# Deep Geological Repository Transportation System Conceptual Design Report

## Crystalline / Sedimentary Rock

APM-REP-00440-0209-R001 September 2021

**Ashton Taylor**
AECOM Canada Limited

nwmo
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## ABSTRACT

**Title:** **Deep Geological Repository Transportation System Conceptual Design Report Crystalline/Sedimentary Rock**
**Report No.:** **APM-REP-00440-0209**
**Author(s):** Ashton Taylor
**Company:** AECOM Canada Limited
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**Abstract**
The Nuclear Waste Management Organization is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) in a suitable rock formation, such as crystalline rock or sedimentary rock, in an informed and willing host community.

This report describes conceptual designs of the transportation system and considers transport of used fuel to a repository sited in either a crystalline or sedimentary rock geosphere. For costing purposes, it is assumed that the DGR facility will receive 5.5 million fuel bundles over a 46-year period. The report describes the systems, equipment, components and associated operations required for the gate-to-gate transport of used nuclear fuel with consideration to routing, equipment, logistics, security, emergency response, personnel, and labour requirements, as well as regulatory and legal requirements.

The system design considers an all road transportation scenario, using two types of transportation packages (i.e., the Used Fuel Transportation Package and the Basket Transportation Package) to transport used nuclear fuel from interim storage facilities to NWMO's deep geological repository.

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Used Fuel Transportation System

# 2021 Transportation Lifecycle Cost Estimate (LCE)

## Design Report

**Final**

Nuclear Waste Management Organization

NWMO Project Reference: T066-2018
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# Executive Summary

The Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of Canada's used nuclear fuel. Canada's plan is known as Adaptive Phased Management (APM). The plan consists of containing and isolating Canada's used nuclear fuel in a deep geological repository (DGR) using a multiple barrier system, within a robust host geology.

A reference design and life cycle cost estimate for the APM DGR project is maintained by the NWMO and is updated every 5 years. This Design Report prepared by AECOM supports NWMO's 2021 Lifecycle Cost Estimate (LCE) by providing a description of the used fuel transportation system (UFTS) for the APM DGR project.

The UFTS assumes that all used fuel will be transported by road, using Used Fuel Transportation Packages (UFTPs) to transport used fuel from Ontario Power Generation (OPG) sites; and Basket Transportation Packages (BTPs) to transport used fuel from all other sites.

The Township of Ignace and Wabigoon Lake Ojibway Nation in Northwestern Ontario and the Municipality of South Bruce and Saugeen Ojibway Nation in Southern Ontario are considered potential host areas for the DGR. Therefore, this report considers the transport of used fuel from interim storage facilities to:

1. A DGR in a crystalline rock environment located in Northwestern Ontario, near the Township of Ignace; and
2. A DGR in a sedimentary rock environment in Southern Ontario, in the Municipality of South Bruce.

The amount of used fuel to be transported is assumed to be 5.5 million used fuel bundles, based on current projections, and on announced life plans for the nuclear reactor fleet. It is assumed that the used fuel processing rate at the DGR will be approximately 120,000 fuel bundles per year, and as such, it is assumed that the transportation program duration will be approximately 46 years.

Used fuel will be transported from eight interim storage facilities, located at six origin sites. **Table 1** summarizes the list of interim storage facilities, corresponding origin sites, transportation packages, projected total used fuel to be transported, and assumed transportation years. The assumed transportation years are conceptual and have been established to support the life cycle cost estimate.

**Table 1: Summary of Used Fuel Transportation**

| Interim Storage Facility | Origin Site | Waste Owner | Transportation Package | Projected Total Used Fuel to be Transported (bundles) | Projected Total Used Fuel to be Transported (shipments) | Assumed Transportation Start Year | Assumed Transportation Finish Year |
|---|---|---|---|---|---|---|---|
| Bruce | Bruce | OPG | UFTP | 2,907,650 | 15,147 | 2050 | 2088 |
| Pickering | Pickering | OPG | UFTP | 902,148 | 4,699 | 2043 | 2050 |
| Darlington | Darlington | OPG | UFTP | 1,268,801 | 6,610 | 2050 | 2088 |
| Chalk River | Chalk River | AECL | BTP | 7,187 | 90 | 2068 | 2068 |
| Douglas Point | Bruce | AECL | BTP | 22,256 | 207 | 2067 | 2068 |
| Gentilly 1 | Gentilly | AECL | BTP | 3,213 | 43 | 2050 | 2050 |
| Gentilly 2 | Gentilly | Hydro Québec | BTP | 129,925 | 1,083 | 2050 | 2054 |
| Point Lepreau | Point Lepreau | NB Power | BTP | 258,820 | 2,157 | 2054 | 2066 |
| | | | **Totals:** | **5,500,000** | **30,036** | **2043** | **2088** |

**Note:** The assumed transportation years are conceptual and have been established to support the lifecycle cost estimates. They are for planning purposes only. The actual shipping logistics will be determined closer to operations.

This Design Report[1] describes the systems, equipment, and components, as well as the associated operations required for the gate-to-gate transport of used nuclear fuel. This includes the associated routing assumptions, equipment, logistics, and operational components such as security, emergency response, as well as regulatory and legal requirements. Key features of the UFTS are summarized as follows.

Routing

Actual travel routes to be used from the origin sites to the destination sites will be determined once a repository location is chosen. For planning and cost estimation purposes, route lengths between each interim storage facility and both potential repository locations have been established.

Equipment

*Transportation Packages:* For this used fuel transportation system, UFTPs will transport used fuel from OPG sites (Pickering, Darlington and Bruce) and have the capacity to transport 192 used fuel bundles each. BTPs will transport used fuel from all other sites (Douglas Point, Chalk River, Gentilly 1&2 and Point Lepreau) and have the capacity to transport a maximum of 120 used fuel bundles each. After completing each shipment, each transportation package will be returned to an origin site to be reused on a later shipment. The sizes of the UFTP and BTP fleets required are based on the shipping assumptions in **Table 1** and include an allowance for maintenance and inspection activities.

*Tractors and Trailers:* Due to weight limitations, only 1 UFTP or 1 BTP can be transported per truck shipment. Both UFTP and BTP shipments are assumed to fit within the dimensional envelopes of a standard tractor-trailer, in line with the maximum allowable dimensions identified in the provincial and federal vehicle weights and dimensions regulations. UFTPs and BTPs will be transported on two separate tractor-trailer fleets. One fleet will transport used fuel in UFTPs from the Bruce, Pickering, and Darlington interim storage facilities, and the second fleet will transport used fuel in BTPs from the other interim storage facilities. The proposed combination is composed of a tractor and a single, self-steer quad semi-trailer. Truck fleet sizes are based on the shipping assumptions in **Table 1** and represent the maximum demand for each type of truck throughout the shipping period, plus 20% spare capacity.

*Escort Vehicles:* This UFTS assumes that one escort vehicle accompanies each shipment to maintain constant surveillance of the shipment. The required escort vehicle fleet sizes correspond with the tractor and trailer fleet sizes.

Logistics and Operations

Each tractor-trailer would have a team of one or two drivers, depending on journey time. Teams with two drivers would rotate duty to meet regulatory requirements as to hours of service and driver operation. Each tractor-trailer would be accompanied by one security escort vehicle. Each security escort vehicle would have the same sized team of personnel as the tractor-trailer. Cycle times have been estimated taking into account: route distances, average speed assumptions, transport team management (i.e., rest stops, crew changes, en route refueling, and un / loading time at each terminal).

Security and Communications

For the transport of used fuel by road, key security and communication provisions for this system are summarized as follows:

- *Escorts:* Category II nuclear material (i.e., these shipments) should be accompanied by escorts, such as nuclear security guards providing surveillance of the shipment.
- *Personnel:* The credentials and trustworthiness of all personnel involved in the transportation process should be verified.
- *Communications:* During the transport of Category II nuclear material, shipments should remain in frequent contact with the shipper, the receiver, local authorities and the response forces along the transport route. This transportation system assumes that both satellite and encrypted cellular phones will be used. Satellite telephones can be used as back-up communications in the event of disruption of primary cellular communications.

[1] Systems, structures, equipment and components associated with operations for the loading and unloading of the used fuel into and out of transportation packages, and the loading and unloading transportation packages onto and from conveyances are outside the scope of work presented in this report.

- *Transportation Communication & Command Centre:* NWMO will operate a central transportation command centre assumed to be located at the DGR facility that will provide a single point of contact for all agencies involved in transportation-related communications, as well as monitor and track used fuel shipments. Best practices and available technologies should be reviewed for tracking and monitoring as they are proven reliable.
- *Additional Equipment:* Tractors, escort vehicles are equipped with safety, security, communication, and emergency response equipment.

Emergency Response

NWMO will provide an emergency response plan to the Canadian regulatory agencies to demonstrate that appropriate emergency measures are in place and that information is available to relevant public emergency response agencies. The purpose of the emergency response plan is to ensure coordination among the NWMO, provincial and local first responders as well as federal agencies. The emergency response plan will identify provisions to ensure that there are appropriate measures in place, in the event that there is an incident involving the transport of used nuclear fuel.

# 1. Introduction

Canada's plan for the long-term management of used nuclear fuel (used fuel) is known as Adaptive Phased Management (APM). The plan consists of containing and isolating Canada's used fuel in a Deep Geological Repository (DGR) within a suitable rock formation.

Canada's used fuel is currently safely managed in facilities licensed for interim storage. These interim storage facilities are located in Ontario, Québec, New Brunswick, and Manitoba. Under the APM DGR plan, used fuel will be transported from these interim storage facilities to the DGR.

The NWMO maintains a reference design and lifecycle cost estimate for the APM DGR project, which is updated every 5 years and summarized in a public document. As part of these updates, NWMO is preparing the 2021 Transportation Lifecycle Cost Estimate (LCE) which includes a used fuel transportation system to safely move used fuel from interim storage sites to the proposed repository site.

This Design Report has been prepared in support of the 2021 Transportation LCE. The Design Report describes all facilities, systems, equipment, and components needed throughout site preparation, construction, operations, and decommissioning of the Used Fuel Transportation System (UFTS).

# 2. Scope and Assumptions

The scope of this work is to develop conceptual designs for a UFTS for the 2021 APM Transportation Lifecycle Cost Estimate. This transportation system consists of an all-road scenario using Used Fuel Transportation Packages (UFTPs) to transport used fuel from Ontario Power Generation (OPG) sites, and Basket Transportation Packages (BTPs) to transport used fuel from all other sites.

NWMO is in the process of identifying a willing host community or region for the repository with plans to select one community by 2023. The site selection process has been underway since 2010. The process started with 22 municipalities and Indigenous communities that expressed interest in learning more about and exploring their potential to host the project. The NWMO has gradually narrowed the focus to fewer areas through technical site evaluations, social research, and engagement to assess the safety and the potential to build partnerships.

The NWMO is currently engaging with two potential siting areas, including First Nations and Métis communities in the area. The Township of Ignace and Wabigoon Lake Ojibway Nation in Northwestern Ontario and the Municipality of South Bruce and Saugeen Ojibway Nation in Southern Ontario are considered potential host areas for the project. Therefore, this report considers the transport of used fuel from interim storage facilities to a) a crystalline rock environment in Northwestern Ontario, near the Township of Ignace, and b) a sedimentary rock environment in Southern Ontario, in the Municipality of South Bruce.

**Table 2** provides an overview of the UFTS analyzed in support of the 2021 APM DGR Lifecycle Cost Estimate.

**Table 2: Transportation System Analyzed in Support of the 2021 APM Transportation LCE**

| Potential DGR Location | Used Fuel Transportation System | Mode | Interim Storage Facility | Package |
|---|---|---|---|---|
| **Northwestern Ontario (Crystalline – Ignace Area) & Southern Ontario (Sedimentary – South Bruce Area)** | 2021 APM Transportation Lifecycle Cost Estimate UFTS | Road | Pickering | UFTP |
| | | | Darlington | |
| | | | Bruce | |
| | | | Chalk River | BTP |
| | | | Douglas Point | |
| | | | Gentilly 1 | |
| | | | Gentilly 2 | |
| | | | Point Lepreau | |

## 2.1 Regulatory Requirements and Guidance

Regulatory requirements and guidance that have been considered in establishing the design basis of this conceptual UFTS and to prepare this LCE report, along with its supporting cost estimates for study/feasibility purposes are described and listed in **Table 3**.

Transportation of used nuclear fuel is regulated by the Canadian Nuclear Safety Commission (CNSC) and Transport Canada. The CNSC regulates the transport of radioactive material through the *Packaging and Transport of Nuclear Substances Regulations.* These regulations are based on requirements established by the International Atomic Energy Agency's (IAEA) *Regulations for the Safe Transport of Radioactive Material*. In Canada, the transportation of dangerous goods is regulated under the *Transportation of Dangerous Goods Act*. Provinces and Territories work with Transport Canada (through established memoranda of agreement) to enforce transportation of dangerous goods requirements for road transport. The *Transportation of Dangerous Goods Regulations* (TDGR), adopted by all provinces and territories, establishes the regulatory requirements for the handling, offering for transport and transport of dangerous goods within Canada.

**Table 3: Summary of UFTS Requirements**

| Regulation or Requirement | | Description |
|---|---|---|
| Canadian Nuclear Safety Commission (CNSC) | Nuclear Safety and Control Act ((S.C. 1997), c.9) | Provides the CNSC with the authority to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment, and prescribed information in Canada. |
| | General Nuclear Safety and Control Regulations (SOR/2000-202) | Provides general regulations for license applications and renewals, exemptions, obligations of licensees, prescribed nuclear facilities and equipment and information, contamination, record-keeping, and inspections. |
| | Radiation Protection Regulations (SOR/2000-203) | Defines the "as low as reasonably achievable" (ALARA) principle and regulations for radiation dose limits etc. |
| | Nuclear Security Regulations (SOR/2000-209) | Defines security-related information requirements and general obligations. |
| | Packaging and Transport of Nuclear Substances Regulations (2015) | Provides requirements for licenses to transport, transport of nuclear substances, record keeping as well as requirements for the design and certification of packages, special form radioactive material and other prescribed equipment. |
| | Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material, Version 2 (REGDOC-2.12.3) | Provides general guidance for information that should be included in a transportation security plan, the transport security measures that should be considered, and how the transportation security plan should be handled to meet requirements related to confidentiality and national security. |
| | Information Incorporated by Reference in Canada's Packaging and Transport of Nuclear Substances Regulations, 2015 (REGDOC-2.14.1) | Regulatory document REGDOC-2.14.1 links the provisions of the PTNSR 2015 to specific paragraphs of the International Atomic Energy Agency's *Regulations for the Safe Transport of Nuclear Material*, the *Nuclear Safety and Control Act*, other CNSC regulations, and related information for use by licensees, applicants, and other regulated persons. |
| International Atomic Energy Agency (IAEA) | Regulations for the Safe Transportation of Radioactive Material – Specific Safety Requirements (No. SSR-6) | Establishes requirements that must be satisfied to ensure safety and to protect persons, property, and the environment from the effects of radiation in the transport of radioactive material. |
| Transport Canada (TC) | Transportation of Dangerous Goods Act and Regulations (1992), c.34 | Promotes public safety in the transport of dangerous goods. The associated regulations, *Transportation of Dangerous Goods Regulations* (SOR/2001-286), establish safety regulations and requirements for training, emergency planning, safety marks and documentation. |
| | Commercial Vehicle Driver Hours of Service Regulations (SOR/2005-313) | Defines the regulations for driver hours of service including cycles, work shifts, deferral hours, and splitting hours for road transportation. |
| Federal Provincial-Territorial Memorandum of Understanding | Heavy Truck Weight and Dimension Limits for Interprovincial Operations in Canada | Defines the regulations to improve uniformity in regulations of weights and dimensions between provinces and territories of eight configurations of vehicles. Ensures consistency between Part IV of the Ontario Highway Traffic Act, the Vehicle Load and Size Limit Regulation under the Québec Highway Safety Code, and the Vehicle Dimensions and Mass Regulations under Part IV of the New Brunswick Motor Vehicle Act. |
| Ministry of Transportation Ontario (MTO) | Commercial Vehicle Driver Hours of Service Regulations (O. Reg.555/06) | Define the regulations for driver hours of service including cycles, work shifts, deferral hours, and splitting hours for road transportation. |
| Ministère des Transports du Québec | Regulation respecting the hours of driving and rest of heavy vehicle drivers | |
| New Brunswick Department of Transportation and Infrastructure | Commercial Vehicle Drivers Hours of Service Regulation (Reg 89-147) | |

## 2.2 Assumptions

The primary assumptions that form the basis for the transportation analyses include the following:

- While a location for the DGR has not yet been chosen; for this project, transportation logistics to two potential DGR locations are assessed:
  - A sedimentary rock environment in Southern Ontario, located in the Municipality of South Bruce; and
  - A crystalline rock environment in Northwestern Ontario, located near the Township of Ignace;
- Used fuel bundles originate from interim storage facilities under the ownership of OPG (Pickering, Darlington, and Bruce), AECL (Douglas Point, Chalk River, and Gentilly 1), Hydro-Québec (Gentilly 2), and New Brunswick Power (Point Lepreau);
- Used fuel bundles from AECL's Whiteshell Laboratories have been consolidated at the Chalk River site;
- The mode of transportation to the DGR is assumed to be by road;
- All used fuel is in the form of CANDU fuel bundles and has cooled for a period of 10 years before it is transported;
- The used fuel inventory comprises of 5.5 million used CANDU fuel bundles;
- This report assumes that NWMO will retain ownership and operations of the transportation system;
- Used fuel is to be transported to the DGR location in UFTPs for all OPG-owned used fuel, and in BTPs for all other used fuel;
- UFTPs and BTPs will be re-used for multiple trips;
- Details as to the design and certification of the BTPs and UFTPs are excluded from this report. However, the cost estimate for the UFTS includes costs for design and certification activities;
- A transport delivery rate of 120,000 bundles per year matching the overall operating capacity of the Used Fuel Packaging Plant (UFPP) is assumed for both transport scenarios; and
- The DGR and transportation program are assumed to be in-service by 2043, by which time it will be fully operational. The used fuel shipments are assumed to occur over a period of 46 years (2043 – 2088).

## 2.3 Battery Limits

The battery limits for this work include the gate-to-gate (all-road) transport of used fuel from eight interim storage facilities (located at six origin sites) to two potential DGR locations. It considers all systems, equipment, and components and activities required for the transport of used fuel between the gates of the origin sites and the gates of the DGR sites throughout four phases of the project: site preparation, construction, operations, and decommissioning.

The eight interim storage facilities identified in **Section 2.2** are located at six origin sites. It is assumed that Bruce and Douglas Point interim storage facilities are located at the same origin site. Likewise, the Gentilly 1 and Gentilly 2 interim storage facilities are located at the same origin site. The remaining interim storage facilities are located at separate origin sites.

At each interim storage facility, the waste owner is responsible for the retrieval of used fuel from storage, preparing and loading the transportation package with used fuel, and loading and securing the transportation package onto the conveyance. Therefore, the conveyance (with secured transportation package) is prepared and ready for transport. As a result, transportation infrastructure, facility infrastructure, equipment for transportation package and conveyance loading, at the storage facilities are excluded from this report. At the DGR facility, this work is assumed to conclude upon arrival of the loaded shipment. Hence the term 'gate-to-gate' appropriately describes these limits. As the transportation packages are reusable, the same limits apply for empty return shipments.

## 2.4 NWMO System Ownership

As per any transportation system, NWMO has different options for UFTS operations.

As part of this study, NWMO considers full ownership of the UFTS in lieu of fully or partially subcontracting operations to an external contractor.

Owning the operations includes purchase, construction, and maintenance of all physical components of the system including conveyances and ancillary transport equipment, infrastructure, and facilities, as well as determination and execution of all operational aspects of the campaign, including, as discussed in this report, routing and logistics.

By fully or partially subcontracting operations, NWMO may choose to hire an external contractor. The benefit to this is that an external operator will have experience in road operations, which could improve operational efficiency.

For this report, it is assumed that ownership and operations of the transportation system are retained by NWMO. This is the most conservative option as it ensures all applicable components are considered, designed, and costed as part of this study.

# 3. Used Fuel Inventory

Used nuclear fuel is currently stored at facilities licensed for interim storage in Ontario, Québec, New Brunswick, and Manitoba. It is assumed that the used fuel currently stored at the facility in Manitoba (Whiteshell Laboratories) will have been transported to one of the facilities in Ontario (Chalk River Laboratories) before the start of DGR operations and, as such, is included in the latter's used fuel inventory.

Based on current projections and announced life plans for the reactor fleet, the total fuel inventory is projected to be 5.5 million used fuel bundles[2]. Total fuel inventories at each interim storage facility are presented in **Table 4**, along with the waste owner, the form of on-site storage (see **Section 3.2**); and the percentage of the total inventory. For further details on the schedule of used fuel shipments, refer to **Section 4**.

**Table 4: Interim Storage Facilities included in the Used Fuel Transportation System**

| Waste Owner | Interim Storage Facility | Form of On-Site Storage | Used Fuel to be Transported (Bundles) | % of Grand Total |
|---|---|---|---|---|
| OPG | Bruce | DSC / modules | 2,907,650 | 52.87% |
| OPG | Pickering | DSC / modules | 902,148 | 16.40% |
| OPG | Darlington | DSC / modules | 1,268,801 | 23.07% |
| | | **OPG Total:** | **5,078,599** | **92.34%** |
| AECL | Chalk River | Baskets | 7,187 | 0.13% |
| AECL | Douglas Point | Baskets | 22,256 | 0.40% |
| AECL | Gentilly 1 | Baskets | 3,213 | 0.06% |
| | | **AECL Total:** | **32,656** | **0.59%** |
| Hydro Québec | Gentilly 2 | Baskets | 129,925 | 2.36% |
| NB Power | Point Lepreau | Baskets | 258,820 | 4.71% |
| | | **Grand Total:** | **5,500,000** | **100.00%** |

The interim storage facilities considered in this report are depicted in **Figure 1**.

[2] For more information on the nuclear fuel waste projections, see *NWMO-TR-2019-14 Nuclear Fuel Waste Projections in Canada – 2019 Update* <https://www.nwmo.ca/~/media/Site/Reports/2020/01/09/19/19/NWMOTR201914.ashx?la=en>

**Figure 1: Interim Storage Facilities and Potential Repository Locations**


- Interim Storage Facilities
  1. Whiteshell Laboratories, Manitoba
  2. Bruce Nuclear Generating Station, Ontario
  3. Pickering Nuclear Generating Station, Ontario
  4. Darlington Nuclear Generating Station, Ontario
  5. Chalk River Laboratories, Ontario
  6. Gentilly Nuclear Generating Station, Quebec
  7. Point Lepreau Nuclear Generating Station, New Brunswick

- Assessments underway in the area
  1. Ignace, Ontario
  2. South Bruce, Ontario

## 3.1 Used Fuel Classification

Used fuel to be transported from each interim storage facility is assumed to be CANDU fuel. Under the Nuclear Security Regulations, used fuel is considered Category II Nuclear Material. Per the Transportation of Dangerous Goods Regulations (TDG), used nuclear fuel falls under Class 7, Radioactive Material. TDG Class 7 is applied regardless of the degree of chemical or radiological hazard of the used fuel. The classification of the used fuel is of particular importance when determining the type of packaging required, as well as labeling and marking criteria for the shipments of used fuel packages.

## 3.2 Used Fuel Bundles, Modules, and Baskets

After discharge from the reactor, used fuel is typically stored in specialized water-cooled pools (wet storage) for a period of 7-10 years to allow the thermal output (heat) and radioactivity to decrease. After this time, the fuel can safely be transferred into dry storage systems. At the interim storage facilities, fuel in dry storage is stored in two forms:

- OPG-owned used fuel is stored in a rectangular racking system known as a module, shown in **Figure 2**. Each module holds 96 fuel bundles in a horizontal orientation. The dry storage system at OPG comprises of buildings containing Dry Storage Containers (DSCs). Each DSC contains a stack of 4 modules (384 fuel bundles).
- Fuel originating at non-OPG facilities is stored in cylindrical containers known as Dry Storage Baskets within large concrete containment systems. The standard production basket, shown in **Figure 3**, holds 60 used fuel bundles in a vertical orientation and is used at the Point Lepreau and Gentilly 2 facilities. Used fuel baskets at the Chalk River, Gentilly 1 and Douglas Point facilities hold fewer used fuel bundles (40, 38, and 54 used fuel bundles, respectively).

**Figure 2: Used Fuel Module**

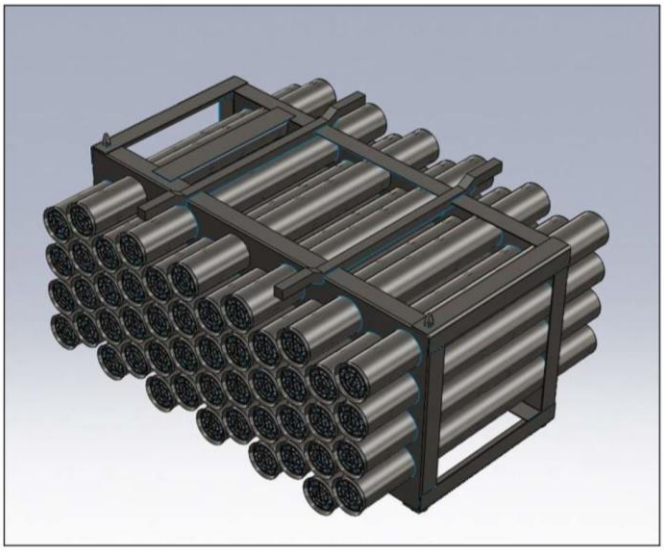
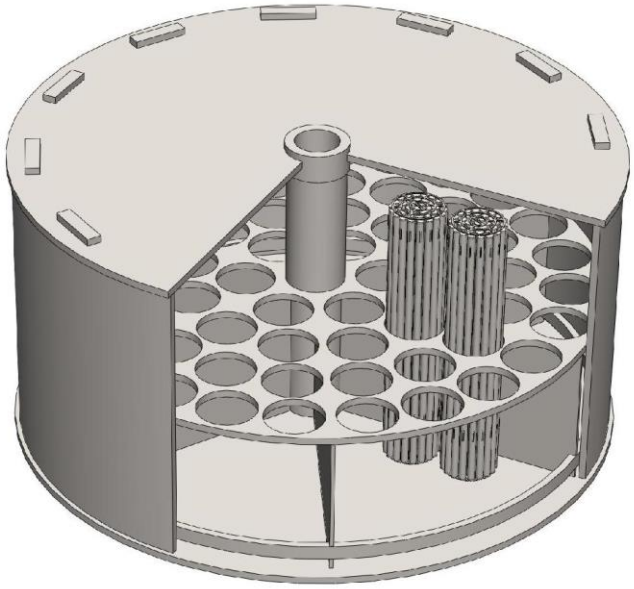


**Figure 3: Used Fuel Basket**



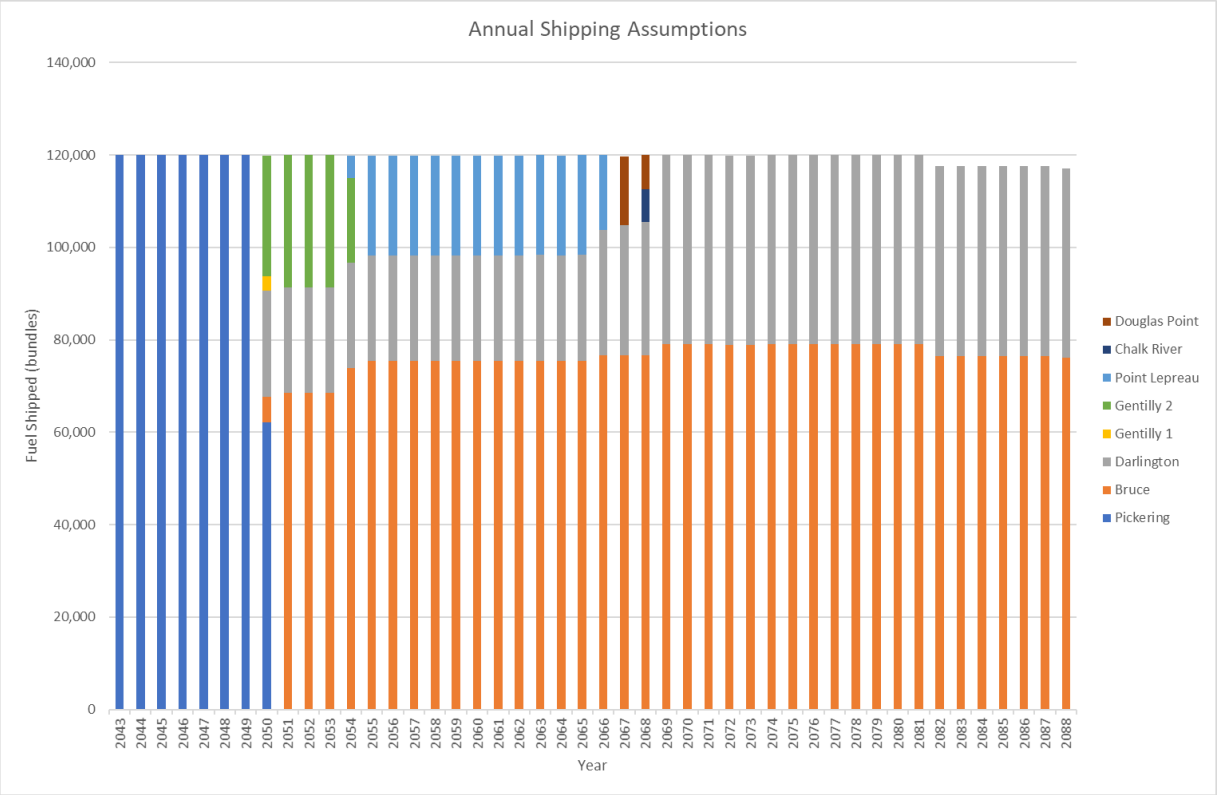
# 4. Schedule of Used Fuel Shipments

This section discusses the assumptions of this report concerning the schedule of used fuel shipments – that is, the amount of fuel assumed to be transported from each interim storage facility in each year. This report refers to these as the "shipping assumptions", which are based on the following:

- Used fuel must be cooled for a period of 10 years before it can be transported, therefore fuel available for transport must be considered.
- The design basis throughput for the Transportation Reception Area at the DGR is 120,000 used fuel bundles per year, which is based on the assumed operating capacity of the UFPP.
- Campaign Duration: At the UFPP's assumed throughput of 120,000 bundles per year, it is assumed to take 46 years to process all 5.5 million bundles.
- Vehicle Capacity: Due to weight limitations, only 1 UFTP or 1 BTP can be transported per truck shipment.
- Vehicle Availability: Trucks are assumed to be available 24 hours per day, 6 days per week, 9 months per year (excluding weather, load/road restrictions, etc.).
- Transport cycle times, as detailed later in **Section 7**.
- Other key considerations and parameters such as transportation package type, shipment size, and timing as described in **Table 5**.

The resulting shipping assumptions (annual used fuel quantities to be transported from each interim storage facility) are shown in **Figure 4** and summarized in **Table 5.** These shipping assumptions are conceptual and have been established to support the lifecycle cost estimates. They are for planning purposes only. The actual shipping logistics will be determined closer to operations. Similarly, the vehicle availability is conservatively chosen to ensure total throughput is achieved with up to 3 months of unplanned delays (not necessarily consecutive).

**Figure 4: Conceptual Annual Shipping Assumptions**




Note: These shipping assumptions are conceptual and have been established to support the lifecycle cost estimates. They are for planning purposes only. The actual shipping logistics will be determined closer to operations.

**Table 5: Summary of Conceptual Annual Shipping Assumptions**

| Interim Storage Facility | Transportation Package | Shipment Size (packages) | Total Used Fuel Transported (bundles) | Total Used Fuel Transported (shipments) | Start Year | Finish Year | Average Shipments per Year |
|---|---|---|---|---|---|---|---|
| Bruce | UFTP | 1 | 2,907,650 | 15,147 | 2050 | 2088 | 388 |
| Pickering | UFTP | 1 | 902,148 | 4,699 | 2043 | 2050 | 587 |
| Darlington | UFTP | 1 | 1,268,801 | 6,610 | 2050 | 2088 | 169 |
| Point Lepreau | BTP | 1 | 258,820 | 2,157 | 2054 | 2066 | 166 |
| Chalk River | BTP | 1 | 7,187 | 90 | 2068 | 2068 | 90 |
| Gentilly 1 | BTP | 1 | 3,213 | 43 | 2050 | 2050 | 43 |
| Gentilly 2 | BTP | 1 | 129,925 | 1,083 | 2050 | 2054 | 217 |
| Douglas Point | BTP | 1 | 22,256 | 207 | 2067 | 2068 | 104 |
| | | **Total:** | **5,500,000** | **30,036** | | | |

Note: These shipping assumptions are conceptual and are subject to future refinement and change.

The shipping assumptions leave unused throughput capacity in some years, particularly towards the end of the transportation campaign (in 2082-2088). However, this does not change the start or finish years, or the estimated numbers of vehicles or packages needed.

# 5. Transport Packages

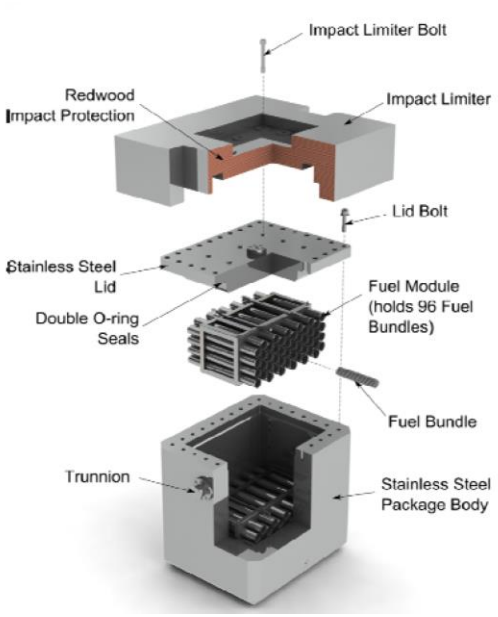
Two transport packages are considered for used fuel shipments: the Used Fuel Transportation Package (UFTP) for transport from OPG sites (Pickering, Darlington, and Bruce); and the Basket Transportation Package (BTP) for shipments from non-OPG sites (Douglas Point, Chalk River, Gentilly 1 & 2, and Point Lepreau).

The following sections describe each transport package, present their key characteristics (such as capacity, weight, and dimensions), outline the number of shipments, and estimated fleet sizes, as well as maintenance, inspection, and decommissioning required to support the UFTS.

## 5.1 Used Fuel Transportation Package (UFTP)

The UFTP consists of a body and lid plus an impact limiter which attaches to the top of the lid. The impact limiter is designed to protect the bolted body/lid connection and the lid seal in the event of an accident during transport. The major components of the UFTP are illustrated in **Figure 5**. The UFTP is a Type B(U) transportation package, the package type required for the transport of used nuclear fuel, and its design is certified by the CNSC.

**Figure 5: Used Fuel Transportation Package (UFTP)**




The UFTP body and lid are made from Type 304 L stainless steel. Radiological shielding is provided by the thick walls of the package. The two long walls are 272 mm thick; the base, lid and short walls are 267 mm thick.

The package lid is held in place by 32 bolts made from Nitronic 60 stainless steel. A flange on the package lid provides an attachment point for lifting the lid. The seal between the package body and lid is provided by two O-rings.

The impact limiter is made from redwood blocks encased in a Type 304 L stainless steel skin (6 mm thick). It is bolted to the package lid using eight Nitronic 60 stainless steel bolts and provides impact protection for the lid closure in the event of an accident by reducing the residual force seen by the package body and lid as the wooden core is crushed by the force of the impact. The impact limiter also serves as a heat shield for the lid and lid seals during a fire.

The UFTP is transported such that used fuel is in the horizontal position. While this report assumes that the UFTP will be used to transport used fuel by road, the UFTP has been designed to be used with all surface modes of transport (i.e., road, rail, and water).

### 5.1.1 UFTP Characteristics

The design characteristics, including capacity, weight, and dimensions of the UFTP are presented in **Table 6**.

**Table 6: Used Fuel Transportation Package (UFTP) Characteristics Summary**

| Key Components | Used Fuel Transportation Package (UFTP) |
|---|---|
| Payload | 2 modules with a total of 192 used fuel bundles<br>(96 used fuel bundles per module). |
| Approximate Assembled Dimensions | Length = 2.4 m<br>Width = 2.0 m<br>Height = 2.2 m |
| Weight (Loaded) | Approximately 35 tonnes |

### 5.1.2 Number of UFTP Shipments

As shown in the conceptual shipping schedule described in **Section 4**, the assumed number of used fuel shipments to be transported in UFTPs for each waste owner and interim storage facility are detailed in **Table 7**.

**Table 7: Used Fuel Transportation Package (UFTP) Shipments**

| Waste Owner | Interim Storage Facility | Start Year | Finish Year | Total Shipments (UFTPs) |
|---|---|---|---|---|
| OPG | Bruce | 2050 | 2088 | 15,147 |
| | Pickering | 2043 | 2050 | 4,699 |
| | Darlington | 2050 | 2088 | 6,610 |
| | **Total:** | **2043** | **2088** | **26,456** |

### 5.1.3 UFTP Fleet

A fleet of UFTPs will be required to transport used fuel in modules from the OPG interim storage facilities to the DGR. The estimated fleet sizes of UFTPs for the potential DGR locations are presented in **Table 8**. These estimates are based on the shipping assumptions described in **Section 4** and include an allowance for return shipments so that the transportation packages can be reused, for loading and unloading the used fuel, and for the activities required to prepare each shipment for transport at each terminal. It is also assumed that there are enough UFTPs at each terminal staging area, prepared and configured for transport, to allow for immediate loading onto empty trucks as they arrive. Finally, it is assumed that UFTPs are available the equivalent of 9 months per year, 7 days per week, 24 hours per day with an allowance of 25% capacity for package maintenance activities (i.e., 25% of the packages within the fleet are assumed to be out of service, undergoing routine inspection, maintenance and servicing).

**Table 8: Used Fuel Transportation Package Fleet Size**

| Potential DGR Location | UFTP Fleet Size (including 25% spares) |
|---|---|
| Northwestern Ontario (Crystalline – Ignace Area) | 21 |
| Southern Ontario (Sedimentary – South Bruce Area) | 14 |

### 5.1.4 Maintenance, Inspection, Replacement, and Decommissioning of UFTPs

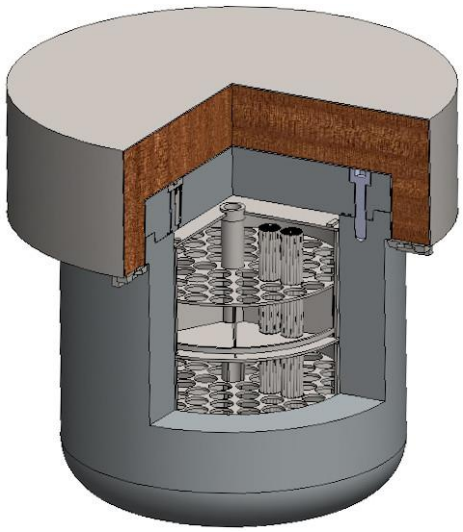
The maintenance of transportation packages includes performing various preventive maintenance activities. It is assumed that package maintenance activities will be conducted at a maintenance facility located at the DGR. Additionally, inspections would need to occur before transport at both the DGR and interim storage facility, it is assumed that there will be space available at applicable facilities for that activity. The estimated package fleet size includes an allowance of 25% for spares to support maintenance requirements.

The operational life of each UFTP is assumed to be 50 years, which is greater than the 46-year length of the transport campaign. Thus, the replacement of the UFTP fleet after the initial purchase is not required. Immediately after the module shipments are complete (starting in the year 2089), the UFTP package fleet will be decommissioned or retired from service.

## 5.2 Basket Transportation Packages

The Basket Transportation Package (BTP) design is still in the conceptual stage. The BTP will be specifically designed to transport used fuel stored and configured in cylindrical baskets. This reusable package design is assumed to be similar to the UFTP, constructed of thick stainless steel for the body and lid with the ends protected by one (or two) impact limiters filled with impact absorbing material. Like the UFTP design, it will be certified as a Type B(U) transportation package. The key features of a two-basket capacity BTP are shown in **Figure 6**.

**Figure 6: Basket Transportation Package (BTP) Concept (one impact limiter is shown)**



### 5.2.1 BTP Characteristics

The proposed design characteristics, including capacity, weight, and dimensions of a BTP are presented in **Table 9**.

**Table 9: Basket Transportation Package Characteristics Summary**

| Key Components | Basket Transportation Package (BTP) |
|---|---|
| Payload | 2 baskets with a total of 120 used fuel bundles<br>(60 used fuel bundles per basket) |
| Approximate Assembled Dimensions | Length = 2.3 m<br>Width = 2.3 m<br>Height = 2.5 m |
| Weight (Loaded) | Approximately 28 tonnes |

## 5.2.2 Number of BTP Shipments

As shown in the conceptual shipping schedule described in **Section 4**, the assumed numbers of used fuel shipments to be transported in BTPs for each waste owner and interim storage facility are detailed in **Table 10**.

**Table 10: Basket Transportation Package (BTP) Shipments**

| Waste Owner | Interim Storage Facility | Start Year | Finish Year | Total Shipments (BTPs) |
|---|---|---|---|---|
| NB Power | Point Lepreau | 2054 | 2066 | 2,157 |
| AECL | Chalk River | 2068 | 2068 | 90 |
| AECL | Gentilly 1 | 2050 | 2050 | 43 |
| Hydro Québec | Gentilly 2 | 2050 | 2054 | 1,083 |
| AECL | Douglas Point | 2067 | 2068 | 207 |
| | **Total:** | **2050** | **2068** | **3,580** |

## 5.2.3 BTP Fleet

As with UFTPs, a fleet of BTPs will be required to transport used fuel in baskets from the non-OPG interim storage facilities to the DGR. Assumptions determining fleet size are the same as those presented in **Section 5.1.3** for UFTPs. The assumed fleet sizes of BTPs for the potential DGR locations are presented in **Table 11**.

**Table 11: Basket Transportation Package Fleet Size**

| Potential DGR Location | BTP Fleet Size (including 25% spares) |
|---|---|
| Northwestern Ontario (Crystalline – Ignace Area) | 12 |
| Southern Ontario (Sedimentary – South Bruce Area) | 9 |

## 5.2.4 Maintenance, Inspection, Replacement, and Decommissioning of BTPs

The maintenance of transportation packages includes performing various preventive maintenance activities. It is assumed that package maintenance activities will be conducted at a maintenance facility located at the DGR. Additionally, inspections would need to occur before transport at both the DGR and interim storage facility, it is assumed that there will be space available at applicable facilities for that activity. The estimated package fleet size includes an allowance of 25% for spares to support maintenance requirements.

The operational life of each BTP is assumed to be 50 years, which is greater than the 18-year length of the transport campaign. Thus, the replacement of the BTP fleet after the initial purchase is not required. Immediately after the basket shipments are complete (starting in the year 2069), the UFTP package fleet will be decommissioned or retired from service.

# 6. Transportation Equipment

A transportation shipment is assumed to consist of a tractor-trailer carrying one transportation package (secured with appropriate tie-downs) accompanied by a separate security escort vehicle.

## 6.1 Transport Tractor and Trailer

Truck transport in Canada is governed by provincial regulatory requirements that specify limitations on shipment dimensions, weight, and the relative placement on the trailer. For BTP shipments, regulations in the provinces of Ontario, Québec, and New Brunswick must be met; however, as UFTPs will only be shipped within Ontario (from OPG sites Bruce, Pickering, and Darlington), only Ontario regulations apply to the UFTP shipments. Both UFTP and BTP shipments are assumed to fit within the dimensional envelopes of a standard tractor-trailer, in line with the maximum allowable dimensions identified in the provincial and federal vehicle weights and dimensions regulations. Based on the package weights, both shipments are also assumed to be within the gross vehicle and axle weight maximum for the standard configuration recommended for their shipment. Therefore, oversize permits are not required.

UFTPs and BTPs will be transported on two separate tractor-trailer fleets. One fleet will transport used fuel in UFTPs from the Bruce, Pickering, and Darlington sites, and the second fleet will transport used fuel in BTPs from all other interim storage facilities. The tractors for both fleets will be of similar design (and commercially available); the trailers will be similar, i.e., within the dimensional envelope of a standard size trailer; however custom-built to accommodate the packages they will be carrying.

The axle configurations proposed for the tractor-trailers are based on the standard vehicle in accordance with provincial vehicle weight and dimensional regulations. The proposed combination is composed of a tractor and a single, self-steer quad semi-trailer. The tractor has a steerable single axle in front and a tandem (double) drive axle at the rear. The flatbed semi-trailer has a single self-steer axle in front and a tridem (triple) axle at the rear. The configuration (without weather cover) is depicted in **Figure 7**.

**Figure 7: Truck Proposed for the Transport of BTPs and UFTPs (UFTP depicted without weather cover)**

Each tractor-trailer unit proposed for the transport of UFTPs and BTPs can carry one package per shipment as depicted in **Figure 7**. A Conestoga cover could be added to the flatbed to protect the UFTP or BTP from the elements during transit.

The approximate dimensions and weights of a tractor-trailer (including an estimate of the Gross Vehicle Weight (GVW)) for both the BTP and UFTP trucks are provided in **Table 12**.

**Table 12: UFTP Truck and BTP Truck Dimensions and Weights**

| Attribute Type | Attribute | UFTP Truck | BTP Truck |
|---|---|---|---|
| Dimension | Length | 23m (75'6") | |
| | Width | 2.6m (8'6") | |
| | Height | 4.15m (13'6") | |
| Weight | Loaded Transportation Package | 35 tonnes | 28 tonnes |
| | Trailer with Loaded Package | 49 tonnes | 42 tonnes |
| | GVW (Tractor-Trailer with Loaded Package) | 57 tonnes | 50 tonnes |

### 6.1.1 Transport Tractor Trailer Features

The BTP and UFTP trucks will include various features to ensure the safe and secure movement of used nuclear fuel. The transport tractor must have the motive power capable of pulling a combined load of the trailer and a fully loaded BTP or UFTP. The commercial trucking industry can supply transport tractor vehicles capable of handling this magnitude of the load. In addition to the engine power requirements, tractor-trailers are assumed to be equipped with the following features:

- Extended cab with an integrated sleeper berth;
- Speed limiters to meet provincial regulations;
- Radar-based collision mitigation system to assist drivers with avoiding collisions;
- Anti-theft electronic immobilizer system (e.g., biometric or handprint scanner);
- Passenger mounted LCD touch screen computer with GPS interface for communications with the Transportation Communication & Control Centre (C&CC);
- Fire extinguishing/suppression equipment to meet the National Fire Code;
- Cellular and/or satellite phone;
- Event recorders and onboard video cameras;
- Anti-lock Braking System (ABS) brakes;
- Ride and stability control with self-steering axles;
- Custom designed mounting frame to spread the load of the UFTP or BTP evenly across the axles;
- CNSC approved UFTP or BTP tie-down system;
- GPS units for remote real-time tracking of the vehicle location (one on the tractor and one on the UFTP or BTP unit carried within the trailer); and
- Emergency Response Personal Protective Equipment.

## 6.2 Security Escort Vehicles

Shipments of Category II nuclear material should be accompanied by one or more escorts. These escorts should maintain constant surveillance of the shipment by travelling in the cargo vehicle or an accompanying vehicle. This report makes the cost conservative assumption that one escort vehicle accompanies each shipment. The security escort vehicle is assumed to be a passenger car or sport utility vehicle weighing at least 2,000 pounds. Vehicle selection should focus on visibility with escort vehicles allowing the driver to see 360 degrees from the driver's seat. As such, cargo vans or panel trucks are not recommended. The required escort vehicle fleet sizes correspond with the truck fleet sizes shown in **Table 13.**

### 6.2.1 Security Escort Vehicle Features

The security escort vehicles are assumed to be equipped with the following features based on the current technology and industry practices:

- Radar-based collision mitigation system to assist drivers with avoiding collisions (factory or dealer installed on escort vehicles);
- Anti-theft electronic immobilizer system (e.g., biometric or handprint scanner) (factory or dealer installed on escort vehicles);
- Passenger mounted LCD touch screen computer with GPS interface for communications with the Transportation C&CC (factory or dealer installed on escort vehicles);
- Telephone and radio communications;
- GPS units for remote real-time tracking of the vehicle location;
- Emergency Response Personal Protective Equipment; and
- Full-size spare tire and changing tools.

## 6.3 Transportation Equipment Quantities

This report assumes two separate fleets of trucks will transport used fuel – one fleet will transport used fuel in UFTPs from Bruce, Pickering, and Darlington, and the second fleet will transport used fuel in BTPs from all other interim storage facilities. **Table 13** shows the estimated sizes of each fleet. The estimates shown in **Table 13** are based on the conceptual shipping schedules described in **Section 4**, and represent the maximum demand for each type of truck throughout the shipping period, plus 20% spare capacity. Spares provide an allowance for scheduled and unscheduled maintenance, delays due to weather, equipment failure, road traffic and closures, and other factors over and above already allowed for under the assumed availability of six days per week, 24 hours per day, and nine months per year.

**Section 6.2** describes how the escort vehicle fleets are of the same estimated size as the truck fleets. The estimated sizes of the fleets are summarized below in **Table 13**.

**Table 13: Estimated Sizes of Truck & Escort Fleets**

| Potential DGR Locations | Shipments | Truck Fleet Size (Tractor and Trailer, including 20% spares) | Escort Fleet Size (Escort Vehicle, including 20% spares) |
|---|---|---|---|
| Northwestern Ontario (Crystalline – Ignace Area) | UFTP | 11 | 11 |
| | BTP | 6 | 6 |
| Southern Ontario (Sedimentary – South Bruce Area) | UFTP | 4 | 4 |
| | BTP | 4 | 4 |

## 6.4 Transportation Equipment Maintenance, Inspection, and Replacement

The useful life and maintenance assumptions for vehicles of the used fuel transportation system are in line with conventional trucking requirements. The approximate useful life of the proposed tractor and trailer is assumed to be 7 years and 10 years, respectively. The approximate useful life of the proposed security escort vehicles is 4 years. All vehicles require ongoing maintenance. It is assumed that vehicle maintenance activities will be conducted at a maintenance facility located at the DGR. The estimated vehicle fleet size includes 20% of spares available to support maintenance requirements.

As per CNSC's Regulatory Document (REGDOC-2.12.3, Version 2) titled Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material, the maintenance, testing and inspection programs and associated schedules for performing repairs and maintenance activities on transportation security systems, technical devices, and equipment will be required. Transportation equipment maintenance practices will also include the maintenance of any additional system equipment (e.g., communication equipment such as cellular phones, CB radios, etc.). See **Section 8** for details on additional system equipment.

Maintenance requirements and replacement intervals for additional system equipment will vary depending on the type of equipment. This report assumes that most replacement intervals will be in the range of 1-3 years, while some intervals could be up to 10 years.

It is assumed that the UFTS vehicle fleet (tractors, trailers, and escort vehicles) have been maintained according to procedures and retired for service at no cost to the program. Furthermore, no credit is given to the value at end of life.

# 7. Transport Routes & Logistics

Transportation logistics comprises of two basic elements: routing and scheduling.

This section provides an overview of the transportation routes; it also describes the logistics of routine shipments, which include scheduling considerations i.e., hours in transit; non-transit times (rest stops; team driving considerations; new driver inspections) and cycle times (loading and unloading times).

Road transport described in this section includes that for the transport of UFTPs from Bruce, Pickering, and Darlington and BTPs from Gentilly 1 & 2, Point Lepreau, Douglas Point, and Chalk River to the potential DGR locations in Northwestern and Southern Ontario.

## 7.1 Route Management and Selection

Route management consists of balancing available resources with transport scheduling. This includes inputs such as vehicle and transport team availability, cycle times for transport and load/unload operations, adherence to driving time regulations, inclement weather, and road restrictions. Route management is also constrained by the regulatory requirements for the transport of Category II Nuclear Material. These include:

- Minimizing the total time that the nuclear material remains in transport;
- Minimizing the number and duration of any transfers of the nuclear material from one conveyance vehicle to another;
- Avoidance of fixed transport schedules for the movement of the nuclear material;
- Varying the routes used to transport the nuclear material, taking into account applicable regulations and ordinances regarding transport routes for radioactive and hazardous materials; and
- Choosing routes that take into account any obvious hazards such as rockslides, floods, or forest fires that could adversely affect the transport at certain times.

It is assumed that used fuel transport will be conducted over roadways designated primarily as Ontario provincial Class IV or greater (or Quebec and New Brunswick equivalent), or municipal class collector or greater as needed to access the provincial highway network, and that road upgrades to support the transportation system are not required based on the defined gate-to-gate battery limits. Actual travel routes to be used from the origin sites to the destination sites will be determined once a repository location is chosen. Route selection will be guided by variables such as:

- Seasonal load capacity restrictions on travelled roadways;
- Load height and weight restrictions along routes;
- Past and projected frequency of road maintenance for the road corridors;
- Potential emergency response times; and
- Available road assistance infrastructure (e.g., garages) along routes.

For planning and cost estimation purposes, route lengths between each interim storage facility and both potential repository locations are summarized in **Table 14**.

Through NWMO's engagement and social research program, a number of additional factors related to route selection have been raised by the public. NWMO will continue to consider these as transportation planning progresses.

# 7.2 Transport Logistics

The transport logistics detail the transport teams and their scheduling. This involves examining the identified routes and incorporating the corresponding stops for required breaks, i.e., rest stops, crew changes, or en route refueling. These stops are based on truck driving regulations, largely outlining driver shift patterns, and service stop requirements, which are described in the following sections.

## 7.2.1 Canadian Truck Driving Regulations

Regulations concerning the requirements for nuclear material shipments have been summarized in **Table 3**. This section outlines the current regulations applicable to UFTP and BTP shipments by road, including the federal and provincial legislation pertaining to hours of service and driver operation. The applicable regulations must be consulted during operational planning to ensure schedules are following the regulations in force at that time.

The following Federal and Provincial legislation represent the primary documents used to establish preliminary operating arrangements:

- Canadian Transportation Act 1996 – Government of Canada;
- Transport Act – Assemblée Nationale du Québec;
- Highway Traffic Act 1990 – Government of Ontario;
- Highways Act – Government of New Brunswick; and
- Commercial Vehicle Drivers Hours of Service Regulations – Government of Canada.

The allowable hours of work for drivers are regulated by the Government of Canada, as outlined in the Commercial Vehicle Drivers Hours of Service Regulations (SOR/2005-313), which establish a 13 hour per day limit on driving hours, and a 14 hour per day limit on total on-duty hours. Crew members may need to be replaced by rested drivers at pre-planned locations, depending on the length of the trip. The three provinces within the study limits have adopted the Federal regulations without imposing further restrictions on driving hours. The following Provincial regulations stipulate maximum driving hours, minimum off-duty hours, and other constraints for commercial vehicle operators:

- Ontario – the Driver Hours of Service regulation;
- Québec – the Regulation respecting the hours of driving and rest of heavy vehicle drivers; and
- New Brunswick – the Commercial Vehicle Drivers Hours of Service Regulation.

As the Ontario regulations are the most stringent on driving hours, these have been used to calculate preliminary transport team cycle times. The regulations in Québec and New Brunswick are also met by the proposed cycle times. It should be noted that the MTO Commercial Vehicle Operators Safety Manual was updated in 2019, and the updates were reflected in the assumptions concerning the duty hours in this report are as follows:

- The arriving transport team may not be the same as the departing transport team; and
- The on-duty (vehicle load/unload) time at the DGR or the origin sites does not have to be conducted by the arriving or departing transport teams.

### 7.2.2 Transport Team Management

Transport teams and the management of transport operations, including driver shift patterns, are determined based on the regulations and service stop requirements.

For Southern Ontario, the UFTP shipments from Bruce, Douglas Point, Pickering, and Darlington can be completed in a single driving shift due to the length of the journeys. However, the BTP shipments from Chalk River, Gentilly 1 & Gentilly 2, and Point Lepreau cannot be completed in a single driving shift. For shipments from all locations, transport teams consisting of two drivers in the vehicle (one off duty, one on duty) are assumed for the entire round trip; this is with the exception of Bruce and Douglas Point, due to the proximity and short travel time to the Southern Ontario DGR, where only a single driver will be required.

For Northwestern Ontario, no shipments can be completed in a single driving shift due to the length of the journeys. For these shipments, transport teams consisting of two drivers in the vehicle (one off duty, one on duty) will be used for the entire round trip.

By breaking each of the routes down into approximate half-hour segments, driver shift patterns and transport cycle times were developed based on the following assumptions:

- A 0.5-hour rest stop is taken after every 5 driving hours, except if the truck is within 0.5 hours of its destination; and
- If the truck is within 0.5 hours of its destination, stopping would result in more on-duty hours (for the stop and, if needed, new driver inspection, on top of the remaining driving time).

The need for driver changes and associated inspections along the route to comply with legislation and ensure safe operations has been factored into the above assumptions.

### 7.2.3 Cycle Times

The cycle times estimated for this report are based on:

- The routes selected as described in **Section 7.1**;
- The transport team management discussed in **Section 7.2.2**;
- An assumed average speed of 60 km/h (excluding stops); and
- An assumed 7 hours unloading and loading time at each terminal.

The cycle times are detailed in **Table 14**.

**Table 14: Approximate Cycle Times by Potential DGR Location and Interim Storage Facility**

| Potential DGR Location | Interim Storage Facility | One-Way Road Distance (km)[3] | Approximate Round-Trip Cycle Time (hours) |
|---|---|---|---|
| Northwestern Ontario (Crystalline – Ignace Area) | **Bruce** | 1775 | 80.5 |
| | **Pickering** | 1725 | 78.5 |
| | **Darlington** | 1725 | 79 |
| | **Point Lepreau** | 2900 | 123.5 |
| | **Chalk River** | 1600 | 74.5 |
| | **Gentilly 1** | 2150 | 95.5 |
| | **Gentilly 2** | 2150 | 95.5 |
| | **Douglas Point** | 1775 | 80.5 |
| Southern Ontario (Sedimentary – South Bruce Area) | **Bruce** | 50 | 16 |
| | **Pickering** | 275 | 23.5 |
| | **Darlington** | 300 | 24 |
| | **Point Lepreau** | 1725 | 78.5 |
| | **Chalk River** | 600 | 35.5 |
| | **Gentilly 1** | 950 | 50 |
| | **Gentilly 2** | 950 | 50 |
| | **Douglas Point** | 50 | 16 |

[3] Distances are rounded to the nearest multiple of 25 km.

# 8. Safety and Security of Transport

The CNSC's Regulatory Document (REGDOC-2.12.3, Version 2) titled Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material (June 2019) sets out security measures to be implemented to ensure the safe transport of used nuclear material.

For transport of used fuel (considered to be Category II nuclear material) by road, these include security measures relating to escorts, personnel, communication, tracking, and others.

**Section 8.1** and **Section 8.2** discuss measures relating to escorts and personnel.

**Section 8.3** and **Section 8.4** discuss measures relating to communication and tracking.

A license is required to transport used fuel. Per section 5 of the Nuclear Security Regulations, the application for a license must include a Transportation Security Plan. The main purpose of the Transportation Security Plan is to assure that nuclear material being transported receives adequate physical protection against any threats that may arise during transport.

The Transportation Security Plan will provide the information required for the license application, including:

- administrative information;
- description of the nuclear material;
- threat assessment which evaluates the nature, likelihood, and consequences of acts or events that may place prescribed information or nuclear material at risk, along with corresponding mitigation measures, including emergency response
- description of the conveyance;
- proposed security measures;
- communication arrangements;
- arrangements with response forces; and
- planned and alternate routes.

The Transportation Security Plan will elaborate on plans for security measures discussed in **Section 8.1** through **Section 8.4**, as well as define the plans for the other security measures required including:

- Provisions for the support of response forces along the transport route;
- Procedures for contacting, during transportation, the response force from any involved jurisdiction or agency;
- Contingency arrangements to address such events as a mechanical breakdown of a transport or escort vehicle, or failure of a shipment to arrive at its destination at the expected time;
- Procedures to be followed during an unscheduled stop or unscheduled delay during transport; and
- Provisions for notifying any response force along the transport route in advance of the actual shipment.

Since a transportation security plan for a licence to transport Category II nuclear material contains "prescribed information", it must be handled in manner to protect it, and all necessary precautions to prevent unauthorized access to it must be in place.

The Transportation Security Plan must be reviewed on a regular basis and updated as required.

## 8.1 Escorts

Shipments of Category II nuclear material should be accompanied by one or more escorts, such as nuclear security guards, authorized pursuant to section 18(2) of the Nuclear Security Regulations. These escorts should maintain constant surveillance of the shipment. Responsibilities may include:

1. Conducting searches of persons, materials, vehicles;
2. Remaining in frequent contact with the shipper, the receiver, the local authorities, and the response forces along the transport route;
3. Inspecting for security breaches and vulnerabilities, and ensuring the secure storage of any transport equipment; and,
4. Responding to and assessing incidents and events.

## 8.2 Personnel

The credentials and trustworthiness of all personnel involved in the transportation process should be verified. Background checks of all personnel involved should be completed regularly, and personnel changes should be minimized. Personnel procedures should be established to ensure security during departure, transport, and arrival, as well as during any stops or shift changes on route.

## 8.3 Communications Requirements

During the transport of Category II nuclear material, the shipments should remain in frequent contact with the shipper, the receiver, local authorities and the response forces along the transport route. Furthermore, the shipper should establish a plan of action in the event that communications are lost during shipment. Communication will be by encrypted messages only (the use of cell phones to send unencrypted messages is not recommended).

In remote regions, there may be gaps in communications coverage. Where it may not be possible to avoid such “black-out” areas along the transport route, other communication arrangements should be proposed. Furthermore, consideration should be given to adopting new communication technologies as they are proven reliable.

This report assumes that both satellite and encrypted cellular phones will be used. Satellite telephones can be used as back-up communications in the event of disruption of primary cellular communications. This report assumes the following communication equipment during operations for each escort vehicle.

- CB radio (on privately licensed frequency);
- CB Antenna;
- Satellite telephone (encrypted, use to be limited to back-up communication if CB radio unavailable); and
- Cellular telephone with carrier service.

## 8.4 Real-Time Tracking and Monitoring

Tracking equipment, such as electronic or satellite tracking devices (transponders), should be used to track and monitor shipments. This report assumes that NWMO will operate a central Transportation Communication & Control Centre (C&CC) located at the DGR facility that will provide a single point of contact for all agencies involved in transportation-related communications, and that will monitor and track used fuel shipments. Best practices and available technologies should be reviewed for tracking and monitoring as they are proven reliable. This report assumes the following tracking equipment during operations for each escort vehicle to support tracking and monitoring.

- GPS Tracking System;
- Carrier service for secure live streaming; and
- Dashboard camera / recorder.

In addition, this report assumes that each escort vehicle, tractor, and transport package will be equipped with a GPS unit for remote real-time tracking of their location. Spare GPS units will be available on each of the available 25% spares of transport packages and 20% spares of tractors and escort vehicles.

# 9. Emergency Response

In Canada, the emergency management community has adopted a standard approach for responding to incidents. Federal, provincial, and local governments use a comprehensive approach to emergency management, which includes having in place measures for prevention, mitigation, preparedness, and response and restoration activities for all modes of transportation.

NWMO will provide an Emergency Response Plan to the Canadian regulatory agencies to demonstrate that appropriate emergency measures are in place and that information is available to relevant public emergency response agencies. The purpose of the Emergency Response Plan is to ensure coordination among the NWMO, provincial, and local first responders as well as federal agencies.

The Emergency Response Plan will identify provisions to ensure that there are appropriate measures in place, in the event that there is an incident involving the transport of used nuclear fuel. The Emergency Response Plan details the response actions that should take place, the resources available to mitigate the situation, and, ultimately, how to return the area to normal.

The Emergency Response Plan will describe responsibilities associated with response as well as define response strategies and concepts. It will also identify resources (i.e., personnel and equipment requirements) and define training and procedures to enable effective response. It will also establish communications / liaison protocols with external emergency response organizations.

The Emergency Response Plan may include, but is not limited to the following:

- description of the emergency response organization and external agencies, as well as their roles, responsibilities, capabilities and duties and how they will interface;
- agreements on assistance with other facilities and/or other organizations;
- plans for mobilizing and deploying resources for response;
- description of response functions and actions (e.g., driver, escort, NWMO transportation command centre staff, first on the scene team, response team, recovery team, etc.);
- protective and response measures;
- training and qualification requirements, as well as drills and joint exercises; and
- communication protocols as well as procedures for alerting and notifying key organizations and personnel as well as the public.

The Emergency Response Plan may identify the need to contract or purchase specialized conveyance recovery equipment. Examples of supporting equipment are listed in **Table 15**. This is in addition to the emergency response equipment already assumed to accompany each shipment as described in **Section 6**, such as personal protective equipment, first aid kits, fire extinguishers, etc.

**Table 15: Possible Conveyance Recovery Equipment**

| Equipment | Purpose |
|---|---|
| Excavator | Excavation of trenches or access ways, ability to cut through heavy steel |
| Rotator Tow Truck | Ability to lift equipment, truck, and trailers |
| Wheeled Dozer | To push debris and away from the site |
| Wheel Loader | To lift and load the debris into haulage vehicles |
| HiWay Tractor | To haul equipment to/from incident locations |
| Heavy Equipment Float Trailer | To carry equipment to/from incident locations |
| Mobile Crane | Ability to lift UFTPs or BTPs |

## Quality information

| Prepared by | Checked by | Verified by | Approved by |
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| Ashton Taylor | Various | Khawar Ashraf | John Warren |

## Revision History

| Revision | Revision date | Details | Authorized | Name | Position |
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| 3 | Nov 27, 2020 | Final | | Khawar Ashraf | Project Manager |
| 4 | Sep 14, 2021 | Final - Revision | | Khawar Ashraf | Project Manager |

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