination, dismantling and/or clean-up.

8.2 Decommissioning Planning

Prior to the Dismantle & Decommissioning phase, OPG will make detailed preparations for the dismantling, and the disposal of the decommissioning nuclear by-products. The Detailed Decommissioning Plan will be developed to align with REGDOC 2.11.2 sec 7.1 two to five years prior to dismantling operations and submitted to the CNSC for acceptance per regulatory requirements. A waste management plan will be developed, which typically includes but is not limited to:

a. Develop a plan for both the short term and, where possible, the long term, for management of all decommissioning nuclear by-products.

b. Develop the procedures for processing radioactive nuclear by-products such as resins, filter media, and metallic and non-metallic by-products generated during the dismantling work.

c. Determine the transport and disposal container requirements for radioactive nuclear by-products and hazardous wastes, including the requirements for shielding and stabilization of the nuclear by-products.

d. Procure and test the transportation and disposal containers for radioactive materials and hazardous waste.

e. Prepare the detailed procedures for the packaging, removal, and disposal of radioactive materials, hazardous waste, and construction debris.

f. Assess or investigate decontamination methods such as chemical cleaning, electropolishing, mechanical abrasion or melting. These decontamination methods may be used to decontaminate scrap metal if the reduction in the volume of the scrap is sufficient to justify further processing. Depending on the efficiencies achieved, metals will be considered as either radioactive nuclear by-products for controlled disposal, lightly contaminated (or activated) for consideration for re-use within the controlled nuclear environment, or metals that are decontaminated to levels below the clearance levels will be released for recycling in the open market.

g. Radioactive releases associated with the decontamination would be managed in accordance with the ALARA principle.

A conceptual DNNP decommissioning timeline is shown in the PSAR [5].

9. CONCLUSIONS

The SRWMS describes the current strategy for the safe management of solid LLW, ILW and used fuel, including irradiated in-core components generated during operations and decommissioning of the DNNP.

The SRWMS was developed and structured to satisfy the requirements of DNNP Construction Licence Application, OPG Waste Management Standard, DNNP project Commitment and CNSC Regulatory Document REGDOC-2.11.1, Waste Management, Volume I: Management of Radioactive Waste and according to steps in the life-cycle management of solid radioactive nuclear by-products, from production in the nuclear facility, through decommissioning and disposal.

The SRWMS for the DNNP ensures all solid radioactive nuclear by-products produced throughout the plant's lifetime from operations to decommissioning are safely controlled, collected, handled, processed, stored and disposed of, and radiation exposure to the plant operating staff and public meets dose and regulatory limits and follows the ALARA principles.

Volumes and activity levels of solid radioactive nuclear by-products generated during normal operations and maintenance at this stage of the design process are provided as an estimate in Appendix A . This strategy, the volumes, and activity levels of the nuclear by-products will be updated during a future licensing phase.

The SRWMS is developed based on the current BWRX-300 design and operational experience in nuclear generating stations. The SRWMS will evolve with the development of BWRX-300 design and best management practices in nuclear generating stations.

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