

APM 2021 DGR Lifecycle Cost Estimate Update Cost Summary Report

NWMO-TR-2021-11 R001

September 2021

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Nuclear Waste Management Organization

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APM 2021 DGR Lifecycle Cost Estimate Update – Repository Cost Summary Report

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Revision Summary		
Revision Number	Date	Description of Changes/Improvements
R000	2021-06	Initial issue
R001	2021-09	Minor text modifications to align with the Conceptual Design Report.

Executive Summary

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of its used nuclear fuel. The APM approach includes centralized containment and isolation of used nuclear fuel (or used fuel) in a deep geological repository constructed within a suitable host rock formation.

APM also includes a used fuel transportation system to safely move used fuel from the interim storage sites to the ultimate repository location.

One of the key considerations in the development of the lifecycle cost estimate is the location of the repository site. The NWMO launched a siting process in May 2010, and 22 communities expressed interest in learning more about APM and the potential to host the project. Since 2010, through a series of more detailed technical and social assessments, the number of communities has been narrowed to two; Ignace in the crystalline rock of northwest Ontario, and South Bruce in the sedimentary rock of southern Ontario. For this cost estimate, the Ignace siting area in crystalline rock has been selected as the reference as it presents a bounding scenario for cost estimating purposes.

Previous estimate updates considered two used fuel inventories; a base case of 3.6M CANDU used fuel bundles and an alternate case of 7.2M used fuel bundles. These two scenarios were performed to allow scaling of the estimate for variable used fuel bundle inventories. This estimate however reflects a single point estimate, based on a projected fuel inventory of 5.5M used fuel bundles. This estimate considers the projected end of life for the current fleet of nuclear reactors in Canada, including the current refurbishment plans for the Bruce Nuclear Site and Ontario Power Generation's Darlington Nuclear Reactor Site.

Project timeline assumptions remain consistent with the 2016 estimate with the exception of the Operations phase which has an extended period reflecting the current projected used fuel inventory. Based on an annual throughput of 120,000 used fuel bundles per year, the Operations phase of the APM project is estimated to be 46 years.

The revised baseline APM lifecycle cost estimate for a single point volume of 5.5 million used fuel bundles is \$24,481M for the repository, and \$1,539M for transportation, for an overall lifecycle cost estimate of \$26,020M. All estimate costs are stated in constant 2020 Canadian dollars.

A summary of the APM cost estimate by implementation phase is as follows:

Table E-1: APM Lifecycle Cost Estimate by Implementation Phase (2020 M\$)

Phases and Key Milestones	Schedule	Repository (2020\$M)	Transportation (2020\$M)	2021 Total Estimate (2020\$M)
Siting	2010-2023	1,221	20	1,241
Detailed Site Characterization and Licensing	2024-2032	1,888	40	1,928
Construction	2033-2042	4,309	150	4,459
Operations	2043-2088	13,351	1,323	14,674
Extended Monitoring	2089-2158	2,041	5	2,046
Decommissioning and Closure	2159-2188	1,671		1,671
Total:		24,481	1,539	26,020

The annual cost and cumulative cost for the APM cost estimate for the Reference inventory of 5.5 million used CANDU fuel bundles is illustrated in Figure E-1.

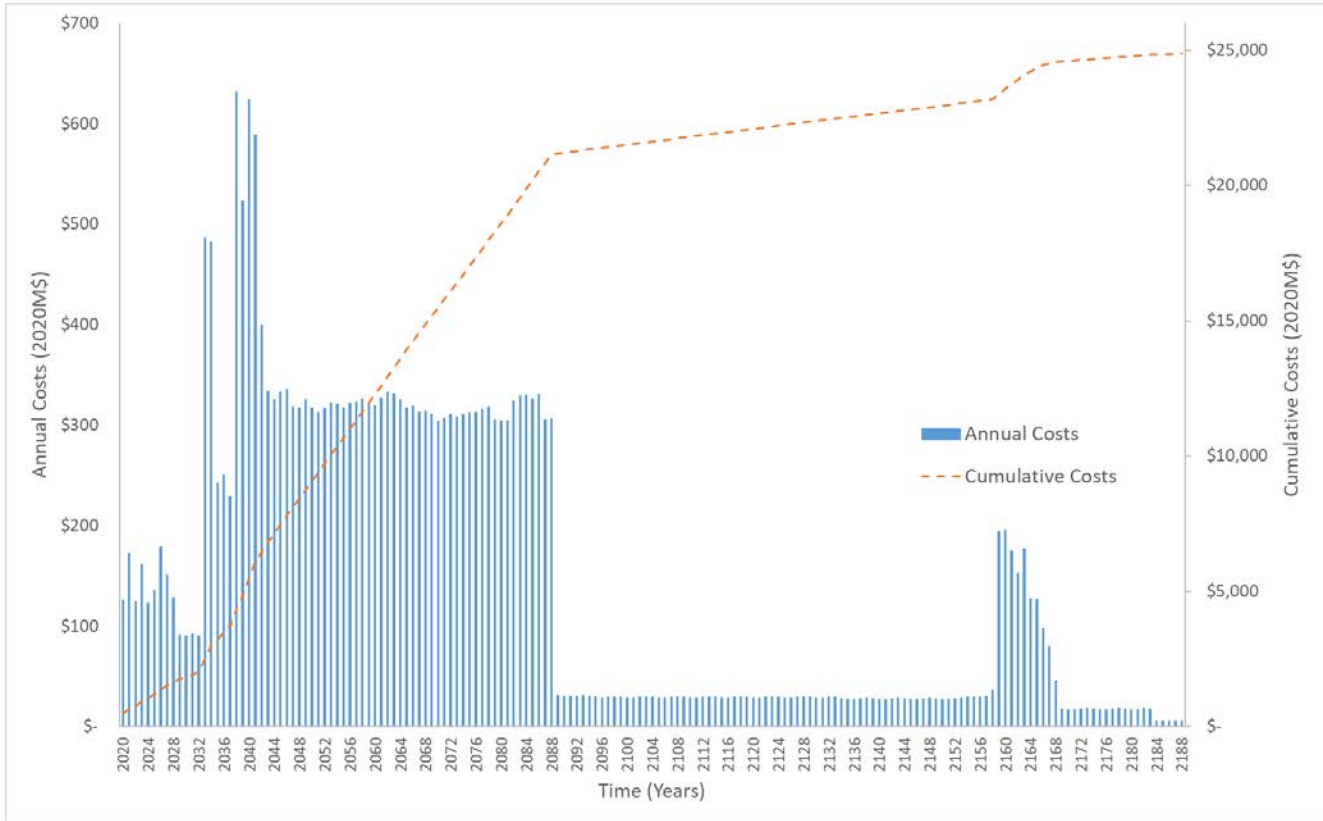


Figure E-1: APM Future Annual and Cumulative Costs

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1. PURPOSE

The purpose of this report is to provide an updated lifecycle cost estimate and schedule for the Adaptive Phased Management (APM) deep geological repository (DGR) for used nuclear fuel. This update replaces the previous APM reference lifecycle cost that was prepared in 2016.

To comply with the Nuclear Fuel Waste Act (NFWA) requirements and the Canadian Nuclear Safety Commission (CNSC) licensing requirement for financial guarantees on Class 3 or higher nuclear facilities, the nuclear industry updates the various lifecycle cost estimates and associated schedules and planning assumption on a five-year cycle. The Nuclear Waste Management Organization (NWMO) is accountable to manage and account for costs of transportation of the used fuel from the waste owners' facilities to the DGR and all facilities, equipment, and associated operation and maintenance activities for the ultimate long-term stewardship of all Canada's used fuel. The information summarized in this report represents an updated APM cost estimate to support the requirements of the *NFWA*.

2. CONTEXT AND METHODOLOGY FOR UPDATE

The NWMO is implementing APM, Canada's plan for the long-term management of its used nuclear fuel. The APM reference approach includes centralized containment and isolation of used nuclear fuel in a DGR constructed within a suitable host rock formation – crystalline or sedimentary rock. Figure 1 provides an illustration of the generic conceptual design for the APM DGR. APM also includes a used fuel transportation system (UFTS) to safely move used fuel from interim storage sites to the repository site.

This cost estimate and schedule presented are for the APM DGR constructed in crystalline rock for a projected used fuel inventory of 5.5 million used CANDU fuel bundles [R-1]. This location and geology represent the bounding scenario for cost estimating.

Consistent with current and past nuclear production in Canada these 5.5 million used fuel bundles have, or are expected to be, produced at Canadian nuclear facilities owned by Ontario Power Generation Inc. (OPG), New Brunswick Power (NBP), Hydro-Québec (HQ), and Atomic Energy of Canada Limited (AECL). Historically, the NWMO prepared two estimates; one for a base case of 3.6M used fuel bundles, and an alternate for 7.2M used fuel bundles to provide for scaling. This is the first point estimate; however, the estimate has the ability to scale should there be a change in projected fuel inventories resulting from new generation capacity or other changes in the industry impacting used fuel generation.

The 2021 cost estimate and schedule update has been prepared by the NWMO with components contracted out to engineering, technical and manufacturing organizations with specific expertise. Since the 2016 update, the NWMO has advanced elements of the conceptual design and associated cost estimate for the APM DGR and UFTS. The most significant changes from the 2016 cost estimate are the continued development and demonstration of the engineered barrier system design and components, and the narrowing of potential siting areas down to two: The township of Ignace in the crystalline setting of Northwestern Ontario, and The Municipality of South Bruce in the sedimentary setting of Southern Ontario.

The APM lifecycle cost estimate timeline began when the NWMO launched the APM site selection process in 2010 and extends through all project phases to the decommissioning and closure period ending in 2188. The next key milestone for the project is the selection of the preferred site for the repository by the end of 2023. This will then initiate the Detailed Site Characterization and Licensing phase which is planned from 2024 to 2032. This phase should

result in the NWMO obtaining the required impact assessment approval and licence to prepare site and construction licence.

The assumed durations for construction, operations, extended monitoring, and decommissioning are provided in Table 1.

Table 1: Assumed Phases and Planning Timelines

Phases	Timeline
Siting (Site Selection and Proof Testing)	2010-2023
Detailed Site Characterization and Licensing	2024-2032
Construction	2033-2042
Operations	2043-2088
Extended Monitoring	2089-2158
Decommissioning and Closure	2159-2188

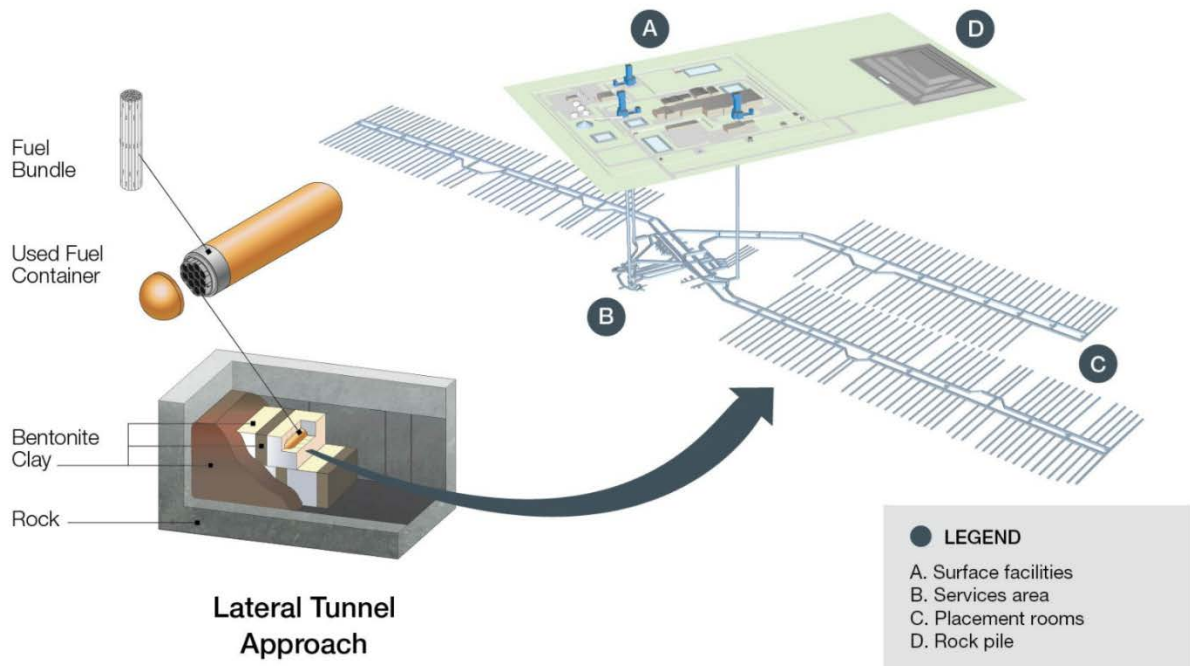


Figure 1: Conceptual APM DGR Design and cut-away showing Engineered Barrier System consisting of Used Fuel Container and Bentonite Clay

The lifecycle cost estimate is consolidated from several components of work that have been carried out since the 2016 estimate was published. These include design and cost updates for APM facility components that have been optimized or altered to reflect changes in technology or innovation. In addition, changes in the site selection process and engineered barrier system have been incorporated into the program plan and captured in this estimate. The estimate also reflects the last 10 years of actual costs for the implementation of the APM program.

The lifecycle cost estimate update was based on the conceptual designs for the following components:

- i. Pre-construction cost estimate, which includes all activities to site selection, detailed site characterization activities, and all the activities supporting the environmental assessment and licensing processes to the start of construction.
- ii. DGR in crystalline rock (construction and operations).
- iii. Used Fuel Packaging Plant (UFPP).
- iv. Engineered barrier system and components.
- v. UFTS program schedule, and transportation logistics from interim storage locations to the APM DGR site; and
- vi. Plans for extended monitoring, decommissioning and closure of the APM facility.

While there have not been any significant changes in the dimensioning of the emplacement rooms from the 2016 update, this latest design has optimized the placement of the shafts (i.e., the latest site layout has all three shafts within the main surface complex) and flexibility in the locating of emplacement panels to account for the in-situ geological conditions. With these changes, there were also changes in the dimensioning of the access tunnels and the configuration of the ventilation system. Refer to Figure 2 for a conceptual layout in crystalline rock.

As part of the cost estimate and schedule update process, all aspects of the APM DGR facility were reviewed and determined to remain valid or have been updated.

Updated Work Element Definition Sheets (WEDS) modified from the baseline APM estimate of 2016 were generated for all the above components and are provided in Appendix B.

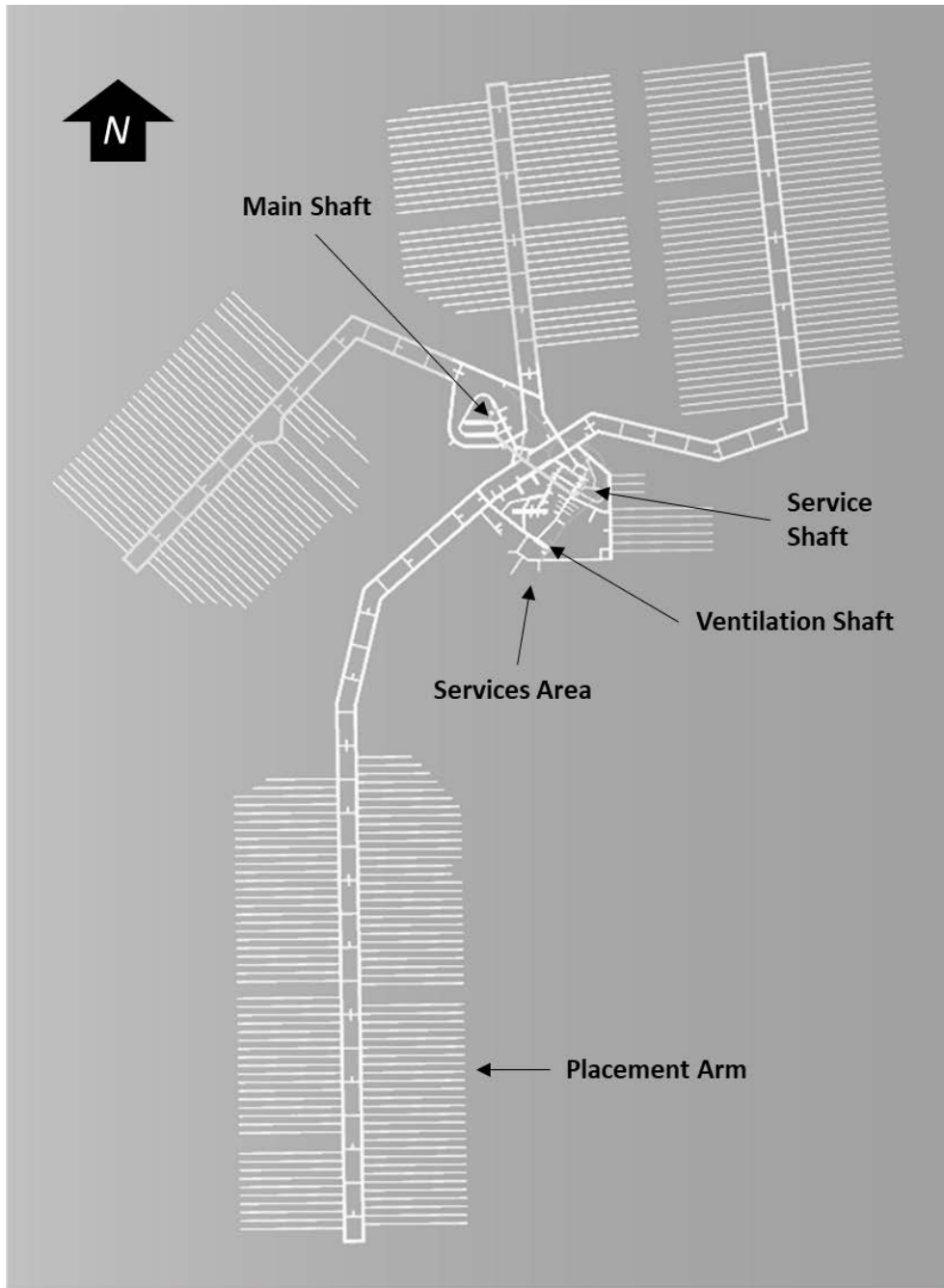


Figure 2: Conceptual Layout in Crystalline Rock

3. KEY ASSUMPTIONS

The following provides the key assumptions supporting the 2021 APM DGR facility cost estimate. Cost estimates are based on these assumptions along with assumptions detailed in the WEDS found in Appendix B of this report.

2021 Estimate Assumptions
The repository will be located within a high-quality (e.g., sparsely fractured) crystalline rock geosphere.
The estimate is based on an APM facility design that receives used CANDU fuel bundles from the Canadian nuclear fuel waste owners (i.e., OPG, NBP, HQ, and AECL).
The repository is sited at the proposed Ignace siting area.
All OPG owned used fuel (Pickering, Darlington, Bruce Nuclear Site) transport will be by road, in the existing module arrangement, utilizing the NWMO certified Used Fuel Transportation Package (UFTP). This requires that OPG transfers the fuel from the existing Dry Storage Containers (DSCs), into the UFTP at the interim storage sites.
All NBP, HQ and AECL (AECL basket-style) used fuel transport will be by road, in the existing and/or suitable used fuel basket arrangement, utilizing a purpose-built Basket Transportation Package (BTP). This requires that used fuel owners transfer the fuel from the existing storage into the BTP at the interim storage sites.
The cost estimate assumes the APM program will be continuous with no hold points or abnormal periods of inactivity whilst awaiting funding approvals, management reviews or licensing decisions. However, the cost estimate has assumed reasonable time periods for the completion of these activities.
APM technical work program activities will proceed in parallel with the schedule for APM siting to support advancement of the siting process, design development and the safety case for a used fuel DGR.
Detailed site characterization will be conducted at the single site selected. Any consideration for further evaluation of more than one site would be completed as part of activities in advance of single site selection (i.e., additional boreholes to support site selection).
The APM facility includes the setup of a temporary construction camp. Any improvement or expansion of town site services or infrastructure is a contingent item subject to discussions between the NWMO and the community.
Construction will begin in 2033 and progress as described to deliver a functional licensed facility at end of the year 2042.
The engineered barrier system design will consist of i) a copper-coated (three-millimeter) steel used fuel container (UFC) containing 48 used fuel bundles and surrounded by ii) a highly compacted bentonite buffer box, and iii) bentonite gap-fill material.
A rate of placement equivalent to 120,000 used fuel bundles per year will be accommodated.
The underground portion of the APM facility is assumed to be a network of horizontal tunnels and placement rooms for the UFCs excavated at a depth of approximately 500 metres, with three (3) vertical shafts extending to surface. During construction of the underground facilities, unsuitable rock conditions are assumed for 10 per cent of the excavations in the placement rooms.
An in-room horizontal placement method (with the UFC in a bentonite buffer box) will be utilized for the UFCs in the underground repository.
Following the start of operations, excavation of placement rooms would proceed concurrently with UFC placement activities, with sequencing of excavation and UFC placement activities, providing separation of these two activities from a personnel, ventilation, and equipment perspective.
After placement of all UFCs is completed, there will be a 70-year period during which underground access will be maintained and the placement rooms will be monitored.

4. BASIS OF ESTIMATE

The following documents the scope, assumptions, sources, and rates used to develop the APM DGR lifecycle cost estimate update, including the transportation of the used fuel from the waste owner's interim storage sites to the APM DGR. The estimate includes the full lifecycle costs, with adequate allowances/contingency, through the phases of siting, detailed site characterization and licensing, site preparation and construction, operations, monitoring, and decommissioning and closure. Key assumptions applicable to the generation of the estimate are included in Section 3 and in the WEDS included in Appendix B. Specific design input assumptions are included in the conceptual design reports [R-2] [R-3].

4.1 SCOPE AND BATTERY LIMIT

The scope of the APM DGR facility and transportation cost estimate incorporates all future planned expenditures, including all capital, operations, maintenance, and administration costs for the lifecycle duration of the APM program.

The APM DGR facility will be self-contained, and have facilities for operation, maintenance, and long-term monitoring. The main surface facilities include the UFPP, the Sealing Materials Compaction Plant, the Main, Service and Ventilation Shaft complexes, administration buildings, and all structures and equipment to meet nuclear security and safeguard regulations. The underground facilities will be comprised of the underground demonstration and services area at the base of the shafts, with access tunnels to the placement room panels in several placement arms positioned to avoid underground fractures as shown in Figure 2. Concepts for the safe transfer and placement of the UFCs have been developed and estimated. Following the operations period, there will be a period of extended monitoring, followed by decommissioning and closure of the facility.

4.2 DESIGN AND COST BASIS

The lifecycle APM cost estimate is based on a set of planning and system design assumptions and dates. The cost estimate was prepared using the current state of the conceptual design of the repository and transportation system. Details of the design and cost basis for the UFTS is provided in Section 5.2.

Estimate costs were prepared for labour, permanent material, equipment, other costs, and allowance/contingency. The estimate was constructed by packaging the overall scope into a Work Breakdown Structure (WBS), which defines the APM program work elements for cost estimating and scheduling purposes. Overall, the cost estimate can be considered as AACE 'Class 4' for the specific design basis/program scope.

4.3 WORK BREAKDOWN STRUCTURE (WBS)

More detailed cost estimating assumptions are captured in the WEDS for each work element of the WBS. The complete WBS is included in Appendix A.

4.4 WORK ELEMENT DEFINITION SHEETS (WEDS)

Detailed cost estimate assumptions pertaining to work at the lower levels of the WBS are documented in the WEDS for each work element. The following information was provided by the estimating lead for each WEDS at the lowest level of the WBS. Changes will be in reference to the baseline cost estimate WEDS.

- Primary estimator ("prepared by")
- WBS code and description

- Deliverables
- Assumptions
- Task start and end year
- Type of cost (fixed, step-fixed or variable)
- Labour (labour ID, start year, finish year, and hours per year)
- Material and equipment (by item)
- Other costs (by item)
- Allowance (as a per cent of the value of labour, material, and equipment, and other)

4.5 CURRENCY AND ESCALATION

The estimate is expressed in constant 2020 Canadian dollars. Estimates generated in the 2016 estimate that were deemed sufficient and not requiring updates were escalated based on rates provided in Table 2.

Table 2: Escalation Factors

APM	Labour	Material & Equipment	Other
from 2015 C\$ to 2020 C\$	1.1194	1.0906	1.1023

4.6 COST CATEGORIES

Labour

Internal and external labour costs where rates are inclusive of payroll burdens, including contractor profit. The cost of labour for non-NWMO work was based on Ontario commercial or industrial rates. Labour rates are consistent for similar worker activity and type.

Labour rates were derived as follows:

- NWMO Program Management rates are derived from the NWMO 2020-2024 Business Plan and are a weighted average based on 2020 NWMO Staff Profile distribution. Rates include a calculated burden.
- DGR rates are derived from industry standards and benchmarking and industrial skilled labour rates, and include conventional labour burden (payroll tax, benefits, etc.). This burden is comprised of involuntary labour surcharges such as payroll taxes, unemployment insurance and employee benefits, including that for sickness, accidents, vacation, and holiday, as well as training.
- Design build costs represent inclusive labour costs and incorporate a range of typical project indirects, including training, tools, supervision, job-site housekeeping, etc.

Material

Permanent material costs (e.g., concrete, cable, pipes, valves, etc.), inclusive of contractor mark ups, required to construct, operate, or maintain the transportation system or DGR facility.

Equipment

Permanent or temporary equipment costs (e.g., hoists, cranes, stand-by generators, etc.), that are rented, leased or purchased, required to construct, operate or maintain the transportation system or DGR facility.

Other

Items such as consumables (fuel, utilities, and non-permanent materials), permits and fees, taxes, communication costs, furniture, spare parts for permanent material and equipment, temporary monitoring equipment, and travel and accommodation expenses, required to construct, operate or maintain the transportation system or DGR facility. For supply and install type contracts, where labour and material costs cannot be easily separated, the estimate is categorized as other.

Allowance/Contingency

Generally, in a project estimate, allowances and contingencies are included to reflect the “known unknowns” and “unknown unknowns”. They are an estimated value for costs that are expected to arise but are not known when or precisely what the impact will be at this juncture of the design evolution. They are usually calculated as a percentage-based sum to cover the cost of known, but presently undefined, requirements for each work element. The allowances and contingencies are nominally 10% to 25% to reflect the level of design and uncertainties. In some cases, additional contingencies have been applied.

4.7 COST TYPES

Each WBS element was identified with a cost type of fixed, step-fixed, or variable as defined below.

Fixed cost – is a cost that is not sensitive to total quantity of used fuel arising, or to facility or system capacity, given a constant used fuel facility throughput rate. For example, most development costs, all siting costs, safety assessment, licensing and approval costs, environmental monitoring costs, many infrastructure costs (roads, surface facilities, utilities), and program costs (program management, public affairs, administration) are not sensitive to total quantity of used fuel arising or the facility or system throughput capacity. Fixed costs are generally unavoidable costs and must be paid irrespective of total used fuel quantity or facility throughput capacity.

Step-fixed cost – is a type of fixed cost that is sensitive to changes in total quantity of used fuel shipped or stored, or to the used fuel throughput capacity of the facility or system. If the total quantity of used fuel changes or the used fuel facility throughput capacity changes, then the size or number and the associated cost of some infrastructure or capital cost items will change. Examples of step-fixed costs are the following:

- Equipment reaches its end of design life (e.g., 10 to 15 years is typical for most equipment), and new equipment needs to be acquired and installed.
- Productivity rates are achieved, and additional resources are required. For example, one staff can process “x widgets”; once “x” is reached, another staff is required until “2x” is achieved, and so forth.

Variable cost – is a cost that is directly proportional to quantity of used fuel. When the quantity of used fuel changes, the estimates will change in direct proportion to the change in quantity of used fuel arising. Examples of variable costs are the following:

- Labour directly involved in handling the used fuel (e.g., packaging used fuel, emplacing used fuel in emplacement rooms).
- The number of transportation trips is dependent on the assumed used fuel bundles; and

- The number of UFCs required is dependent on the assumed used fuel bundles.

5. COST ESTIMATE SUMMARY

Table 3 illustrates the full lifecycle estimate for the DGR Repository and Transportation by project phase. These estimates are described in Sections 5.1 and 5.2, respectively.

Table 3: APM Lifecycle Cost Estimate by Implementation Phase

Phases and Key Milestones	Schedule	Repository (2020\$M)	Transportation (2020\$M)	2021 Total Estimate (2020\$M)
Siting	2010-2023	1,221	20	1,241
Detailed Site Characterization and Licensing	2024-2032	1,888	40	1,928
Construction	2033-2042	4,309	150	4,459
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Extended Monitoring	2089-2158	2,041	5	2,046
Decommissioning and Closure	2159-2188	1,671		1,671
Total:		24,481	1,539	26,020

5.1 REPOSITORY ESTIMATE

The Repository cost estimate was prepared by NWMO and external subject matter experts. It includes program management, licensing, construction, operation, long term monitoring and decommissioning through to closure.

The most significant change in project phases since the 2016 estimate is the extension of the operating period to 46 years (additional 16 years). Other changes are described in the following sections and supported through the detailed WEDS in Appendix B.

The following sections provides a high-level description of the key elements of the repository estimate.

5.1.1 Program Management

Program Management includes all costs related the siting process, detailed site characterization and licensing through to issuance of a site preparation, construction and operating licenses. Some program management elements (Stakeholder Relations & Engagement, Geosphere Monitoring, Environmental, Safety Assessment, Technical Research and Collaboration, Common Services) extend over more than one phase.

The estimate was updated consistent with the 2020-2024 Business Plan. It assumes NWMO selects a single site by end of 2023 and obtains a license to commence construction by 2033. Elements that extend beyond the business plan period were reviewed and optimized by subject matter experts as appropriate.

Table 4 below provides a summary of the Program Management cost estimates at the WBS3 Level.

Stakeholder Relations & Engagement

Critical to the success of APM program is the involvement of the Canadian public, including First Nation and Métis peoples, at all stages of implementation and in key decisions through open, transparent, and inclusive engagement processes. The NWMO will seek and be responsive to a diversity of views and perspectives. The NWMO will communicate and consult actively, promoting thoughtful reflection and facilitating a constructive dialogue in different aspects of APM implementation.

The process to select an APM DGR site in an area with an informed and willing host was initiated in May 2010. The siting process begins with a period of learning and capacity building for communities. The APM program assumes communities elect to progress through subsequent steps of screening, feasibility study and preliminary field investigations. The assumptions for this cost estimate are that a single site is selected by 2023 to enter into more detailed site characterization and licensing. All costs associated with ongoing municipal and indigenous community engagement are included in this WBS.

Geoscience/Detailed Site Characterization

Technical activities for initial geoscience investigations and ongoing site geoscience and detailed site characterization activities are captured as part of this WBS. This includes surface-based borehole drilling, borehole investigations, installation of surface and underground monitoring equipment and instrumentation, and ongoing monitoring of these activities during all phases.

Environmental

Technical activities related to initial environmental investigations and ongoing environmental activities are captured as part of this WBS. This includes field investigations, environmental assessment preparation, and ongoing environmental oversight.

Licensing

Staffing, resources, CNSC fees, and costs associated with regulatory reviews, for all phases of facility licensing, are included in this WBS. The ongoing costs for maintenance of the licences are also captured. This includes estimates of annual CNSC oversight fees. IAEA staff and equipment costs to meet the international safeguard requirements are recovered through CNSC fees.

Safety Assessment

All costs associated with the development of the safety case in support of licensing submissions, as well as the maintenance of the safety case through implementation phases, are included in this WBS.

Technical Research and Collaboration

A number of technical and scientific activities are being conducted to further increase confidence in the safety case for the APM facility and to improve the NWMO's understanding of

key scientific processes that may influence repository safety. These activities to build confidence and process understanding include models of the engineered-barrier system, groundwater flow system evolution, integrated safety assessment models, and full-scale demonstration of repository technology both in Canada and with international partners via joint projects and international research facilities.

Engineering and Design

Engineering and design includes all activities related to the development of conceptual, feasibility and preliminary designs for the APM facility. The work activities include the optimization and proof testing activities related to the engineered-barrier design in advance of single site selection. Following site selection, site-specific designs will be further developed in support of the licence application with the costs captured in this WBS.

Areas where technology requires additional development for deployment in the APM program are generally focused around the used fuel processes. Canada has demonstrated leadership in CANDU fuel transfer operations, and this domestic expertise will be investigated for fuel transfer operations. Similar advancement programs are required for monitoring, used fuel container placement and retrieval, and sealing system demonstration.

Governance

This WBS captures the costs associated with the ongoing maintenance of the NWMO's various governance processes and oversight. These include the Board of Directors, Advisory Council, and other forums from which the NWMO receives guidance and/or oversight.

Common Services

Overall business, administrative and management function that will provide the necessary back-office support to the APM program, including the provision and/or management of finances, systems, people, infrastructure, and supplies. Costs associated with the NWMO's common services include, but not limited to, the corporate executive office, finance, procurement, IT, performance assurance, and human resources.

Table 4: Program Management WBS Cost Estimate Summary

WBS Level 2	2021 Estimate (2020M\$)
Stakeholder Relations and Engagement	1,653
Geoscience/Detailed Site Characterization	658
Environmental	170
Licensing	664
Safety Assessment & Technical Research and Collaboration	642
Engineering and Design	924
Governance	61
Common services	698
Total	5,471

5.1.2 Used Fuel Container (UFC)

In 2016 a cost estimate to manufacture and deliver an empty UFC to the APM DGR was assembled based on inputs from various external experts in the manufacturing sector.

That cost estimate has been updated in this Report to reflect learnings from proof testing activity since that time.

These updates included:

- Refinement of the processing sequence and equipment
- Copper costs updated to current market price
- Copper coating process to include post-deposition machining.

The UFC cost estimate considers five stages of the UFC production sequence. The five stages (in production sequence) are:

- Fabrication of the steel core and internal fuel basket;
- Copper coating of the exterior steel core, using electro-deposition;
- Closure welding of the UFC (cost of consumable material estimated only);
- Copper coating over the closure weld zone, using copper cold spray (cost of consumable material estimated only); and
- Transportation of the empty UFCs (without used fuel) to the UFPP.

The steel vessel component costs consist of an estimate for the core and internal basket, and an estimate for the materials consumed in the closure weld process.

Estimates for the manufacture of the steel core and internal basket were based on a realistic manufacturing sequence developed from analysis of technical specifications and UFC conceptual designs with a sound understanding of the requirements and experience to meet nuclear procurement standards.

The cost estimate for electro-deposition coating is for coating of the UFCs to a target copper thickness of approximately four millimeters with machined finish of 3mm thickness.

The estimate for the closure weld zone considers the costs of welding wire, shielding gas, and electricity. The copper coating component costs account for the materials consumed in the cold-spray process.

Closure zone operations (welding and coating) occur at the UFPP. The labour costs for these are considered in the UFPP estimate.

Transportation costs are all-inclusive for the transportation of the empty UFCs from a hypothetical site of manufacture (assumed to be within 100 kms of the site) to the UFPP located at the APM DGR site using 2020 shipping rates. UFCs and baskets will be manufactured and assembled off-site and shipped to the APM DGR site as a completed item. Transportation does not include any movement of used fuel; costs for transporting used fuel from nuclear reactor sites are addressed in the transportation cost estimate.

Table 5: UFC Cost Summary

UFC Cost	2021 Estimate (2020M\$)
Cost per UFC	36,224
Annual Cost (\$ Million)	91
Total Cost (\$ Million)	4,166

5.1.3 Surface Facilities

The APM DGR facility will be self-contained, and have facilities for operation, maintenance, and long-term monitoring. The surface facilities will have an area with restricted access, including the UFPP, and shaft complexes. As well, there will be facilities outside the restricted area such as the Administration Building, Sealing Materials Compaction Plant, Concrete Batch Plant, and all other surface facilities.

The surface facilities that are unique to the used fuel repository are the UFPP, the Sealing Materials Compaction Plant, and the Main, Service and Ventilation Shaft complexes. These surface facilities are summarized below. All other surface facilities are detailed in the WEDS in Appendix B.

Table 6: Surface Facility Cost Estimate by Work Package

Surface Facilities	2021 Estimate (2020M\$)
Used Fuel Packaging Plant	2,826
Sealing Materials Equipment and Production	1,800
Shafts, Headframes and Hoisting Systems	513
Additional Surface Facilities	763
Total	5,903

Used Fuel Packaging Plant (UFPP)

The used nuclear fuel will be received at the UFPP from the originating interim storage sites. The used fuel will be transported in certified road transportation packages (Used Fuel Transportation Packages (UFTPs) or Basket Transportation Packages (BTPs) as outlined in the Used Fuel Transportation System (UFTS) section, Section 5.2. The Transportation Packages will be received at the UFPP, and the used fuel bundles will be removed, inspected, catalogued, and repackaged into UFCs. The filled UFCs will be sealed, copper coated, inspected and inserted into buffer boxes, consisting of highly compacted bentonite manufactured as two halves with a cavity in each half to house the UFC. The buffer box and UFC will be dispatched via a shielded cask for placement in the underground repository.

The UFPP facility layout and conceptual design has been updated to adopt a modular approach which consists of multiple work processing cells that support specific processes in parallel to maximize the process availability and flexibility. The UFPP updated design is based on a single

storey ground level facility with various defined areas within for all necessary processing and support functions including:

- UFTP/BTP Receiving and Laydown Area
- BTP Processing Area
- UFTP Unloading Cells
- UFC Loading Cells
- UFC weld cells
- Decontamination Cells
- UFC Copper Application and Machining Cells
- UFC Copper Annealing and Non-Destructive Examination (NDE) Cells
- UFC Final Survey and Buffer Box Loading Cell
- Contingency Cell
- Canning cell
- UFC Transfer Hall and Intracell transfer system
- Incoming UFC and Incoming Buffer Box receiving and laydown area
- Other process support areas

UFPP operations costs are proportional to the volume of UFCs to be processed and handled annually to achieve the target rate of 120,000 used fuel bundles per year, which is 2,500 UFCs per year. The UFPP equipment and layout allows for multiple simultaneous activities to occur.

A summary of the UFPP cost elements for the engineered barrier system design is as follows:

Table 7: UFPP Cost Estimate Summary by Cost Component

UFPP Cost Component	2021 Estimate (2020M\$)
Project Management/Building Design and Construction of UFPP	136
UFPP Equipment Design, Supply and Install	528
Building Services Design Supply & Installation (UFPP)	502
Commissioning (UFPP)	107
UFPP Operations	1,553
Total	2,826

Sealing Materials Compaction Plant

Sealing Materials Compaction Plant will produce three types of repository sealing materials for the encapsulation of UFCs: a) highly compacted bentonite in the form of buffer boxes, b) 100% bentonite gap fill material, and c) various highly compacted bentonite blocks used as spacers and to seal the entrances of placement rooms. The UFC will be pre-packaged, above ground in the UFPP, into a rectangular-shaped buffer box. The buffer boxes will be manufactured as top and bottom halves with a cavity in each half to house the UFC. The buffer boxes with UFCs will be stacked in the placement rooms and the space around the stack of buffer boxes will be backfilled with gap fill material. In the placement rooms the center-to-center spacing between the encapsulated UFCs is 1.3 metres in the crystalline rock setting. The plant will employ custom-designed presses and molds for manufacturing the buffer boxes and blocks with specialized lifting devices in place to handle the formed materials.

The estimate for the production of the sealing materials includes the equipment and facilities of the sealing materials plant, as well as the material, labour and power required to operate the plant for the life of the facility.

Main, Service and Exhaust Ventilation Shafts

The APM DGR facility includes three shaft complexes – the Main Shaft, Service Shaft, and Exhaust Ventilation Shaft. The Main Shaft complex serves as the exclusive conveyance structure for the surface-to-underground transfer of the buffer boxes (with UFCs). The Service Shaft complex is a multi-purpose hoisting facility with three hoisting systems for movement of personnel and materials into and out of the repository. The Service Shaft complex incorporates equipment for delivering excavated rock to surface (skips), a main service hoist for movement of personnel and materials to the underground repository, and an auxiliary hoist for personnel movement both during normal operations and emergencies. The Exhaust Ventilation Shaft complex handles most of the repository exhaust and serves as a secondary means of egress from the underground repository.

The shaft diameters and in-shaft services have been reviewed and updated with mining industry best practices and safety requirements. The Main Shaft diameter and hoisting capacity did not change relative to 2016 design. However, a limited number of redundant services were added to the design (service water piping, power, and communications cables). Similarly, the Service Shaft design remained largely unchanged with the primary change being the auxiliary hoist. The auxiliary hoist was changed to a Blair-type hoist to allow the elimination of timber guides in the shaft which are considered to be a fire risk. The Exhaust Ventilation Shaft diameter has been increased to ensure air flow velocities remain below the critical velocity range where water droplets may form and remain suspended within the shaft. A limited number of redundant services were added to the Exhaust Ventilation Shaft design (service water piping, power, and communications cables). Like the Service Shaft the auxiliary hoist in the Exhaust Ventilation Shaft was changed to a Blair-type hoist.

The cost estimate for the shaft complexes includes the excavation associated with the sinking of the three shafts, the maintenance and periodic replacement of the hoist rope and associated equipment, as well as the sealing and decommissioning of the shaft complexes at the end of the extended monitoring period.

Table 8: Main, Service and Exhaust Ventilation Shafts Cost Estimate Summary

Shaft, Headframe and Hoist Complexes Cost Component	2021 Estimate (2020M\$)
Service Shaft and Headframe	188
Main Shaft and Headframe	172
Ventilation Shaft and Headframe	129
Hoist Rope Replacement	23
Total	513

Additional Surface Facilities

Additional surface facilities are those facilities required for operation of the APM DGR. These include the preparation of the site access roads, transmission towers, excavated rock management area and construction indirects. Details of the costs and assumptions used are found in the WEDS specific to each facility building included in Appendix B.

5.1.4 Underground Facilities

The scope of the underground facilities estimate includes the excavation of the underground repository, including the services area, perimeter and access tunnels, and placement rooms, and includes the underground ventilation system and underground operations (i.e., buffer box/UFC placement).

Underground Facility Excavation

The underground facilities are comprised of two main areas: a) service area located at the base of the three shafts, and b) the placement rooms located on placement arms extending from the service area. The service area would provide a range of facilities to support APM DGR operations, including the Underground Demonstration Facility (UDF), charging stations, refuge stations, offices, washrooms, mobile equipment shop, lube bay, material storage areas, explosives and detonator magazines, and rock dump and rock breaker (which feeds the loading pocket at the base of the Service Shaft). Details of these areas can be found in the conceptual design report [R-2] and the WEDS found in Appendix B.

The basic arrangement of the underground repository involves a series of parallel, dead-end placement rooms organized into panels. The panels of rooms are located on either side of twin access tunnels that extend full length of each placement arm. All underground openings will be excavated by controlled drill and blast methods. The placement rooms will have a rectangular shape of nominal dimensions 3.2 metres wide by 2.4 metres high by approximately 305 metres long.

Initial construction of the underground repository would span a period of approximately 10 years. During this time, the service area (including the UDF), the twin access tunnels along each placement arm, and one panel of placement rooms would be developed. Following the start of operations, excavation of placement rooms would proceed concurrently with UFC placement activities. Sequencing of excavation and UFC placement activities would provide separation of these two activities from a manpower, ventilation, and equipment perspective.

The most significant change relative to 2016 reference design has been the layout of the placement rooms. In the 2016 reference design the overall layout had a rectangular shape with two shafts leading to a service area at one end of the underground repository and the exhaust ventilation shaft at the other end. Whereas this reference design is based on the placement arm concept described above.

Underground Ventilation, and Mining Heat and Power

A series of surface fans and underground booster fans will be required to achieve the designed air flow distribution in the underground repository. A surface-based fresh air heating plant will be used to heat air in winter months. Auxiliary fans and ducting that are in the underground access tunnels will direct airflow into active placement rooms.

The cost estimate for the underground ventilation, and mining heat and power includes emergency power generation, the design, procurement, installation, and commissioning of the ventilation system, including spares and eventual decommissioning, as well as costs incurred for mine heating and electricity required for the fans, hoisting, pumps, etc., during operations.

The unit price increase of propane has resulted in an increase in the cost for heating and power to the underground facilities during construction and operations. Details are found in the WEDS in Appendix B.

A significant redesign of the underground ventilation system was carried out by external experts, identifying equipment and specifications based on modelling techniques. The updated ventilation system design assumes that all underground equipment will be battery powered.

UFC Placement

Concepts for the safe transfer and placement of the UFCs have been developed based on a review of proven nuclear industry material handling concepts, as well as related work by other national radioactive waste management organizations. Additional details are found in the conceptual design report [R-2] and associated WEDS in Appendix B.

The loaded transfer cask will be delivered underground to the entrance of a placement room where the buffer box is removed from the transfer cask inside a shielded structure. Placement of the buffer box (with UFC) inside the placement room will be performed by remote-controlled equipment. Remote handling is required because the buffer boxes (with UFCs) must be transferred without shielding inside the placement room.

The cost estimate for UFC placement includes a set of placement equipment for use in the UDF, as well as the remote communication system, UFC handling systems, UFC placement equipment, and labour and indirects for final panel UFC placement.

Table 9: Underground Facilities Cost Estimate by Work Package

Underground Facilities	2021 Estimate (2020M\$)
Underground Excavation	1,179
Underground Ventilation, and Mining Heat and Power	917
UFC Placement	666
Total	2,762

5.1.5 Operations Management

Operations management encompasses the:

- a) management and administrative functions covering the day-to-day operation of the APM DGR facility during the operations phase,
- b) the indirect labour and equipment required to operate the APM DGR during facility operations (excluding indirects accounted for in underground excavation work elements), and
- c) operation and maintenance of surface buildings and associated facilities (excluding the UFPP, Sealing Materials Compaction Plant, or mining or placement activities).

Operations management includes operational safety and radiation protection, with key monitoring programs addressing:

- Worker occupational health and safety.
- Environmental monitoring at the surface and underground.
- Site security and emergency response plans; and
- Support systems, including fire detection and suppression.

5.1.6 Extended Operations and Decommissioning

Subsequent to the cessation of used fuel placement activities, there will be a period of extended monitoring. Extended operations include the operation, maintenance/refurbishment, and management of the DGR for the extended monitoring period (70 years). This will include

monitoring and preservation of key surface and underground facilities and monitoring the geotechnical integrity of the APM DGR, etc.

Following the receipt of regulatory approval, the APM DGR facility will be decommissioned, and the underground repository sealed. Decommissioning and closure encompasses management, construction, and operation of related facilities, and decommissioning and closure of the surface and underground facilities. Included in decommissioning is the operation and management of the APM DGR for the years during decommissioning, including staffing, as well as all facilities and equipment needed for decommissioning activities. Further details are found in the WEDS in Appendix B.

5.2 TRANSPORTATION

The APM Used Fuel Transportation System (UFTS) design and lifecycle cost estimate has been updated by NWMO subject matter experts and an external engineering firm with technical expertise in transportation system design, infrastructure, planning, routing, and logistics.

The cost estimate update was prepared with activities that make up the work for each element identified at the lowest level of the WBS. The estimate considers all activities related to an all-road transportation system and 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 APM DGR site through all phases of the program.

The cost estimating methodology for the update of the UFTS cost estimate assessed the design basis of the previous baseline UFTS estimate and provided a “bottom up” review and estimate update. The estimate was updated based on the following key design basis changes:

- a) Change to the use of site-specific Transportation Packages; using Used Fuel Transportation Packages (UFTPs) to transport used fuel from Ontario Power Generation (OPG) owned sites, and Basket Transportation Packages (BTPs) to transport used fuel from all other nuclear sites;
- b) Site-specific used fuel inventory and transportation logistics changes; and
- c) Consideration of site-specific distances from the interim storage facilities to the potential APM DGR location.

Additional details are found in the conceptual design report [R-3] and associated WEDS in Appendix B.

The battery limits for the UFTS are consistent with the previous (2016) lifecycle cost estimate and considers gate-to-gate (all road) transport of used fuel from eight interim storage facilities (located at 6 origin sites) to a potential DGR location. This battery limit between interim storage and the transportation work activities aligns with the expected licensing responsibilities between the waste owner and the NWMO. The waste owner will own and operate the transfer from interim storage through to loading the transportation package. The NWMO will be the licence holder and operator of the transportation package and associated vehicle. The UFTS cost estimate assumes the waste owner has retrieved the used fuel from their interim storage facilities and loaded the UFTP/BTP, prepared for transport to the DGR Facility. All the costs to transport the UFTP/BTP to the repository site are considered in the APM estimate.

At the interim storage facilities, used fuel in dry storage is stored in two forms: Modules and Baskets. The design and cost estimate has been updated assuming two different Transportation Packages and associated equipment and conveyances, and to eliminate the need to transfer used fuel stored in baskets into modules prior to transferring to a Transportation Package.

OPG-owned used fuel is stored in a rectangular racking system known as a module. Each module holds 96 used fuel bundles. The dry storage system at OPG comprises of a manufactured high-density container referred to as the Dry Storage Container (DSC). Each DCS contains a stack of 4 modules (384 fuel bundles). The UFTP is designed to transport used fuel bundles in the horizontal position in two (2) modules or 192 used fuel bundles.

Used 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 holds 61 used fuel bundles in a vertical orientation and is used by HQ and NBP. Used fuel baskets at the AECL sites hold fewer used fuel bundles, ranging from 38 to 54 used fuel bundles. The BTP is still in the conceptual design stage, however, will be specifically designed to transport used fuel stored and configured in a cylindrical basket, transporting two baskets per BTP.

The used fuel inventories and transportation schedules are based on the most recent used fuel waste projections provided by the various nuclear waste owners. Quantities of used fuel assumed to be generated by each nuclear waste owner are listed in Table 10, including the estimated number of shipments from each nuclear site. The used fuel inventory is used to allocate the equipment costs of the UFTS (i.e., conveyance, packages, vehicle maintenance) between the nuclear waste owners. Shipment logistics are used to calculate costs based on the number of shipments and an assumed distance to the APM DGR site, as well as the cost schedule.

Table 10: Used Fuel Inventory and Shipments by Nuclear Waste Owner

Owner	Bundles	Shipments
OPG	5,078,599	26,456
AECL	32,656	340
HQ	129,925	1,083
NBPN	258,820	2,157
Total (rounded)	5,500,000	30,036

5.2.1 UFTS Cost and Schedule Estimate

The 2021 cost estimate update is consistent with the NWMO 2021-2025 business planning assumptions and costs. The 2021 UFTS cost estimate update is shown in Table 11 by program phase and in Table 12 by WBS Level 2.

Table 11: UFTS Cost Summary by Phase

Program Phase	2021 Estimate (2020M\$)
Siting	20
Detailed Site Characterization and Licensing	40
Construction	150
Operations	1,323
Extended Monitoring	5
Decommissioning and Closure	-
Total	1,539

5.2.2 UFTS Summary by WBS Level 2

Details of the UFTS WBS Level 2 are provided below:

Transportation Analyses and Assessments

This WBS comprises the detailed design and route selection process which will depend on the actual inventories and interim storage locations at the time of commissioning. It includes mode and route development work, such as studies to assess the feasibility of transporting used fuel from the interim storage facilities to the APM DGR and identifying preferred shipping routes. This scope also includes the near-term cost details, including logistics studies, risk analysis, operational concepts, emergency response plans, and examination of occupational and public radiological safety during the transport of used fuel for transportation system optimization. In addition, the identification and design of the necessary transportation equipment and facilities, including local access infrastructure, transportation packages (including package optimizations of the UFTP and BTP), trailers and security escort vehicles. Results will be used during route and site selection, site licensing, and environmental assessments.

Transportation Packaging Certification and Licensing

This WBS covers obtaining the required certifications for transportation packaging designs and safety analyses, registration and licenses to transport used fuel from the Regulatory Authority.

Capital Equipment and Facilities

This covers the design, procurement, construction, testing, and commissioning of all equipment or facilities to implement the used fuel transportation system. It includes the transport vehicles, transport packages, maintenance and transfer infrastructures. Included within lower levels of this WBS is the detailed design, procurement, and commissioning of the trailers and tractors for the transportation system.

This WBS is further subdivided into work elements for each nuclear reactor site and for “non-site specific” (also referred to as “common”) components. In addition, the detailed design, documentation for licensing certification, procurement and manufacturing, testing, and commissioning of the UFTPs and BTPs and associated equipment are included. Equipment

and facilities associated with the APM DGR receiving facility include equipment for real-time tracking and emergency response.

Transportation System Operations

These elements include all activities to operate the transportation system from loaded UFTP/BTP reception at the nuclear waste owner's facility to the delivery of the loaded UFTPs or BTPs at the APM DGR facility. Overall, the operational phase of the transportation system is determined by the used fuel inventory and the emplacement rate (e.g., 120,000 bundles per annum).

This WBS element is subdivided into several components to account for each step, as follows:

- **Project Management:**
This encompasses project-level management of the transportation system, including reporting to line management.
- **Transportation logistics from interim storage sites to the APM DGR facility.**
UFTP transportation logistics comprise of two basic elements: routing and scheduling. This element 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).
- **Transportation logistics at the APM DGR facility:**
UFTP transportation logistics at DGR includes real-time tracking and the operation of the emergency response system during the shipping period, which includes completed emergency response plans with all necessary documentation, and staffed emergency system ready to activate needed resources and deploy a recovery system for the transportation package.
- **Transportation vehicles maintenance :**
UFTP transportation vehicles maintenance encompasses transportation system vehicle maintenance.

Environmental Management

Environmental management work, as defined under this WBS element, encompasses the following, and continuing throughout system operations:

- The setup and monitoring of transportation aspects within an Environmental Management System in accordance with ISO 14001.
- Auditing of comparable supplier management systems.
- Liaison with Regulatory Authorities regarding associated requirements.
- Assistance with transportation aspects of environmental assessment work; and
- Planning of environmental monitoring activities as needed.

Decommissioning

The decommissioning WBS element includes the:

- a) development and approval of plans to decommission the transportation systems (e.g., transportation packages, trucks, trailers, etc.) (and undertaking those plans).
- b) decontamination of used fuel transportation packages and auxiliary equipment (as required), and

c) management/storage of the decommissioning wastes.

Program Management

Program management includes management direction and oversight of the transportation program, including contract management, financial, scheduling, quality assurance, and corporate overheads. Activities are staged accordingly to align with the overall APM schedule.

Table 12: UFTS Cost Summary by WBS Level 2 (2020 \$ Million)

Used Fuel Transportation System	2021 Estimate (2020M\$)
Transportation Analyses and Assessments	112
Capital Equipment and Facilities	210
Transportation System Operations	1,015
Transportation Packaging Certification and License to Transport	10
Environmental Management	8
Decommissioning	9
Program Management	174
Total	1,539

6. REFERENCES

[R-1] NWMO. 2020. Nuclear Fuel Waste Projections in Canada – 2020 Update, NWMO-TR-2020-06.

[R-2] NWMO. 2021. Deep Geological Repository Conceptual Design Report Crystalline / Sedimentary Rock Environment APM-REP-00440-0211-R000

[R-3] NWMO. 2020. Used Fuel Transportation System 2021 LCE Transportation Lifecycle Cost Estimate (LCE) Design Report, APM-REP-00440-0209.

APPENDIX A: WORK BREAKDOWN STRUCTURE

WBS NUMBER	DESCRIPTION
STAKEHOLDER RELATIONS AND ENGAGEMENT	
580.05.10	STAKEHOLDER RELATIONS AND ENGAGEMENT
580.05.90	STAKEHOLDER RELATIONS AND ENGAGEMENT STAFFING
580.15.20	CENTRE OF EXPERTISE
580.15.60	LAND ACQUISITION
GEOSCIENCE/DETAILED SITE CHARACTERIZATION	
580.30.20	GEOSPHERE MONITORING
580.30.30	GEOSCIENCE VERIFICATION
580.30.90	GEOSCIENCE / DETAILED SITE CHARACTERIZATION - STAFFING
ENVIRONMENTAL	
580.85.10	ENVIRONMENTAL MONITORING
580.85.20	HUMAN HEALTH MONITORING AND EIS
580.85.30	SOCIAL AND ECONOMIC MONITORING
580.85.90	ENVIRONMENTAL STAFFING
LICENSING	
580.35.10	LICENSING - CNSC FEES
580.35.90	LICENSING STAFFING
580.35.20	SAFEGUARDS
SAFETY ASSESSMENT, TECHNICAL RESEARCH & DESIGN	
580.10.90	SAFETY ASSESSMENT AND RESEARCH - STAFFING
580.10.10	SAFETY ASSESSMENT - PSR
580.10.20	SAFETY ASSESSMENT - SUPPORT FOR LTC REVIEW
580.10.40	POST CLOSURE MANAGEMENT (NEW)
580.10.30	SAFETY ASSESSMENT - FSR, OPERATIONS AND CLOSURE
ENGINEERING AND DESIGN	
580.20.90.20	ENGINEERING AND DESIGN - GENERAL TECHNICAL SUPPORT STAFFING
580.20.10	ENGINEERING AND DESIGN - REPOSITORY DESIGN AND CONSTRUCTION LICENCE SUPPORT
580.20.70	ENGINEERING AND DESIGN - REPOSITORY DESIGN AND OPERATION LICENCE SUPPORT
580.20.30	PROOF TESTING
580.20.40	ENGINEERING AND DESIGN - CENTRE OF EXPERTISE ACTIVITIES
580.20.50	ENGINEERING AND DESIGN - TECHNICAL OVERSIGHT OF EPC CONTRACTS
580.20.60.10	UDF PERFORMANCE TESTS

WBS NUMBER	DESCRIPTION
580.20.60.20	UDF EBS EMPLACEMENT DEMONSTRATIONS
GOVERNANCE	
580.80	GOVERNANCE STRUCTURE
COMMON SERVICES	
580.90	COMMON SERVICES
USED FUEL CONTAINER	
580.45.40.20	SUPPLY OF BASKETS AND UFCS
Surface Facilities	
USED FUEL PACKAGING PLANT	
580.40.40.10.10	PROJECT MANAGEMENT/BUILDING DESIGN AND CONSTRUCTION OF UFPP
580.40.40.10.20.10	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (RECEIPT OF UFTPS)
580.40.40.10.20.15	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (TRANSFER BASKETED FUEL INTO MODULES)
580.40.40.10.20.20	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (INSPECTION)
580.40.40.10.30.10	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (UFC FUEL LOADING)
580.40.40.10.30.30	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD UFC)
580.40.40.10.30.40	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD CAP REMOVAL)
580.40.40.10.30.50	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD NDE)
580.40.40.10.30.60	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER COLD SPRAY)
580.40.40.10.30.70	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER MACHINING)
580.40.40.10.30.80	UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER NDE)
580.40.40.10.45	BUFFER BOX ASSEMBLY (UFPP)
580.40.40.10.50	BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)
580.40.40.10.60	COMMISSIONING (UFPP)
580.45.40.10	UFPP OPERATION
SEALING MATERIALS EQUIPMENT AND PRODUCTION	
580.40.10.30.20.20	CONCRETE PLANT
580.40.40.20	SEALING MATERIAL COMPACTION PLANT (SMCP)
580.45.50.60.10	BACKFILL MATERIAL (SMCP & CONCRETE)
SHAFTS, HEADFRAMES & HOISTING SYSTEMS	
580.40.10.30.20.50	SERVICE SHAFT AND HEADFRAME
580.40.60.20	MAIN SHAFT AND HEADFRAME
580.40.60.30	VENTILATION SHAFT AND HEADFRAME
580.45.50.100	HOIST ROPE REPLACEMENT

WBS NUMBER	DESCRIPTION
ADDITIONAL SURFACE FACILITIES	
580.40.10.30.20.40	CAMPSITE AND CAMPSITE OPERATIONS
580.40.20	SITE IMPROVEMENTS
580.40.30	VISITOR CENTRE – DGR SITE
580.40.50.100	PUMPHOUSE & INTAKE
580.40.50.110	WATER STORAGE TANK AREA
580.40.50.120	WATER TREATMENT PLANT
580.40.50.130	PROCESS WATER SETTLING POND
580.40.50.140	SERVICE SHAFT WATER SETTLING POND
580.40.50.150	STORM RUN-OFF POND
580.40.50.160	SEWAGE TREATMENT PLANT
580.40.50.170	LOW LEVEL LIQUID WASTE STORAGE BUILDING
580.40.50.180	ACTIVE LIQUID WASTE TREATMENT (ALWT) SYSTEM
580.40.50.190	WASTE MANAGEMENT AREA
580.40.50.20	ADMIN BLDG
580.40.50.220	LOW LEVEL WASTE STORAGE BUILDING
580.40.50.230	ELECTRICAL SWITCHYARD
580.40.50.240	TRANSFORMER AREAS
580.40.50.250	VISITORS CENTRE
580.40.50.30	AUXILIARY OFFICE BUILDING
580.40.50.40	QC OFFICES & LABS
580.40.50.50	GARAGE BUILDING / WAREHOUSE
580.40.50.60	WALKWAYS/SERVICeways
580.40.50.70	FUEL TANK AREA
580.40.50.80	SECURITY CHECKPOINTS
580.40.70.10	FACILITY ELECTRICAL DISTRIBUTION
580.40.70.30.10	FIRE WATER
580.40.70.30.20	POTABLE WATER
580.40.70.30.30	PROCESS WATER
580.40.70.30.40	SEWERAGE
580.40.70.30.50	STORMWATER AND DRAINAGE
580.40.70.40.10	BREATHING AIR
580.40.70.40.20	SERVICE AIR
580.55.40	ENVIRONMENTAL RESPONSE EQUIPMENT
580.55.50	RADIOLOGICAL MONITORING EQUIPMENT
580.55.60	NON-RADIOLOGICAL MONITORING EQUIPMENT
UNDERGROUND FACILITIES	
UNDERGROUND EXCAVATION	
580.40.10.30.20.70	TUNNEL AND SERVICE AREA EXCAVATION

WBS NUMBER	DESCRIPTION
580.40.10.30.20.80	INFRASTRUCTURE CONSTRUCTION EQUIPMENT
580.40.10.30.20.90	UNDERGROUND MOBILIZATION EQUIPMENT (CONSTRUCTION)
580.40.10.30.20.100	UNDERGROUND MOBILIZATION EQUIPMENT (OPERATIONS)
580.40.60.60	ACCESS TUNNELS
580.40.60.50	EARLY MAIN UDF
580.40.60.70	INITIAL PLACEMENT ROOMS (PANEL A)
580.40.60.80	ROOM EXCAVATION (SECOND STAGE) PANEL B
580.45.50.40	ROOM EXCAVATION (THIRD STAGE) PANEL C
580.45.50.50	ROOM EXCAVATION (FOURTH STAGE) PANEL D
580.45.50.150	ROOM EXCAVATION (FIFTH STAGE) PANEL E
580.45.50.160	ROOM EXCAVATION (SIXTH STAGE) PANEL F
580.45.50.170	ROOM EXCAVATION (SEVENTH STAGE) PANEL G
580.45.50.180	ROOM EXCAVATION (EIGHTH STAGE) PANEL H
580.45.50.190	ROOM EXCAVATION (NINTH STAGE) PANEL I
580.45.50.200	ROOM EXCAVATION (TENTH STAGE) PANEL J
580.45.50.210	ROOM EXCAVATION (ELEVENTH STAGE) PANEL K
580.45.50.220	ROOM EXCAVATION ADDITIONAL PANEL
UNDERGROUND VENTILATION AND MINING HEAT AND POWER	
580.40.50.90	EMERGENCY POWER GENERATION
580.40.60.40	VENTILATION SYSTEM
580.45.50.120	MINING HEAT AND POWER
UFC Placement	
580.40.10.30.10	UDF EQUIPMENT ENGINEERING DEMONSTRATION
580.40.70.20	FACILITY COMMUNICATION SYSTEM(S)
580.45.50.60.20	UFC EQUIPMENT ENGINEERED BARRIER EMPLACEMENT EQUIPMENT
580.45.50.60.30	PLACEMENT LABOUR
580.45.50.110	INDIRECTS FOR FINAL PANEL UFC PLACEMENT
OPERATIONS MANAGEMENT	
580.45.20	DIRECT OPS MANAGEMENT (INC QA)
580.45.30	OPERATIONS INDIRECTS (INC FIRE & SECURITY)
580.45.40.40	O&M OF AUXILIARY SURFACE FACILITIES
EXTENDED OPERATIONS AND DECOMMISSIONING	
580.45.50.130	EXTENDED OPERATIONS (INC SUPPORT SERVICES)
580.45.50.140	EXTENDED OPERATIONS EQUIP REPLACE/REFURB/MAINTAIN
580.60.10	DECOMMISSIONING MANAGEMENT
580.60.130	SITE CLEANUP (DECOMM)

WBS NUMBER	DESCRIPTION
580.60.150	DECOMM INDIRECTS (INC HEAT, CONSUMABLES)
580.60.160	DECOMM WASTE DISPOSAL
580.60.170	FINAL CLOSURE
580.60.30.10	BACKFILL MATERIAL PLANT (SUPPLY AND OPERATE)
580.60.30.20	WASTE PROCESSING AND HANDLING FACILITY
580.60.40	AUXILIARY SURFACE FACILITIES DECOMM
580.60.50	USED FUEL PACKAGING PLANT (UFPP) DECOMM
580.60.60	SEALING MATERIAL COMPACTION PLANT DECOMM
580.60.70.10	ALWT
580.60.70.20	LILW STORAGE
580.60.70.30	LLW STORAGE
580.60.80	UFC HANDLING SYSTEMS
580.60.90	PERM VENT FAN REMOVAL (DECOMMISSIONING)
580.60.100.10	ACCESS TUNNELS AND DRIFTS
580.60.100.20	SERVICE SHAFT
580.60.100.30	MAIN SHAFT
580.60.100.50	VENTILATION SHAFT DECOMM
TRANSPORTATION	
TRANSPORTATION ANALYSES & ASSESSMENTS	
680.20	TRANSPORTATION ANALYSES & ASSESSMENTS
TRANSPORTATION PACKAGING CERTIFICATION AND LICENSE TO TRANSPORT	
680.25	TRANSPORT LICENSING
ENVIRONMENTAL MANAGEMENT	
680.55	ENVIRONMENTAL MANAGEMENT
CAPITAL EQUIPMENT & FACILITIES	
680.40	CAPITAL EQUIPMENT & FACILITIES
680.40.10	TRANSPORTATION VEHICLES
680.40.10.10	TRANSPORTATION VEHICLES FOR NON-SITE-SPECIFIC
680.40.10.100	TRANSPORTATION VEHICLES FOR DOUGLAS POINT
680.40.10.30	TRANSPORTATION VEHICLES FOR BRUCE
680.40.10.40	TRANSPORTATION VEHICLES FOR PICKERING
680.40.10.50	TRANSPORTATION VEHICLES FOR DARLINGTON
680.40.10.60	TRANSPORTATION VEHICLES FOR POINT LEPREAU
680.40.10.70	TRANSPORTATION VEHICLES FOR CHALK RIVER
680.40.10.80	TRANSPORTATION VEHICLES FOR GENTILLY 1

WBS NUMBER	DESCRIPTION
680.40.10.90	TRANSPORTATION VEHICLES FOR GENTILLY 2
680.40.20.10	TRANSPORTATION PACKAGES NON-SITE-SPECIFIC
680.40.20.100	BTP TRANSPORTATION PACKAGES DOUGLAS POINT
680.40.20.30	UFTP TRANSPORTATION PACKAGES BRUCE
680.40.20.40	UFTP TRANSPORTATION PACKAGES PICKERING
680.40.20.50	UFTP TRANSPORTATION PACKAGES DARLINGTON
680.40.20.60	BTP TRANSPORTATION PACKAGES POINT LEPREAU
680.40.20.70	BTP TRANSPORTATION PACKAGES CHALK RIVER
680.40.20.80	BTP TRANSPORTATION PACKAGES GENTILLY 1
680.40.20.90	BTP TRANSPORTATION PACKAGES GENTILLY 2
680.40.40.10	EQUIPMENT FOR TRANSPORTATION LOGISTICS FOR REAL TIME TRACKING
680.40.40.20	EQUIPMENT FOR EMERGENCY RESPONSE
TRANSPORTATION SYSTEM OPERATIONS	
680.50.10	PROJECT MANAGEMENT
680.50.30.20	TRANSPORTATION LOGISTICS FROM BRUCE TO DGR
680.50.30.30	TRANSPORTATION LOGISTICS FROM PICKERING TO DGR
680.50.30.40	TRANSPORTATION LOGISTICS FROM DARLINGTON TO DGR
680.50.30.50	TRANSPORTATION LOGISTICS FROM POINT LEPREAU TO DGR
680.50.30.60	TRANSPORTATION LOGISTICS FROM CHALK RIVER TO DGR
680.50.30.70	TRANSPORTATION LOGISTICS FROM GENTILLY 1 TO DGR
680.50.30.80	TRANSPORTATION LOGISTICS FROM GENTILLY 2 TO DGR
680.50.30.90	TRANSPORTATION LOGISTICS FROM DOUGLAS POINT TO DGR
680.50.40.10	TRANSPORTATION LOGISTICS DGR EMERGENCY RESPONSE
680.50.40.20	TRANSPORTATION LOGISTICS DGR REAL TIME TRACKING
680.50.50	TRANSPORTATION VEHICLES MAINTENANCE
680.50.60	TRANSPORTATION PACKAGE MAINTENANCE
PROGRAM MANAGEMENT	
680.90	PROGRAM MANAGEMENT
DECOMMISSIONING	
680.60	DECOMMISSIONING

APPENDIX B: WORK ELEMENT DEFINITION SHEETS (WEDS)

STAKEHOLDER RELATIONS & ENGAGEMENT

580.05.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: L. Frizzel/J.
Matear

Organization: NWMO

Description

Siting Area Municipal Engagement/Community Relations

Before site selection is completed, the workplan includes community engagement activities to assess the social suitability of the APM project in the preferred siting areas and region from the perspective of non- Indigenous communities (i.e., municipalities). Assessments address community well-being, interest, potential for partnership and potential for willingness. After site selection and through to post-closure monitoring, the workplan includes social engagement to sustain partnership, relationships and reputation, and required assessments in support of the impact assessment and license applications.

The workplan includes partnership-related research with key community leaders, engagement activities and deliverables including those to satisfy questions about safety, water and transportation among others. Activities include virtual and in-person community briefings and meetings; open houses; attendance at fairs/festivals and municipal association conferences; presentations to schools, service clubs, first responder groups and others; workshops and other public information events in the communities and region; surveys, third party reviews; stakeholder mapping; resource programs for communities and neighbouring municipalities, engagement of opinion leaders, regional planning groups and partnership working group; community visits to waste management facilities, NWMO proof test facility in Oakville and eventually the Centre of Expertise.; development of confidence in and supportive relationships for used fuel transportation amongst experts, opinion leaders, corridor communities, politicians and host communities.

The work program also includes:

Maintaining storefront offices in potential host communities, implementing well-being investments in the communities, reports on social research, third party reviews, social suitability for the APM project and the potential for partnership, negotiating draft hosting agreements with communities, stock-taking and the preparation of and the submission of the municipal report for the Impact Assessment.

Establishing social acceptability for: 1) detailed site characterization, 2) submission of the impact assessment and licensing documentation, and 3) municipal support for the APM project at public hearings.

Training and support to ensure capacity building and resilient, sustainable partnerships.

Indigenous Relations

Before a site is selected, Indigenous engagement includes activities to assess the social acceptability of the APM project in potential host community and area from the perspective of First Nation and Métis communities. Assessments address community confidence in safety, well-being, interest, and potential for willingness.

The workplan also includes formal consultation activities as required/delegated by the Federal or Provincial Crown. After site selection, the workplan includes social engagement to sustain Gakinamotiimin (learning together), relationships and reputation, and required assessments in support of the impact assessment and

license applications.

Activities also include further identification and mapping of First Nation and Métis interests, land use, influence in the study area; briefings, meetings, open houses, workshops and other events for learning and to assess suitability and to establish and sustain partnership; third-party reviews; resource program for First Nation and Métis communities in the area; visits to waste management facilities, the NWMO proof test facility in Oakville and eventually the Centre of Expertise; development of confidence and supportive relationships for used fuel transportation among key Indigenous organizations (e.g. MNO, AFN, NAN, CAP, Red Sky Metis).

Other engagement includes that national and provincial Indigenous organizations and the Council of Elders and youth, training and support for capacity building and sustained liaison with Indigenous organizations in New Brunswick, Ontario and Quebec.

The workplan also includes the NWMO's commitments to reconciliation and interweaving traditional knowledge.

Deliverables also include:

Security intelligence and staffing requirements up until start of Operations.

Reports on Indigenous social research, third party reviews, suitability for the APM project, gakinamotiimin, agreements or MOUs with First Nation and Metis communities.

Establishing social acceptability for: 1) detailed site characterization, 2) submission of the impact assessment and licensing documentation, and 3) support for the APM project at public hearings.

Training and support to ensure capacity building and resilient, sustainable relationships.

Support for independent research and studies, to be determined by Indigenous groups and communities.

Stakeholder Relations/Communications

NWMO activities to build and maintain sustainable, long-term relationships with key stakeholders, including all levels of government (municipal, provincial, federal), international stakeholders, industry and related associations, media, interest groups/NGOs and social media communities.

The NWMO will seek and be responsive to a diversity of views and perspectives. The NWMO must communicate actively, promoting awareness, understanding and support, while prompting thoughtful reflection and facilitating a constructive dialogue in different aspects of APM implementation.

Work programs include tracking public opinion, monitoring/managing media and social media, crisis management, website upgrades and maintenance, managing and investing in corporate sponsorships and donations, content development/deployment across platforms, promotion/advertising, government relations outreach, outreach with interest groups including ENGOs/NGOs and employee/retiree communications programs. Work also includes training and support to ensure capacity building internally and externally, and sustained liaison among key stakeholder groups among the audiences listed above.

Includes NWMO participation in international information sharing (e.g., NEA Forum for Stakeholder Confidence); research on citizen priorities and concerns with APM implementation; and other studies and workshops associated with societal values and public policies.

Workplans also include:

Print, audio visual and digital content development, production and translation into French and Indigenous languages; website upgrades/maintenance; ad campaign content and deployment; promotional products and gifts; employee/retiree communications programming; youth engagement programming, media/social media monitoring and management.

Development and publication of annual/triennial reports and implementation plans, including funding support for the Advisory Council to develop their triennial reports.

Corporate sponsorships and donations; crisis management; communications training (e.g. media training presentation training, gr training, communication skills training support for stakeholders, etc.).

Briefings and presentations with government officials, municipal associations and other organizations. Public attitude research and data analysis, including but not limited to analysis to support web and social media.

Exhibit development, deployment and maintenance (not including Centre of Expertise)

Deliverables

As per description

Assumptions

Allowance

An overall contingency/allowance of 10% has been included from 2026-2032. An allowance of 25% has been applied for years 2033 and beyond.

	2020K\$	Start Year	2020
Labour Cost	\$0	Finish Year	2183
Material Cost	\$0	Duration	164 years
Other Cost	\$572,324	WBS Type	Fixed
Subtotal	\$572,324		
Allowance	\$96,865		
Total Cost	\$669,189		

STAKEHOLDER RELATIONS & ENGAGEMENT STAFFING

580.05.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: L. Frizzel

Prepared by: L. Frizzel

Organization: NWMO

Description

Staffing support to Stakeholder Relations and Engagement objectives as per 2020 Business Plan through the years 2020 - 2032, and in support of WBS elements 580.05.10 (Stakeholder Relations & Engagement).

Deliverables

none.

Assumptions

staffing:

2020 to 2024 - as per business plan.

2024 – 2032 – consistent with business plan through the entire period. (36FTE)

2043 – 2088 - during Operations 15FTE

2089 - 2183 – 10 FTE

Allowance

An overall contingency/allowance of 10% has been included from 2026-2032. An allowance of 25% has been applied for years 2033 and beyond.

	2020K\$	Start Year	2020
Labour Cost	\$401,337	Finish Year	2183
Material Cost	\$0	Duration	164 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$401,337		
Allowance	\$80,819		
Total Cost	\$482,156		

SAFETY ASSESSMENT - PSR

580.10.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

SAFETY ASSESSMENT FOR CONSTRUCTION LICENCE (2026-2028):

This task is to provide preclosure and postclosure safety assessment contributions to Preliminary Safety Report (PSR) for the reference site. It assumes that the IA and Licence to Prepare Site (LTPS) documents have already been prepared and submitted. The preclosure assessment will address conventional and radiological safety for normal, upset and accident conditions associated with the operating and monitoring phases.

The postclosure assessment will address the anticipated effects on human and non-human biota following decommissioning and closure. Both radiological and non-radiological contaminants will be considered.

Deliverables

SAFETY ASSESSMENT FOR CONSTRUCTION LICENCE (2026-2028):

Preliminary Safety Report

Operational Safety Assessment report.

Postclosure Safety Assessment report.

Preliminary ALARA Assessment.

Conventional Safety Assessment.

Radon Assessment.

Preliminary Flood Hazard Assessment

Computer codes and support documents.

Key supporting reports, including Reference Data; Features, Events and Processes.

Assumptions

SAFETY ASSESSMENT FOR CONSTRUCTION LICENCE (2026-2028):

Assessment builds on report(s) for IA and LTPS produced by 2024 for the selected preferred site.

Work is carried out iteratively, with interim version released in 2026, and final version in 2028. Note that these do not include any allowance for delay due to IA/LTPS process.

Preliminary design, Geosynthesis and Descriptive Geosphere Site Model, and Environmental data are fixed at end 2026 (data freeze).

Preliminary ALARA assessment is initial estimate of doses, and does not provide significant ALARA optimization. This will be addressed in Operating Licence stage.

Work is shared in-house and external contractors.

Cost estimate based on 1.9 M\$/yr (0.9 postSA, 0.5 preSA, 0.5 supporting).

Does not include:

Transportation safety assessment (see 680.20)

NWMO SA staff costs for SA (see 580.10.90)

NWMO SA staff costs for IA/LTPS support (see 580.10.20)

Base technical research costs (see 580.10.90)

Allowance

An overall contingency/allowance of 10% has been included based on level of design and uncertainty.

	2020K\$	Start Year	2026
Labour Cost	\$0	Finish Year	2028
Material Cost	\$0	Duration	3 years
Other Cost	\$6,283	WBS Type	Fixed
Subtotal	\$6,283		
Allowance	\$628		
Total Cost	\$6,911		

SAFETY ASSESSMENT - SUPPORT FOR LTC REVIEW

580.10.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

SUPPORT DURING CONSTRUCTION LICENCE REVIEW (2029 - 2032):

This task is to support the public review and hearings, and respond to review panel and regulatory questions on the Preliminary Safety Report (PSR) / Licence to Construct (LTC) submission. It is anticipated that during this period there would be a continued level of safety assessment to address topics to support the review and also to prepare for subsequent detailed design.

Deliverables

SA SUPPORT DURING CONSTRUCTION LICENCE REVIEW (2029 - 2032):

Prepare responses to review questions.

Presentation material for public and regulatory review. Participation in public review of PSR materials.

Topical technical reports.

Assumptions

SA SUPPORT DURING CONSTRUCTION LICENCE REVIEW (2029 - 2032):

Public review starts in 2029, with award of licence by end 2032.

2032 is primarily review of recommendations and license condition handbook preparation.

Work is shared in-house and external contractors.

Cost estimate of 0.4 M\$/yr.

Does not include:

Transportation excluded (see (680.25))

NWMO SA staff costs and Base Technical Research Costs (see 580.10.90 Safety Assessment and Research)

Allowance

An overall contingency/allowance of 10% has been included based on level of design and uncertainty

	2020K\$	Start Year	2029
Labour Cost	\$0	Finish Year	2032
Material Cost	\$0	Duration	4 years
Other Cost	\$1,764	WBS Type	Fixed
Subtotal	\$1,764		
Allowance	\$176		
Total Cost	\$1,940		

SAFETY ASSESSMENT -FSR, OPERATIONS AND CLOSURE

580.10.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

FINAL SAFETY ASSESSMENT FOR OPERATING LICENCE (2033-2042):

This task is to provide the preclosure and postclosure safety assessment contributions during the construction phase and ultimately to the Final Safety Report (FSR). The FSR document will be submitted in support of the application for a Licence to Operate.

The preclosure assessment will address conventional and radiological safety for normal, upset and accident conditions associated with the operating and monitoring phases. It will include a final ALARA assessment and flood hazard assessment. The postclosure assessment will address the anticipated effects on human and non-human biota following closure. Both radiological and non-radiological contaminants will be considered. Both documents will update the safety case based on information obtained during underground excavation, the geoscientific verification program, and the early Underground Demonstration Facility operation.

OPERATIONS SAFETY ASSESSMENT (2043 - 2088)

This task is to provide safety assessment support during the facility operating period. Specific items include:

Preparation of periodic safety assessment reports to support continuation of the site Operating Licence.

Assessment of topical issues as may be required, including any follow-up issues from Operating Licence approval and from operation of Underground Demonstration Facility and facility performance monitoring.

Maintenance and improvement of the safety and performance assessment computer codes, including reference databases and tools, under a suitable QA system.

Maintenance of the reference site numerical model.

Training of qualified staff to ensure continued capability to support the licence-basis safety case.

EXTENDED MONITORING SAFETY ASSESSMENT (2089 - 2158):

This task is to provide safety assessment activities during the 70-yr Extended Monitoring period, including:

Preparation of periodic safety assessment reports to support renewal of Operating Licence.

Continuous maintenance and improvement of repository safety assessment models.

Ongoing application / interpretation of basic research and in-situ tests in the UDF or Centre of Expertise.

Maintenance of qualified technical staff.

DECOMMISSIONING SAFETY ASSESSMENT (2159 - 2183):

Safety Assessment support for the application for Decommissioning Licence.

Deliverables

SAFETY ASSESSMENT FOR OPERATING LICENCE (2033-2042):

Final Safety Report.

Preclosure Safety Assessment report.

Postclosure Safety Assessment report.

Final ALARA Assessment.

Conventional Safety Assessment.

Radon Assessment.
 Flood Hazard Assessment
 Updated computer codes and support documents.
 Key supporting reports, including Reference Data, Features, Events and Processes.

OPERATIONS SAFETY ASSESSMENT (2043 - 2088):

Up-to-date reference repository safety assessment model.
 Periodic updates to the Final Safety Report (FSR) as required for supporting renewal of the site Operating Licence.
 Annual report describing ongoing results to further validate or improve the reference safety assessment model.

EXTENDED MONITORING SAFETY ASSESSMENT (2089 - 2158):

Up-to-date reference repository safety assessment model.
 Periodic updates to the FSR for supporting renewal of the site Operating Licence.

DECOMMISSIONING SAFETY ASSESSMENT (2159 - 2183):

The Decommissioning period is assumed to last 25 years, including 3 years licence preparation and 2 years for approval.
 Decommissioning will include an Impact Assessment. Costs for this IA are included here.
 The existing FSR will be updated, but is otherwise sufficient to support the decommissioning IA/licence application.
 Preparation for the IA/Licence application begins at the start of the Decommissioning phase.
 The IA addresses all issues related to obtaining the Decommissioning Licence and the Licence to Abandon.

Assumptions

SAFETY ASSESSMENT FOR OPERATING LICENCE (2033-2042):

The assessment will build on work performed for the Impact Assessment (IA) and Preliminary Safety Report (PSR); however, information from the Underground Demonstration Facility (UDF) and the final design will be used.
 There will be an update to the safety case in 2037 based on initial geological results, and communicated to the CNSC prior to proceeding with the remainder of the underground construction.
 Data freeze for the FSR will occur in 2038.
 The FSR and related documents will be filed at end 2040. The regulatory review and approval period takes 2 years, with the Operating Licence approved by end 2042.
 Work includes internal and external.
 External Safety Assessment costs estimated as 0.5 M\$/yr ramping up to 1.5 M\$ for submission of Operating Licence application.

OPERATIONS SAFETY ASSESSMENT (2043 - 2088):

46 years operation
 Includes maintenance of safety case basis during operating period.
 Does not include:
 Geoscience / geotechnical monitoring.
 Environmental monitoring, follow-up environmental monitoring, or preparation of annual REMP reports.
 Monitoring of repository as needed to support operations, including both the conventional Health, Safety & Environmental program as well as Radiation Protection.
 UDF and external Technical Research costs
 NWMO staff costs

Costs are estimated as 0.4 M\$/yr through first 5 years, then 0.2 M\$/yr after.

EXTENDED MONITORING SAFETY ASSESSMENT (2089 - 2158):

70 years duration

Includes maintenance of safety case basis during extended monitoring period.

There is no used fuel handling activity during this period.

Does not include: Same list as above under Operations

DECOMMISSIONING SAFETY ASSESSMENT (2159 - 2183):

25 year duration, including 3 years licence preparation, 2 years for approval and 20 years for decommissioning/closure. Ends with site in final state but still NWMO licenced nuclear facility.

Decommissioning will include an Impact Assessment. Costs for this IA are included here.

The existing FSR will be updated, but is otherwise sufficient to support the decommissioning IA/licence application.

Preparation for the IA/Licence application begins at the start of the Decommissioning phase.

The IA addresses all issues related to obtaining the Decommissioning Licence and the Licence to Abandon.

Allowance

 An overall contingency/allowance of 25% has been included based on level of design and uncertainty.

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2183
Material Cost	\$0	Duration	151 years
Other Cost	\$42,769	WBS Type	Fixed
Subtotal	\$42,769		
Allowance	\$10,692		
Total Cost	\$53,461		

POST CLOSURE MANAGEMENT

580.10.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

POSTCLOSURE MANAGEMENT (2184-2188):

This task is to address the monitoring, licensing and handover from NWMO to post-closure institutional control. It starts with the completion of closure, with the site decommissioned and closed and returned to intended final state.

Deliverables

Preparation of Final Safety Report (FSR).

Archiving of Key Information Files, such as design basis, inventory and safety assessment data, models and reports.

Establishment of postclosure trust funds.

Turnover to institutional control.

Assumptions

5 years of postclosure monitoring to establish that systems are working.

Apply for Licence to Abandon after 5-years; 2 years for licence review.

The Impact Assessment (IA) created for the Decommissioning licence addresses all relevant EA issues; this is a confirmatory application. The FSR will include information obtained during the Decommissioning phase, including information on the actual seal installation characteristics, and the actual as-decommissioned facility.

1 year after licence received for turnover of documents and closure of NWMO.

Costs include NWMO staff/contractor costs (8 FTE persons), environmental monitoring, licensing, external supporting studies.

Costs include establishing trust funds to pay for ongoing future costs, notably site inspection and environmental monitoring, and two university chairs with expertise relevant to DGR.

Costs assume no trust fund specific to IAEA for safeguards.

Costs do not include installation of additional postclosure monitoring equipment (assumed to be continued use of existing monitoring equipment or replaced and funded through decommissioning).

Cost estimate of 5 M\$/yr based on 8 NWMO staff/contractors @ 2.4 M\$/yr, 0.3 M\$/yr monitoring, 1.5 M\$/yr licencing, 0.4 M\$/yr SA, 0.5 M\$/yr supporting studies.

Allowance

An overall contingency/allowance of 25% has been included based on level of design and uncertainty.

	2020K\$
Labour Cost	\$0
Material Cost	\$0
Other Cost	\$25,000
Subtotal	\$25,000
Allowance	\$6,250
Total Cost	\$31,250

Start Year	2184
Finish Year	2188
Duration	5 years
WBS Type	Fixed

SAFETY ASSESSMENT AND RESEARCH

580.10.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

Period covers detailed site characterization and licensing, construction, operations, extended monitoring and decommissioning and closure.

Safety and Research staff support the safety case through:

Maintenance of the licence-basis safety case

Maintenance of the site reference geosphere model

Maintenance of the reference safety assessment computer codes

Direction of the external and UDF research program, including measurement of relevant parameters for the safety case.

International exchange with other relevant waste management organizations.

Interpretation and application of results from literature, NWMO research, UDF results, and repository performance monitoring.

Interaction with community and other stakeholders.

Maintain competent staff, ensure transfer of knowledge.

Staff may be assigned between safety assessment and technical research work to align with current priorities, such as during periods of preparing licence submissions.

Includes SA and TR Staffing 2020 forward supporting IA and Licence to Prepare Site Application.

Does not include:

- Staffing after closure

- External research costs and UDF costs

- UDF technicians and repository staff that provide services to UDF.

The Technical Research and Collaboration work scope covers external research and development activities to support and extend the science basis for the repository design and safety case. It includes university core programs that also provide new staff and help maintain the knowledge basis for the repository. It extends through to closure of the repository, and establishment of postclosure funds. This work program is distinct from the siting assessment, proof testing programs and geoscience verification programs. UDF tests are also tracked separately.

Deliverables

Staffing required to support deliverables as per WBS# 580.10.10-30

Includes third party costs for:

Core university programs for improving process understanding, development of new personnel, and maintenance of science basis;

580.10.90

Collaborating with other national waste management organizations, including experiments at other underground facilities;
 Developing improved methods for site characterization;
 Developing general models of processes / behavior / stability (e.g. used fuel, THM, groundwater);
 Development of regional understanding or non-reference materials that provides context for site-specific assessments.

Does NOT include:

UDF tests (i.e. covers research outside of site).

Site characterization, geoscience verification and monitoring, proof testing, environmental monitoring.

Assumptions

Staffing estimated as follows:

- 22 FTE 2025-2032, reducing to 16 FTE by 2042, 12 FTE through 2053 (first 10 years of operations), 9 FTE through 2086, 5-6 FTE through to 2183
- Final staff level based on 1 Mgr, 1 PostSA, 1 PreSA, 1 Geo, 1 EBS expertise.

2020-2024 - 3rd Party contract costs are as per the 2020-2024 business plan

2025-2032 - \$4M/yr based on historic spend rate and focus in this period on supporting the first licences.

2033-2042 – \$3M\$/yr External costs reduced since repository specific studies would be conducted following the start of construction, but most external costs would continue to allow interpretation of site-specific results.

2043-2088 - \$1M/yr. External costs reduced, with receipt of licence and focus on in-situ tests and monitoring.

Allowance for some university chairs and international collaboration projects to continue to help interpret and extend understanding from in-situ tests.

2089-2183 (Extended monitoring and closure) – 0.45 k\$/yr (3x150 k\$/yr external projects)

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included for 2033 and beyond,

	2020K\$	Start Year	2020
Labour Cost	\$249,233	Finish Year	2183
Material Cost	\$0	Duration	164 years
Other Cost	\$173,986	WBS Type	Fixed
Subtotal	\$423,218		
Allowance	\$86,000		
Total Cost	\$509,218		

CENTRE OF EXPERTISE

580.15.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Gibson

Organization: NWMO

Description

The Centre of Expertise will be located in the preferred siting area, at or near the site of the repository (specific location to be determined in collaboration with the partnership communities). The Centre will initially be used to support the multi-year testing and assessment of the site on technical safety and community well-being related dimensions. It will be home to an active technical and social research and technology demonstration program involving scientists and other experts in a wide variety of disciplines including geoscience, engineering, environmental, socioeconomic and cultural impact assessment.

An engineering test facility will be located within the Centre of Expertise to develop materials and equipment to be used in the repository. The Centre will also house demonstration equipment that displays the packaging and container placement process.

The Center of Expertise will be expanded to include support to the construction and operation to the deep geological repository. It will become a hub for knowledge sharing across Canada and internationally. It can focus on engaging members of the community to learn more about the APM project via public viewing galleries and interactive displays.

Opportunities to work with the community to sustain and enhance the natural environment will also be explored. The technologies and monitoring processes involved in operating a repository may have wider applications; for example, the monitoring and protection of natural water systems in the area. Specialists leading the implementation and operation of the repository could also support environmental sustainability planning in the area.

Deliverables

For the purposes of developing a preliminary estimate in support of financial planning (applicable to all elements), the following facility features/areas have been included:

Distinct technical areas providing for demonstrating used fuel transfer (fuel handling cell, used fuel container processes, buffer box assembly), emplacement, and buffer system;

Maintenance/shop area for equipment maintenance, as well as, space for labs in support of field activities;

General warehousing and storage;

Transportation display/storage area;

Building services (i.e. electrical room, HVAC, fire protection, IT/I&C);

Administration and office space for NWMO staff (provision of space for common services);

Geoscience and environmental activities (i.e. core storage, lab equipment, etc.);

Visitor's center and display/conference space.

Staffing levels in support of the Centre of Expertise are incremental to those existing FTE's that would utilize the facility once constructed (e.g. technical, engagement, aboriginal, etc). These are staff required to support the facility function and have been assumed to be one (1) facility manager, two (2) technical resources, and

three (3) administration/building operations positions.

Assumptions

It is assumed that approximately 100,000 square feet would be required for the Centre of Expertise. This would be comprised of approximately 37,000 square feet for offices, meeting rooms, common areas, as well as public spaces/visitor centre. The visitor centre space at the Centre of Expertise would be distinct from the visitor centre space provided for as part of the surface facilities (580.40.50.250). The remaining 63,000 square feet would be comprised of warehousing/storage, used fuel/emplacement demonstration areas, maintenance and transportation, building services, and geotechnical/environmental areas.

Approximately 4 acres is assumed to be required for the facility, comprising the building footprint, parking and staging, as well as landscaping areas. No site acquisition fees have been included, as it is assumed that the land has already been acquired as part of the land access programs.

It is assumed that the facility and associated services will cost \$21M to construct over 2 years, starting 2026. An allowance of \$4M has been included in 2022-2025 for detailed design and bid package development. A \$10M allowance for facility equipment/displays (Materials and Equipment) has been included. This is a placeholder and assumes that much of the equipment in support of the technical areas will be transferred from existing Phase 2 and Proof Testing activities.

Facility Operations costs have been estimated at \$750,000 per year. Assumes \$400k per year for fixed operating costs (e.g. repair and maintenance, service contracts for site maintenance, security, etc.), and \$350k per year for variable operating costs (e.g. heat, water, sewerage, etc).

Design details of the facility will be developed with the partnership communities with their preferences in mind.

Schedule/Milestone Assumptions:

Identify the NWMO's own requirements and boundaries for what the NWMO will accept in terms of the communities' vision for the CoE (2021)

Identify the communities' vision for the CoE and finalize joint requirements (2020-2023)

Location of facility has been determined (2023)

Permits and approvals have been received (2025)

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2022
Labour Cost	\$58,196	Finish Year	2088
Material Cost	\$0	Duration	67 years
Other Cost	\$95,156	WBS Type	Fixed
Subtotal	\$153,352		
Allowance	\$29,150		
Total Cost	\$182,502		

LAND ACQUISITION

580.15.60

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Gibson

Organization: NWMO

Description

This is a placeholder for the purchase and licensing costs for crown land in Ignace region.

Also included is the purchase of additional land in South Bruce during 2021-2023. These costs are offset by the sale of all South Bruce land acquired since 2020 once a construction start in Ignace is confirmed.

Deliverables

Land acquisition in time for construction.

Assumptions

Site preparation and access roads are captured as part of geoscience and construction WEDS.

Allowance

No additional Allowance included.

	2020K\$	Start Year	2020
Labour Cost	\$0	Finish Year	2025
Material Cost	\$0	Duration	6 years
Other Cost	\$44,038	WBS Type	Fixed
Subtotal	\$44,038		
Allowance	\$0		
Total Cost	\$44,038		

ENGINEERING AND DESIGN - REPOSITORY DESIGN AND CONSTRUCTION LICENCE SUPPORT

580.20.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Work activities include the development of the APM Deep Geological Repository Facility Designs to ~50% detailed design level prior to the Licence to Construction submission in 2029.

Deliverables

Design activities will focus in the following areas (list is not exhaustive):

Repository Design

Surface facilities (non-nuclear): Aboveground amenity buildings including admin., auxiliary / mine dry, quality control, security, etc.; sealing materials compaction plant; concrete batch plant; conventional waste management facilities; process and storm water management control (ponds and drainage); electrical systems; compressed air system; and balance of site infrastructure.

Shafts, Headframes, and Hoists: development of main, service, and ventilation shaft including shaft design, shaft liners, and supports; headframes; and hoisting systems and loading pocket(s).

Underground facilities: Services area and underground amenities including offices, washrooms, refuge stations, utilities, communications, maintenance area, fuel/charging stations, central stores, etc.; Underground Demonstration Facility (UDF); placement room design; development; subsurface ventilation; and subsurface drainage and dewatering.

Operational Safety, Monitoring, and Process Control Systems

Off-sites: site access infrastructure, waste rock management area, etc.

Used Fuel Packaging Plant

Used Fuel Handling and Container Processes

Transportation Package receipt and unload

Fuel receipt, handling, and sorting

Containerization of the fuel: multiple fully hot cells for welding, copper coating, machining, and inspection of the Used Fuel Containers

Assembly of UFC into bentonite buffer overpack

Radioactive waste management systems: active liquid and solid waste handling Ventilation system and monitoring

Safeguard and security systems

Engineered Barrier System Design Development and Optimization

Advance technical R&D to further optimize the design for future mass production and cost effectiveness

Advance handling and emplacement technologies

Advance scientific R&D into post-closure engineered barrier processes including corrosion and microbial

activity

The design activities outlined above will include consideration of the full project lifecycle: site preparation, construction, operations, decommissioning, and closure.

Assumes the following cost schedule:

2023-2024: \$12.5M for first year after single site selected for 3rd party design and development activities to support a design package to support the Construction Licence submission; additionally, this work will support the Impact Assessment and License to Prepare Site clarifications during the review panel. \$15M for second year in phased ramp up.

2025 – 2027: \$20M/year allocated for continued 3rd party design services.

2028 – 2032: \$12.5M for 2028 (ramp down), followed by \$5M/year allocated for continued 3rd party design services. Reduction due to reduced effort during review phase. Team focus will be on clarifications and design changes stemming from CNSC review of the Licence to Construct.

2025 & 2031: Additional \$1M/year for technical support during Impact Assessment (2025) and Licence to Construct submission timing CNSC (2031).

Assumptions

Assumes that the Engineered Barrier Design and Proof Testing work is completed and the engineered barrier concept has been demonstrated proving it is feasible and the correct concept to move forward with further optimization for mass production in the early 2040s.

Assumes single site selected in 2023. Assumes License to Construct submission in 2029; bulk of engineering work packages are needed to be completed by end of 2027.

The construction estimate for facilities and structures assumes design/build unit prices. Therefore, costs to advance the detailed design to ~100% (build) are not included under this WBS.

Allowance

An overall contingency/allowance of 10% has been included for all work in 2026-2032.

	2020K\$	Start Year	2023
Labour Cost	\$16,622	Finish Year	2032
Material Cost	\$0	Duration	10 years
Other Cost	\$123,524	WBS Type	Fixed
Subtotal	\$140,146		
Allowance	\$7,350		
Total Cost	\$147,496		

PROOF TESTING

580.20.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Proof Testing is a series of activities undertaken to verify that novel aspects of a design concept can meet performance requirements and can be implemented in a safe and cost effective manner. It is usually conducted at the Conceptual Design stage in order to minimize licensing and implementation risks.

Proof Testing involves fabrication of scale models, mockups and/or prototypes and testing, resulting in a formal, documented body of knowledge that can be used to illustrate the proof to the regulator, the NWMO Board of Directors, and the public. Proof Testing can be related to a variety of aspects of the Design concept, such as confirmation of material properties under expected operational conditions, long-term performance, manufacturability or constructability (including serial production and Quality Control of high-usage components and materials such as containers or buffer/backfill), automation techniques, material and container handling under repository conditions, operational inspection and monitoring techniques, etc.

Deliverables

Used Fuel Container:

Design testing to demonstrate that our computer models correctly predict the performance of the used fuel container. These components include:

Crush test of components including the weld and shell of the used fuel container.

External pressure testing of the used fuel container.

Corrosion and radiologic analyses proving the performance of the copper coating.

Buffer Box:

Laboratory analysis of manufactured bricks and blocks as well as the development of manufacturing procedures

Emplacement and Sealing System:

Demonstration that buffer boxes can be emplaced without damage and that the required in-situ dry density within the emplacement room can be achieved.

The design, manufacture, and demonstration via prototypes of the repository emplacement equipment concepts.

External Reviews:

External reviews will be conducted and consist of both independent technical reviews through the establishment of international industry experts, as well as, on-going review by the Canadian Nuclear Safety Commission (CNSC).

Assumptions

Refer to Proof Testing PEP APM-PEP-00120-0202 and APM-PLAN-00120-0202 for more information. Schedule aligns with current plans to obtain site. Activities cease at the end of 2022.

Allowance

Actual costs and Business Plan phase costs carry 0% allowance.

	2020K\$	Start Year	2020
Labour Cost	\$15,225	Finish Year	2022
Material Cost	\$0	Duration	3 years
Other Cost	\$30,837	WBS Type	Fixed
Subtotal	\$46,062		
Allowance	\$0		
Total Cost	\$46,062		

ENGINEERING AND DESIGN - CENTRE OF EXPERTISE

580.20.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

The Centre of Expertise will include space to allow NWMO Engineering to continue R&D and testing of the Engineered Barrier System and Used Fuel Packaging Plant concepts.

Deliverables

Operation of the Centre of Expertise:

engineering test facility for the Used Fuel Container technology
buffer box - bentonite clay shaping and forming technology development and demonstration
container / buffer box placement technology development and demonstration
other repository tests and demonstrations (geoscience, environment, safety, engineering, etc.)
meetings, workshops, conferences and engagement activities
public and invited guest tours of the facility - viewing galleries and interactive displays
workshops and courses aimed to expand learning about the APM project
facility for international visitors and training

Cost Basis:

2026-2032: \$4M / year to support moving the existing equipment to the facility, installation of new equipment and modification for continued demonstration, and for supporting 3rd party contracts and material supply.
2033-2088: \$1.5M / year is included during the construction and operations phases to allow continued demonstration to the public.

Assumptions

Assumes the Centre of Expertise is constructed in 2026-2027 with starting of activities to prepare for move in 2026. See Centre of Expertise (WED #580.15.20).

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2026
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	63 years
Other Cost	\$112,000	WBS Type	Fixed
Subtotal	<i>\$112,000</i>		
Allowance	\$23,800		
Total Cost	\$135,800		

580.20.40

ENGINEERING AND DESIGN - TECHNICAL OVERSIGHT OF EPC CONTRACTS

580.20.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Retain 3rd party contracts in support of EPC or EPCM oversight (i.e. specialty engineering services, peer reviewers, independent QS and auditors, etc.).

Deliverables

As per Description

Assumptions

None

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2026
Labour Cost	\$0	Finish Year	2042
Material Cost	\$0	Duration	17 years
Other Cost	\$17,000	WBS Type	Fixed
Subtotal	\$17,000		
Allowance	\$3,200		
Total Cost	\$20,200		

UDF PERFORMANCE TESTS

580.20.60.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: P. Gierszewski

Prepared by: P. Gierszewski

Organization: NWMO

Description

Underground Demonstration Facility (UDF) performance tests. Installation of in-situ performance tests and their monitoring, extraction and analysis. Does not include engineering proof tests for excavation, placement and retrieval. Tests may be conducted in an UDF test adit constructed shortly after shafts are joined, or in UDF test placement rooms excavated later. Some of the first tests will support the Licence to Operate, however most will not have results in time to support the operating licence, and will extend in to the operating period. Some tests will continue to the end of the extended monitoring period. At that time, any remaining tests will be decommissioned as needed to support the closure application.

Deliverables

Underground performance tests to support licence basis and ultimate closure decision.

Assumptions

Timing assumes that UDF adit is accessible for tests in 2038, based on allowing 5 years for detailed design and shaft excavation after Licence to Construct in 2033 to point where UDF rooms are excavated and accessible.

Includes:

Design, fabrication and equipment costs for experiments and instruments; external laboratory or analyses costs.

Specialty installation or removal equipment that is not part of the normal DGR equipment.

External modelling contract costs for data analysis / interpretation.

Dedicated UDF Technician labour costs

Does not include:

Room excavation and basic mining support (e.g. drilling, maintenance, power), which are covered under the underground construction / operations costs.

Underground operators, which are included in construction / operations costs,

Research scientist staff, which are included in the Technical Research staffing WED.

Geoscience verification tests, environmental monitoring, and engineering excavation/placement /retrieval demonstrations are covered under other WEDs.

Costs for prototype equipment and standard UFC/buffer/gapfill materials.

External research not directly related to a UDF test is covered under the Technical Research WED.

Cost estimate basis:

27.5 M\$ over 2035-2042 period (including installation of two major tests – heated prototype and shaft seal test)

13 M\$ over 2043-2047 for installation of further tests after Licence to Operate received and retrieval of first series of tests (includes tunnel seal test and pilot nuclear test).

0.5 M\$/yr for monitoring and analysis of tests for the remainder of operating period (2048-2088).

0.25 M\$/yr for monitoring and analysis of tests for the extended monitoring period (2089-2158).
 5 M\$ for closure and analysis of tests at end of extended monitoring period (2158).
 Up to 2 dedicated UDF technicians, especially 2039-2047, to help setup and operate the experiments.
 Total 134.5 FTE and assumed loaded 200 k\$/tech FTE

Allowance

An overall contingency/allowance of 25% has been included based on level of design and uncertainties

	2020K\$	Start Year	2036
Labour Cost	\$26,900	Finish Year	2183
Material Cost	\$0	Duration	148 years
Other Cost	\$83,750	WBS Type	Fixed
Subtotal	\$110,650		
Allowance	\$27,663		
Total Cost	\$138,313		

UDF EBS EMPLACEMENT DEMONSTRATIONS

580.20.60.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Underground Demonstration Facility (UDF) tests related to the excavation optimization and demonstrating the emplacement/retrieval of the Engineered Barrier System (EBS) including the Used Fuel Container (UFC), bentonite buffer (compacted and granular gap fill), and room seal.

The purpose of these are to support construction and the Licence to Operate. Some of the tests will occur after Operations begin and continue to be monitored during operations and potentially during the extended monitoring. At that time, any remaining tests will be decommissioned as needed to support the closure application.

Deliverables

There are a total of 5 demonstrations related:

Optimization of Drill and Blast (2036-2037)

During excavation of the UDF trial emplacement rooms (1-3) the drill and blast technology and procedures will be tested and optimized to minimize the Excavated Damage Zone (EDZ) and over/underbreak; as well as, confirm excavation tolerances

2. Trial Emplacement and Retrieval Test (2038)

Initial emplacement trials of the EBS and retrievals using the emplacement equipment. The rooms will be backfilled with granular bentonite; but not sealed using a concrete plug/bulkhead.

3. Full-Scale Emplacement Trial w. Heated Prototypes (2040)

Emplacement trials of ~6 instrumented and heated prototype containers using the emplacement equipment. The rooms will be fully backfilled with granular bentonite and sealed using a concrete plug/bulkhead.

4. Integrated Systems Test (2042)

Emplacement trial of ~20 pre-operations engineered barriers in an emplacement room. These will be containers and buffer fabricated using the reference production processes including closure with "mock" used fuel in the Used Fuel Packaging Plant (UFPP). Emplacement will use the reference emplacement equipment including full-automation. The IST room will have extra instrumentation for monitoring during emplacement and after room sealing.

5. Pilot Emplacement Room (2043-2044)

Emplacement trial of the first ~20 engineered barriers in the pilot emplacement room. These will represent the first emplacement of containers with used fuel inside. The pilot room will have extra instrumentation for monitoring during emplacement and after room sealing.

Assumptions

Underground Demonstration Facility (UDF) is accessible for tests in 2038, based on allowing 5 years for detailed design and shaft excavation after Licence to Construct in 2033 to point where UDF rooms are excavated and accessible.

Includes:

580.20.60.20

Design, fabrication and equipment costs for experiments and instruments; external laboratory or analyses costs.

Specialty installation or removal equipment that is not part of the normal DGR equipment.

External modelling contract costs for data analysis / interpretation.

Costs for prototype equipment and standard UFC/buffer/gap fill materials.

Dedicated UDF Technician labor costs.

Does not include:

Room excavation and basic mining support (e.g. drilling, maintenance, power), which are covered under the underground construction / operations costs.

Underground operators, which are included in construction / operations costs.

Engineering support staff, which are included in the Engineering staffing WED (580.20.90.20).

Emplacement equipment, which are included in the UDF Equipment WED (580.40.10.30.10).

Monitoring costs, which are in the UDF Performance Demonstration WED (580.20.60.10).

Decommissioning costs, which are in the UDF Performance Demonstration WED.

UFC/Buffer processing costs for the Integrated Systems Test and Pilot Emplacement Room, which are in the UFPP Commissioning (580.40.40.10.60).

Allowance

An overall contingency/allowance of 25% has been included based on level of design and uncertainties.

	2020K\$	Start Year	2035
Labour Cost	\$2,912	Finish Year	2043
Material Cost	\$12,725	Duration	9 years
Other Cost	\$2,075	WBS Type	Fixed
Subtotal	\$17,712		
Allowance	\$4,428		
Total Cost	\$22,140		

ENGINEERING AND DESIGN - REPOSITORY DESIGN AND OPERATION LICENCE SUPPORT (NEW)

580.20.70

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Work activities include the continued development of the APM Deep Geological Repository Facility Designs; specifically those related to final engineered barrier optimization to demonstrate operational confidence, prior to construction in 2043.

Deliverables

Design activities will focus in the following areas:

Engineered Barrier System Design Development and Optimization

Finalize Engineered Barrier design to support procurement engineering and pre-production trials

Incorporate design changes from the results of the Underground Demonstration Facility Emplacement Demonstrations (WED # 580.20.60.20)

Facility Repository Design and Licence Support

Any optimization or outstanding issues encountered during construction that would require rework to achieve the Operations Licence

Assumes the following cost schedule:

2033 – 2042: \$3M/year has been allocated for these 3rd party design and development activities and licensing support.

Assumptions

Assumes that the Engineered Barrier Design is selected from the results of the Proof Test Program and the additional R&D during the Licence to Construct phase (WED #580.20.10). This

Assumes that the Engineered Barrier Design is selected from the results of the Proof Test Program and the additional R&D during the Licence to Construct phase (WED #580.20.10). This work assumes final minor

optimizations, procurement engineering, and pre-production trials; as well as, finalization of design specifications. It will incorporate the findings of the UDF Emplacement Demonstrations (WED #580.20.60.20).

The construction estimate for facilities and structures assumes design/build unit prices and construction will be underway. Costs for facility design changes or facility are not included under this WBS.

Allowance

An overall contingency/allowance of 25% has been included.

	2020K\$
Labour Cost	\$0
Material Cost	\$0
Other Cost	\$30,000
Subtotal	\$30,000
Allowance	\$7,500
Total Cost	\$37,500

Start Year	2033
Finish Year	2042
Duration	10 years
WBS Type	Fixed

ENGINEERING AND DESIGN - GENERAL TECHNICAL SUPPORT STAFFING

580.20.90.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: C. Boyle

Organization: NWMO

Description

Engineering and Design staffing included herein covers the activities in Repository Design and Construction Licence Support (WED# 580.20.10), Repository Design and Operation Licence Support (WED# 580.20.70), UDF EBS Emplacement Demonstrations (WED# 580.20.60.20), Centre of Expertise Activities (WED# 580.20.40), Technical oversight of EPC Contracts (WED# 580.20.50), and Technical Research & Collaboration - UDF Performance Tests (WED # 580.20.60).

Deliverables

Staff to support Engineering and Design activities.

Assumptions

Staffing Levels:

2026-2032: Site Characterization and Construction License Phase

Staffing levels as per the 2020 – 2024 business plan. Increase in hires beginning 2024 to support the 2028 License to Construct. (35 FTE)

Key activities:

Oversight of EPCM activities in areas of: Engineered Barrier System optimization, Used Fuel Packaging Plant development, and Repository Development (see Engineering and Design – Repository Design and Licence Support (WED#580.20.10))

Staff will also support continued R&D at the Center of Expertise

Staff will also support Site Preparation (beginning in 2028)

2033-2042: Construction and Operation License Phase

Staffing levels constant; however, personnel will transition to implementation and construction focus (35 FTE)

Key activities:

Oversight of EPC construction activities in areas of: Engineered Barrier System optimization, Used Fuel Packaging Plant development, and Repository Development (see Engineering and Design – Repository Design and Licence Support (WED#580.20.10))

Staff will also support continued R&D at the Center of Expertise and Underground Demonstration Facility - Emplacement Demonstrations

Staff will also support Site Preparation (beginning in 2028)

2043-2088: Operations

Staffing levels are all in support of the Center of Expertise activities; as all technical staff required for operation of the facilities are part of the DGR operating staff. (5 FTE)

2089-2188: Extended Monitoring and Decommissioning and Closure

Staffing levels are further reduced during monitoring (2089-2158) (2 FTE). Increase in engineering staff to support EPC decommissioning and closure activities (2159-2188) (5 FTE)

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2026
Labour Cost	\$197,689	Finish Year	2183
Material Cost	\$0	Duration	158 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$197,689		
Allowance	\$42,716		
Total Cost	\$240,405		

GEOSPHERE MONITORING

580.30.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: S. Hirschorn

Organization: NWMO

Description

Geosphere monitoring begins when Detailed Site Characterization is completed. Geosphere monitoring will continue at the selected site for all subsequent life-cycle phases. Geosphere monitoring will initially include only surface-based instrumentation during the licensing and construction phases and while Geoscience Verification is on-going (WBS#580.30.30). Geosphere monitoring will gradually transition to include both surface and underground instrumentation as verification proceeds to end of the construction phase and will continue throughout the operational phase. It is assumed that new long-term monitoring instrumentation will not be installed during the operational phase, only maintenance and possible replacement of previously installed instruments.

During the extended monitoring period following operations, the facility will remain open and accessible. The estimate assumes a maintenance and replacement frequency for monitoring equipment and preparation of annual reports.

Deliverables

Geosphere monitoring data will be collected from the established network of shallow groundwater monitoring wells (~ upper 100 m), multiple-level groundwater monitoring systems in deep boreholes (~ 1000 m), surface-based microseismic monitoring stations and GPS stations. Monitoring data will also be collected from underground boreholes, extensometers, stress cells, and a micro-seismic network. Groundwater monitoring data will consist of periodic (ex: quarterly) measurements of hydraulic pressures and temperatures, and periodic collection of groundwater samples for hydrogeochemical analyses for the purpose of establishing background conditions and variability. The seismograph network will help identify the location and magnitude of seismic events specifically in the region around the site to supplement the seismic record from the national network in Northern Ontario and support seismic hazard assessments. GPS stations will provide positional coordinates on a temporal basis that will be interpreted to assess surface rebound rates that may still be occurring following deglaciation. Extensometers, stress cells and the micro-seismic network will help monitor deformation of the geosphere around the repository during and after operations. Both the seismograph and GPS networks and selected instrumented boreholes will produce continuous, temporal data from automatic data acquisition systems accessed remotely.

The main deliverables during Geosphere Monitoring include a database of far-field and near-field hydrogeological, seismic and deformation monitoring data, maintenance of the associated existing monitoring network; and reporting and interpretation of hydrogeological/geologic site characterization and monitoring data gathered. These deliverables will support the maintenance and updating of the DGSM and associated geosphere (ex. hydrogeologic and geomechanical) numerical models as needed.

Assumptions

All geoscience related costs from 2024 through 2028 are included in the Detailed Geosphere Site Characterization estimate (WBS# 580.30.90)

Geosphere Monitoring activities are assumed to commence in 2029 and will continue throughout the entire life cycle of the facility (2182). The monitoring work will be surface-based only through to the end of site development and construction phase (2042) and will include surface and subsurface monitoring post-2042 through to 2182. It is assumed that no additional monitoring installations will be added beyond those installed as part of detailed site characterization (WBS# 580.30.10) and Geoscience Verification (WBS# 580.30.30). Some routine maintenance/replacement will be required throughout the Geosphere Monitoring phase.

It is assumed that once site construction is completed the monitoring work will become less intensive. The estimated cost has been distributed evenly from 2029-2182.

Staffing is included in the overall Geoscience labour WBS element (580.30.90).

Allowance

An overall allowance of 10% has been included for 2029 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2029
Labour Cost	\$0	Finish Year	2182
Material Cost	\$0	Duration	154 years
Other Cost	\$108,910	WBS Type	Fixed
Subtotal	<i>\$108,910</i>		
Allowance	\$26,803		
Total Cost	\$135,713		

GEOSCIENCE VERIFICATION (NEW)

580.30.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: S. Hirschorn

Organization: NWMO

Description

Geoscience Verification begins during the site development and construction phase and ends once construction is completed, prior to the operational phase. Geoscience verification will include work activities completed during sinking of shafts, during underground demonstration facility development and construction of the central services area, access tunnels and associated boundary rooms at either end of future placement panels. In the current crystalline conceptual underground layout, there are three access tunnel arms that are excavated in different directions away from the central services area. Verification activities include both verification of geotechnical design parameters and geoscience parameters used in the safety case.

Geoscience Verification activities will include one-time geological/geotechnical mapping of excavation walls (shafts, tunnels), drilling and testing of underground boreholes at selected locations along the main shaft and tunnels to assess excavation damage, test in-situ hydraulic properties, collect/test core samples from underground boreholes to verify geomechanical, petrophysical, thermal, geochemical and transport properties. Groundwater samples will also be collected from instrumented boreholes and seepage faces as available. Instrumentation will also be installed to measure initial conditions such as hydraulic pressures in lateral boreholes, in-situ stresses, rock loading, deformation responses of shafts and tunnels during construction and underground microseismic network. A subset of these underground instruments will be identified for longer-term monitoring and then included in geoscience monitoring (WBS# 580.30.20). The exact location of these instruments will be site-specific and will be summarized in a future construction/testing plan supported by predictive modelling.

Deliverables

Deliverables from Geoscience Verification will consist of: a detailed record of geotechnical and geological descriptions (lithological and structural) of excavated surfaces during shaft development and at all underground excavation locations; measurements of underground in-situ stresses, rock loading, hydraulic pressures, and groundwater quality; supplementary database of underground rock mass properties from core testing; monitoring systems to provide a temporal record of hydraulic pressure and groundwater quality data, excavation deformation, in-situ stress, microseismic events, thermal evolution; reporting and interpretation of new geosphere characterization and annual monitoring datasets; ; maintenance and updating of the associated geoscience data management system; maintenance and updating of the DGSM and associated geosphere numerical models (e.g. hydrogeologic, geomechanical, hydrogeochemical, thermal).

Assumptions

Geoscience Verification activities are assumed to commence in 2033 during shaft sinking and end in 2042 at the end of the site development and construction phase and prior to turnover to operations. It is assumed that Geoscience Verification represents the underground continuation of geoscience data gathering activities. The work will directly support verification of geotechnical properties as well as updating of the DGSM and associated geoscientific submodels that support the Safety Case associated with an operations license.

Geoscience verification activities accounted for in this WED do not include drilling and testing of pilot holes to support shaft excavation, or ahead of advancing faces during lateral development or probe holes associated with blasting rounds.

Staffing is included in the overall Geoscience labour WBS element (580.30.90).

Allowance

An overall allowance of 25% has been included for 2033 - 2042.

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2042
Material Cost	\$0	Duration	10 years
Other Cost	\$39,822	WBS Type	Fixed
Subtotal	\$39,822		
Allowance	\$9,956		
Total Cost	\$49,778		

GEOSCIENCE STAFFING AND DETAILED SITE CHARACTERIZATION

580.30.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: S. Hirschorn

Organization: NWMO

Description

Complete surface-based geosphere characterization of the site selected through the Phase 2 siting project. This program builds on the geoscience investigations completed as part of the Phase 2 for the selected site. Site characterization activities would continue to involve field, laboratory, integration and modelling activities to support Geoscience, Safety Assessment, Repository Engineering, Impact Assessment and Licensing functions.

Surface-based investigations will include a coordinated campaign of deep borehole drilling and testing, extensive laboratory testing of selected core samples, surface-based geophysical surveys, groundwater monitoring and seismic monitoring. The number of boreholes that will be required is site-specific and will be finalized based on outcome of Phase 2 geoscience investigations. Characterization activities will also include detailed surface geologic mapping with a focus on nature and distribution of bedrock lithology and in particular the acquisition of fracture-specific information for a crystalline site.

A series of complementary studies will be completed to support Geosynthesis development including an erosion assessment, a neotectonic survey, a seismic hazard assessment, a natural resource assessment, and long-term stability assessment.

NWMO staff as required to support and manage work program objectives. Beyond 2028, this WBS element is staffing only in support of WBS 580.30.20 Geosphere Monitoring, and 580.30.30 Geoscience Verification.

Deliverables

Deliverables include a network of seismographs established to monitor micro-seismicity at the site and in the region around the site. A network of shallow and deep groundwater monitoring systems will be established in selected boreholes to support baseline assessments of hydraulic heads and groundwater chemistry.

Deliverables include the Descriptive Geosphere Site Model (integrated 3D geological model, Discrete Fracture Network (DFN), hydrogeological, geophysical, geomechanical, hydrogeochemical, thermal and transport models), supporting geosphere characterization documentation, complementary study reports, updated Site Database and Geosynthesis.

Beyond 2028, this WBS element is staffing only in support of WBS 580.30.20 Geosphere Monitoring, and 580.30.30 Geoscience Verification.

Assumptions

Detailed site characterization activities are assumed to commence in 2024 and be completed in 2028. The fieldwork activities are assumed to be most intensive in years 2024-2026, with data interpretation, integration and modelling being the main focus of 2027 and 2028, along with any additional fieldwork that arises from the earlier work.

Costs associated with establishing the geosphere site monitoring network are included within the estimated \$133M during detailed site characterization activities. Refer to WBS 580.30.20 for the on-going geosphere site monitoring activities and associated costs post-detailed site characterization, and WBS 580.30.30 for the geoscience verification costs.

Geoscience staffing levels include 18 FTE during Site Selection and Licensing, and reduces during each phase, with 3 FTE included in the Monitoring and Closure phases.

Allowance

An overall allowance of 10% has been included for 2029 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2020
Labour Cost	\$175,354	Finish Year	2183
Material Cost	\$0	Duration	164 years
Other Cost	\$252,709	WBS Type	Fixed
Subtotal	\$428,063		
Allowance	\$44,243		
Total Cost	\$472,306		

LICENSING - CNSC FEES

580.35.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

CNSC and Impact Assessment Agency fees are calculated based on the anticipated FTE of regulatory effort during each licensing period. Licence issuance or renewals result in an increase in regulatory effort for a 2 year period of time.

LICENSING COSTS TO ISSUE SITE PREP AND CONSTRUCTION LICENCE (2024-2032):

Regulatory costs to obtain IA approval and Site Preparation & Construction Licences – 10 FTE

LICENSING COSTS DURING CONSTRUCTION (2033-2040):

Regulatory costs during the Construction period post licence issuance – 5 FTE

LICENSING COSTS TO ISSUE THE OPERATIONS LICENCE (2040- 2043):

Regulatory costs during the licensing period – 8 FTE

LICENSING COSTS DURING THE OPERATIONS PERIOD (2044 - 2088):

Regulatory costs during the Operations period – 4 FTE (6 FTE for every licence renewal on a 10 year cycle)

LICENSING COSTS DURING THE EXTENDED MONITORING PERIOD (2089 - 2158):

Regulatory costs during the Extended Monitoring period 0.5 FTE

DECOMMISSIONING AND CLOSURE (2159- 2183):

Regulatory costs during the Decommissioning and Closure periods – 3 FTE

Deliverables

Licences are received from the CNSC and annual regulatory compliance efforts are completed as planned.

Assumptions

CNSC Cost Recovery Regulations remain as current in 2020.

CNSC FTE cost recovery rate increases equivalent to the anticipated cost of living increase over the time period and there is no sudden increase in rates due to collective bargaining.

NWMO costs for the materials supporting licence compliance and licence issuance/renewal are included in the subject matter WEDS.

Allowance

An overall allowance of 10% has been included for 2024 – 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$
Labour Cost	\$0
Material Cost	\$0
Other Cost	\$182,668
Subtotal	\$182,668
Allowance	\$39,300
Total Cost	\$221,968

Start Year	2021
Finish Year	2183
Duration	163 years
WBS Type	Fixed

SAFEGUARDS

580.35.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: P. Gierszewski

Organization: NWMO

Description

Safeguards are primarily a means of nuclear material accounting complimented by containment and surveillance. The safeguards measures applied to the DGR facility will vary for each phase and has been grouped into three basic phases; pre-operations, operations, and post-closure phase. The International Atomic Energy Agency (IAEA) determines the required safeguards based on the design and layout of the APM DGR Facility. The IAEA is responsible for implementing safeguards internationally. While the IAEA may implement safeguards, from the design phase through to post- operations, including providing the labour and material involved in the design and installation of equipment, the IAEA is a non-profit organization and all costs are recovered through contributions made by Member States. The Canadian Nuclear Safety Commission (CNSC) is the Canadian regulatory body and pays the IAEA fees, recovering these costs through licensing fees from the facility owners. The level of effort and scope of safeguards is related to the movement of fuel and therefore is estimated separate from the CNSC Fees which are found in 580.35.10.

Costs included are those that will indirectly be provided to the IAEA, which covers the cost of inspectors, labour, and material for implementing safeguards at the DGR Facility. Details of the labour and equipment required for the DGR Facility are found in APM Lifecycle Cost Estimate – Summary of Security and Safeguards – APM-REF-00402-38792.

Deliverables

Pre-Operations Phase (2026-2042)

Safeguards related activities commence in the site characterization stage (i.e. after site selection)

1 FTE/yr for maintaining interface with CNSC and IAEA as necessary (from years 2026-2043).

Additional 2 FTE/yr for implementing safeguards at the DGR Facility when construction starts (from years 2034 – 2043).

1 FTE/yr of IAEA staffing to support installation/set up activities (2034 – 2043) – a 1:1 correlation of NWMO to IAEA staff is assumed.

\$1M/year IAEA monitoring activities/tools including satellite imagery, aerial photography, geophysical monitoring, starting 5 years before operations.

Costs for Safeguard equipment, installation, IAEA inspection personnel, data collection/analysis etc. (paid for by IAEA and recovered from Member states through License)

Operations (2043-2088)

-3 FTEs/yr for maintenance of safeguard program.

-Office Space for IAEA inspector (\$3850/m² for 16m²).

-Allowance for lighting, power, data communication (assume 10% of equipment capital costs (\$1.6M) per year.)

3FTE/yr (IAEA staff) for inspection and analysis – a 1:1 correlation of NWMO to IAEA staff is assumed.

\$1M/year IAEA monitoring activities/tools including satellite imagery, aerial photography, geophysical monitoring, starting 5 years before operations.

Extended Monitoring, Decommissioning and Closure (2089-2183)

Safeguards will continue through to Closure, as the repository remains a licenced nuclear facility with maintained access to the emplacement room areas. Level of staff effort is reduced due to the lack of throughput of nuclear materials; however monitoring equipment will still need to be operating 24/7 to confirm that no nuclear material is moved.

- 0.5 FTE/yr for maintenance of safeguard program
- 0.5 FTE/yr for IAEA staff for inspection
- 1 M\$/yr IAEA monitoring activities/tools including satellite imagery, aerial photography, geophysical monitoring (may be reduced if the Used Fuel Packing Plant is decommissioned),

See Postclosure management for expectations after closure.

Assumptions

Per CNSC assumption - 1 FTE equals 1800 hours at a rate of \$280 per hour.
 \$11k per piece of equipment, including installation and cabling for 141 pieces of equipment identified in TDM.
 Assume 10% per year for maintenance/consumables of Safeguard equipment.
 A key assumption for this estimate is that the NWMO will obtain approval for integrated safeguards similar to OPG.

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2026
Labour Cost	\$0	Finish Year	2183
Material Cost	\$0	Duration	158 years
Other Cost	\$339,749	WBS Type	Fixed
Subtotal	\$339,749		
Allowance	\$84,517		
Total Cost	\$424,267		

LICENSING - STAFFING

580.35.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

Staffing for the period covering the siting, site preparation, construction, and initial operations licensing (2020 – 2042) consists of 4FTE.

Licensing staffing included in the staffing for Operations (2043 – 2088) WED 580.45.20 and the staffing for Decommissioning (2159 to 2183) WED 580.60.10.

Licensing staffing is not required during the Extended Monitoring period (2089 to 2158).

Deliverables

None

Assumptions

None.

Allowance

An overall allowance of 10% has been included for 2024 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2020
Labour Cost	\$15,666	Finish Year	2042
Material Cost	\$0	Duration	23 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$15,666		
Allowance	\$2,355		
Total Cost	\$18,021		

UDF/ PROTOTYPE ENGINEERED BARRIER - EMPLACEMENT EQUIPMENT

580.40.10.30.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Underground development facility (UDF) equipment encompasses specialty equipment required for the research functions of the UDF. These functions will be specified in detail as UDF design and licensing proceeds.

The current contracting strategy is to procure the UDF on an Engineer, Procure and Construct, EPC, basis, in which the contractor's price includes detailed design. Facility requirements will be developed by NWMO as part of Repository Engineering, Safety Assessment and allied efforts. Support installations associated with the UDF, such as maintenance shops, located in the main and service shaft complex, are included in work element 580.40.10.30.20.70, "Tunnel and Service Area Excavation")

Deliverables

Final design-basis prototypes for the transfer and emplacement of the engineered barrier system including Used Fuel Container, compacted bentonite block overpack, bentonite spacer block, granular bentonite gap fill material, and room plug installation. Set of equipment includes:

- UFC Transfer Cask
- Trolley for UFC Transfer
- Cask Shielding Canopy
- Shielding Canopy
- Trolley Hydraulic
- Cylinder Cart
- Placement Vehicle
- Floor Plate Handling
- System Bentonite Spacer
- Block Trolley Bentonite
- Gap Fill Material Delivery System
- Tow Vehicle
- Floor Plate Placement System
- Room Plug Installation System (e.g. forms)

Assumptions

Initial cost allotment on the basis of a full set of Used Fuel Container (UFC) emplacement equipment for testing and evaluation.

The equipment will be the final design-basis prototypes. It is assumed that these will be able to be used for the production operations; however, some design modifications are assumed to be needed (e.g. for field changes, etc.). These costs are captured in Engineered Barrier Emplacement Equipment (WED #580.45.50.60.20).

580.40.10.30.10

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2035
Labour Cost	\$0	Finish Year	2038
Material Cost	\$21,492	Duration	4 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$21,492		
Allowance	\$5,373		
Total Cost	\$26,865		

UG MOBILE DEV AND SUPPORT EQUIP - YEARS 11 TO 56

580.40.10.30.20.100

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

This WBS section includes all the underground mobile equipment that was previously built into the unit development cost and distributed across all development excavation WBS codes. The equipment is grouped by the construction period, years 1 to 10 (see WBS 580.40.10.30.20.90) and operations period, years 11 to 56 (this WBS); and also by: large equipment (not required during operations stage), placement room, and support equipment.

Deliverables

Placement Room

NWMO Small Jumbo - Sandvik DD220
 NWMO Small LHD - Sandvik LH203
 NWMO Haul Truck - Rear-dump, articulated, 32.6 mt
 Scissor Lift - Emulsion Charger - A64-SL

Support Equipment

Personal Carrier - Miller Truck 8200
 Lube Truck - Miller Truck 8200
 Boom Truck Shaft Station - A64 Boom 2-1300
 Electricians Truck - Miller Truck 8200 manbasket

Assumptions

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2086
Material Cost	\$53,632	Duration	44 years
Other Cost	\$0	WBS Type	Variable
Subtotal	\$53,632		
Allowance	\$13,408		
Total Cost	\$67,041		

580.40.10.30.20.100

CONCRETE PLANT

580.40.10.30.20.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: I. Ahmed

Organization:

Golder
Associates Ltd.

Description

Detailed design, construction and commissioning of a concrete batch plant.

The batch plant would include 4 binder storage silos to produce a low heat, high performance (LHHP) concrete. The binders include: cement, silica fume, silica flour and slag. The binder used is reflective of the current LHHP concrete mix design.

The batch plant would be outfitted with admixture addition capacity to allow for a reduced water content for LHHP concrete mix design as well as a hot water system to make winter batching possible. The batch plant will be housed within a building, where the concrete can be centrally mixed and delivered to the Service Shaft via a ready-mix truck or conveyors.

Five heated aggregate storage domes are included as part of the overall batch plant facility.

Deliverables

The concrete batch plant includes the following key elements:

- Front End Loader
- Ready-Mix Truck
- Aggregate Storage Bin
- Aggregate Batcher and Transfer Conveyor
- 100 tonne Cement Silo
- 30 tonne (each) Silica Fume, Silica Flour, Slag Silos
- PD Blowers
- Cement Weigh Hopper
- Hot Water Heating System
- Bulk Bag System
- Twin Shaft Mixer
- High Pressure Washer
- Central Dust Collector
- Admixture Tanks
- Admixture Pumps
- Stacking Conveyor
- Aggregate Hopper and Belt Feeder
- Short Aggregate Container Fill Conveyor
- Bulker for Binder Storage (Intermediate)
- Air Compressor
- Aggregate Storage Domes w/Heated Concrete Slab
- Boiler System for Heating Concrete Foundations

580.40.10.30.20.20

Assumptions

Batch plant to be 20 to 25 m3 per hour capacity; sized on a basis of pouring concrete bulkheads at the placement room entrances. Pricing derived from commercially available central mix batch plant. A combination of database values/vendor budget estimates for fixed plant equipment and factored costs for plant direct (infrastructure) and indirect (engineering, commissioning and construction support) costs have been used to build the estimate. A quote was received from BMH Systems on a central mix concrete batch plant.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2034
Labour Cost	\$490	Finish Year	2034
Material Cost	\$5,340	Duration	1 years
Other Cost	\$1,883	WBS Type	Fixed
Subtotal	\$7,713		
Allowance	\$1,928		
Total Cost	\$9,641		

CAMPSITE AND CAMPSITE OPERATIONS

580.40.10.30.20.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Provision for the set up and operation of the temporary camp complex for mine/construction workers during the construction period.

Deliverables

Construction camp complex (maximum capacity of 600-persons) including accommodations; medical centre, airstrip, infrastructure as roads, drains, lighting; kitchen, cafeteria; fuel storage area and recreation facilities. Camp will include all services including potable and fire water, sewage collection and treatment, solid waste collection & disposal and electrical power supply.

Assumptions

Campsite specified to provide initial construction area support (sewerage, helipad, water, waste) and accommodation for contract crews.

Pricing based on commercially available genset, trailer and tankage rates; road costs consider representative northern Ontario per-km rates.

Operational costs budgeted as a camp vendor charge of \$60 per person/per day (includes food, all camp indirects).

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$49,991	Finish Year	2042
Material Cost	\$79,585	Duration	10 years
Other Cost	\$74,831	WBS Type	Fixed
Subtotal	\$204,407		
Allowance	\$51,102		
Total Cost	\$255,509		

SERVICE SHAFT AND HEADFRAME

580.40.10.30.20.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

The construction of the shaft collar, erection of permanent headframe, installation of hoisting system, installation of ventilation fans, the sinking of the Service Shaft and the excavation and construction of rock handling systems. It is assumed the permanent concrete tower headframe will be used for sinking, including the cost of temporary sinking hoists where required. This shaft is to be sunk in parallel with the Exhaust Ventilation Shaft (EVS); however, due to the requirement for more set-up time is completed after the EVS. The work excludes installation of permanent fresh air ventilation fans and heaters at this facility installed on surface. Fan installation is covered by work element 580.40.60.40.

Deliverables

A 7.0 m finished internal diameter, concrete-lined 0.5 m thick liner, shaft, complete with associated infrastructure.

Assumptions

The collar is 30 m in depth. Shaft sinking will utilize the permanent headframe, and the permanent Blair drum auxiliary hoist. There will be a tower-mounted Koepe hoist for the skips and main cage to be serviced by an Alimak elevator. An auxiliary hoist will also be provided for a total of three hoists. The permanent headframe is 64 m in height and constructed of concrete. The shaft depth is assumed to be approximately 575 m to allow for a surge capacity above the loading pocket, and to allow for the overwind/underwind required for safety concerns.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2034
Material Cost	\$0	Duration	2 years
Other Cost	\$150,514	WBS Type	Fixed
Subtotal	\$150,514		
Allowance	\$37,629		
Total Cost	\$188,143		

SERVICE AREA

580.40.10.30.20.70

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavation of tunnels in the services area to the starting boundary of each placement arm – just beyond the first cross-cut that establishes the flow through ventilation and arm sump and/or electrical sub-station; tunnels interconnecting the services facilities; support services excavations; ramps to the upper and lower levels and vent raises. It excludes the early and main UDF areas and required Access Tunnel development for the main UDF accesses and vent system loop.

Deliverables

Provision of tunnels and service areas, including:

Main Shaft access

Main Shaft station (to battery limit with shaft scope)

Booster Fan station

Booster Fan access tunnel

Service Shaft station (to battery limit with shaft scope)

SA tunnels (access tunnels for service shaft, offices, RAR and FAR, crosscuts, remuck bay and wash bay exit)

Cask storage access, drifts, service area access, wash bay access and welding bay exit

Cask storage loop

Tow tractor parking

Truck dump and rock breaker

Main tunnels through SA (drifts, crosscuts)

Office

Washrooms

Refuge station

Sump

Pump stations (2)

Electric sub-stations (9)

Explosives mag access tunnel

Explosives parking

Explosives magazine

Detonator magazine

Bentonite and mining material storage

Mining gear storage

Slings and stand storage

Warehouse

Electrical shop

Hose & hydraulic shop

Millwright shop

Work bench tool bay

580.40.10.30.20.70

Wash bay
 Lube service bay and satellite lube
 Welding bay
 Heavy duty repair bays
 Battery maintenance area and electrical room switch
 Ramp to upper (FA) level main tunnel
 Elevated surface ramps
 Upper (FA) level main tunnel
 Upper (FA) level electrical substation
 Upper level fresh air raise accesses
 Upper level fresh air raises
 Ramp to lower (RA) level main tunnel
 Lower (RA) level collector sumps
 Lower (RA) level electrical substation
 Lower (RA) level remuck bays
 Lower (RA) level rock pass
 Lower (RA) level loading pocket
 Lower (RA) level loading pocket access
 Lower (RA) level loading pocket drift
 Lower level return air raise accesses
 Lower level return air raises

Initial underground geosphere characterization assessment work will be conducted during excavation of tunnels and rooms, and in the test rooms.

Assumptions

Work conducted on an Engineer-Procure-Construct Basis by contractor. Estimated on the basis of all-inclusive development and installation rates. Development to be scheduled for 350 days per year, 24 hours per day.

All-inclusive pricing for per linear metre of mine development as per Golder costing model. Note that per unit (\$/m) are worked up from individual crew components and are different between crystalline and sedimentary mine development. Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Main Shaft access (9m x 5m): 107 metres
 Main Shaft station (10m x 5m): 60 metres
 Booster Fan station (9m x 14m): 75 metres
 Booster Fan access tunnel (9m x 4m): 167 metres
 Service Shaft station (10m x 5m): 30 metres
 SA Tunnels (access tunnels for service shaft, offices, RAR and FAR, crosscuts, remuck bay and wash bay exit) (5m x 5m): 782 metres
 Parking Slash (4m x 4m): 108.3 metres
 Parking Slash (4m x 5m): 174.7 metres
 Cask storage access, drifts, service area access, wash bay access and welding bay exit (6.5m x 5m): 409.7 metres
 Cask Storage Loop (Eq. length) (12m x 4m): 227 metres
 Tow Tractor parking (9m x 5m): 20 metres
 Truck dump and rock breaker (9m x 7m): 10 metres
 Main Tunnels through CSA (drifts, crosscuts) (9m x 4m): 2384 metres
 Office (7m x 7m): 45 metres
 Washrooms (4m x 4m): 20 metres

Refuge Station (5m x 5m): 64 metres
 Sump (5m x 5m): 75 metres
 Pump Stations (2) (5m x 6m): 40 metres
 Electric Sub-Stations (9) (6m x 5m): 150 metres
 Explosives Mag Access Tunnel (5m x 5m): 80 metres
 Explosives Parking (5m x 5m): 9 metres
 Explosives Magazine (7m x 7m): 20 metres
 Detonator Magazine (5m x 4m): 10 metres
 Bentonite and Mining Material Storage (10m x 5m): 30 metres
 Mining Gear Storage (10m x 5m): 30 metres
 Electrical Shop, Hose & Hydraulic Shop, Millwright Shop, Slings and Stand Storage and Work Bench Tool Bay (6.5m x 5m): 66 metres
 Warehouse/Office (7m x 4m): 40 metres
 Wash bay (7m x 8.5m): 20 metres
 Lube Service Bay and Satellite Lube (7.5m x 6m): 48 metres
 Welding Bay (9m x 6m): 30 metres
 Heavy Duty Repair Bays (12m x 10m): 50 metres
 Battery Maintenance Area and Electrical Room Switch (5m x 5m): 10 metres
 Ramp to Upper (FA) Level Main Tunnel (5m x 5m): 176 metres
 Elevated Surface Ramps (12m x 10m): 30 metres
 Upper (FA) Level Main Tunnel (9m x 5m): 338 metres
 Upper (FA) Level Electrical Substation (6m x 5m): 15 metres
 Upper Level Fresh Air Raise accesses (5m x 5m): 217 metres
 Upper Level Fresh Air Raises – (4m diam): 138 metres
 Ramp to Lower (RA) Level Main Tunnel (5m x 5m): 684 metres
 Lower (RA) Level Collector Sumps (5m x 5m): 30 metres
 Lower (RA) Level Electrical Substation (6m x 5m): 15 metres
 Lower (RA) Level Remuck Bays (5m x 5m): 30 metres
 Lower (RA) Level Rock Pass (5m diam): 31 metres
 Lower (RA) Level Loading Pocket (7.5m x 5m): 6 metres
 Lower (RA) Level Loading Pocket access (5m x 5m): 86 metres
 Lower (RA) Level Loading Pocket drift (5m x 5m): 28 metres
 Lower Level Return Air Raise accesses (5m x 5m): 283 metres
 Lower Level Return Air Raises (4m diam): 123 metres

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2036
Labour Cost	\$48,621	Finish Year	2038
Material Cost	\$23,370	Duration	3 years
Other Cost	\$3,850	WBS Type	Fixed
Subtotal	\$75,842		
Allowance	\$18,960		
Total Cost	\$94,802		

UG INFRASTRUCTURE INSTALLATIONS & CONSTRUCTION

580.40.10.30.20.80

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

This WBS covers the cost major equipment and construction of the underground infrastructure that was previously included as part of the development unit cost and distributed in the excavation WBS codes.

Deliverables

Maintenance Shops:

Underground Mobile Equipment Shop (all sub-sections) – Construction & Equipment

5 Tonne Bridge Crane (welding bay)

15 Tonne Bridge Crane (Heavy duty and service repair bays)

3 Tonne Jib Crane (warehouse area)

Underground Millwright Shop, Construction & Equipment

Underground Electricians Shop, Construction & Equipment

Underground Small Battery Repair Shop, Construction & Equipment

Refuge Stations, Offices & Washrooms:

Outfit Refuge Stations - Placement Arm 5 x 5 x 15 (5 installations crystalline)

Outfit Refuge Stations - Service Arm 5 x 5 x 64 (1 installation stations crystalline) ratio 4.25x larger

Outfit UDF Offices (10 workstations/offices plus lunch room facilities)

Outfit Washrooms

Auxiliary Development Heading Fans & Duct

UG Auxiliary Fans - Large Headings - 150 kW at 1.22 m diameter vane axial fan (typical of Howden – Alphair units)

Placement Room Auxiliary Fans (fans for Panel 1 & Main UDF)

Placement Room Header Steel Vent Ducting (1.37 m diameter for Panel 1 & Main UDF)

Placement Room Auxiliary Fans (double stage (2fans) 610mm diameter at 22kW each fan)

Sumps & Dewatering Pumps

Main Sump Pump Bases, Dam Walls, Agitator System & all Piping/Valves Construction

Main Dewatering Sump - Positive Displacement Pumps

Main Dewatering Sump - Agitator Systems

Collection Sump Pumps & Construction - SHAFT BOTTOMS

Collection Sump Pumps & Construction - PLACEMENT ARMS

Electrical & Communications - Main Line Cables & Sub-Station

Underground Electrical Sub-Station – Major at Shaft Station(s) (2 MVA Substation)

Underground Electrical Sub-Station – Standard Throughout DGR (750 kVA Substation)

Underground Communications Centre – Standard Throughout DGR

Underground Electrical Cable Distribution System - Cables

580.40.10.30.20.80

Storage Areas

Underground Communications Cable Distribution System - Fibre Optic Cables
 Underground Storage Area - Bentonite, Construction & Equipment
 Underground Storage Area - Mining Gear, Construction & Equipment
 Outfit Detonator and Explosives Magazine

Miscellaneous

Install Rockbreaker and Grizzly
 Air Compressor (delivery pressure: 7.58 bar, flow 0.33 to 0.35 m3/s)
 Cap Lamps & Ancillary Gear
 Concrete Floors - Access Tunnels, Cross-Cuts, All Infrastructure Areas, UDF Areas, (except Placement Rooms)

Assumptions

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$6,239	Finish Year	2042
Material Cost	\$65,337	Duration	10 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$71,575		
Allowance	\$17,894		
Total Cost	\$89,469		

UG MOBILE DEV AND SUPPORT EQUIP - YEARS 1 TO 10

580.40.10.30.20.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

This WBS section includes all the underground mobile equipment that was previously built into the unit development cost and distributed across all development excavation WBS codes. The equipment is grouped by the construction period, years 1 to 10 (this WBS) and operations period, years 11 to 56 (see WBS 580.40.10.30.20.100); and also by: large equipment, placement room, and support equipment.

Deliverables

Large Equipment

NWMO Large Jumbo - 2 Boom EV 14.1m x 9.3m face

NWMO Large LHD - 3.1 cu m EV LHD - hardrock

NWMO Large Haul Truck - Rear-dump, articulated, 32.6 mt

Development Bolter - MacLean MEM975 - EV

Development Emulsion Charger - Emulsion Loading truck, 6m x 6m heading

Scissor Lift - A64-SL

NWMO Raisebore - Robbins 92R - 2.4m to 6m ø

Placement Room

NWMO Small Jumbo - Sandvik DD220

NWMO Small LHD - Sandvik LH203

Scissor Lift - Emulsion Charger - A64-SL

Support Equipment

Grader - M116

Personal Carrier - Miller Truck 8200

Lube Truck - Miller Truck 8200

Shotcrete Sprayer - 30 cu m/hr (spray ht = 17m)

Transmixer - TM3

Boom Truck Shaft Station - A64 Boom 2-1300

Electricians Truck - Miller Truck 8200 manbasket

Assumptions

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$36,407
Other Cost	\$0
Subtotal	\$36,407
Allowance	\$9,102
Total Cost	\$45,508

Start Year	2033
Finish Year	2042
Duration	10 years
WBS Type	Fixed

SITE IMPROVEMENTS

580.40.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Initial site infrastructure requirements in support of the start of construction.

Deliverables

Preparation of the site, including:

- Site civil preparation for site facilities (clearing, blasting, grading, initial landscaping)
- Main access road (inc. drainage ditches and hydro tower allowance)
- Transmission towers (25 m high, every 200 m)
- High voltage lines and grid tie-in
- Inner/outer zone site roads
- Parking Lots (Paved)
- Truck weigh scale (25 m long), scale house, and traffic lights.
- Helipad - 30 m dia., include drainage and lighting
- Allowance for internal site rail (total of 1.2 km) including switchgear
- Excavated rock management area (ERMA), including fencing, gate, access road and storm water runoff pond
- All perimeter fencing, access gates, signage, and lighting

Assumptions

Rail access to the site is not required.

Land acquisition is accounted for in other work elements.

Surface preparation is calculated for surface facilities footprint only.

All work conducted on a design-build basis, using design-build labour rates that account for typical construction indirects.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$48,543	Finish Year	2034
Material Cost	\$68,348	Duration	2 years
Other Cost	\$50,124	WBS Type	Step Fixed
Subtotal	\$167,015		
Allowance	\$41,754		
Total Cost	\$208,769		

580.40.20

VISITOR CENTRE - DGR SITE

580.40.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: C. Lee

Organization: NWMO

Description

Indirect labour and equipment costs incurred during the facility design and construction stage of the project which are not included in Engineer, Procure, Construct (EPC) price items.

EPC procurement is used comprehensively: construction phase indirects are limited to visitor's centre operations and maintenance of surface facilities after hand-over to owner.

Refer to WBS 580.40.50.250 VISITORS CENTRE.

Deliverables

Operation of the Visitor's Centre and incidental care/upkeep for structures after completion by EPC contractor.

Assumptions

Visitor's centre operation budgeted as six persons, one shift. Incidental maintenance budgeted as crew of 4 surface construction works (surface construction worker labour rate includes janitorial, waste disposal, etc.)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$18,253	Finish Year	2042
Material Cost	\$0	Duration	10 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$18,253		
Allowance	\$4,563		
Total Cost	\$22,816		

SEALING MATERIALS COMPACTION PLANT (SMCP)

580.40.40.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: I. Ahmed

Organization:

Golder
Associates Ltd.

Description

The detailed design, construction, supply, installation, testing and commissioning of a fully operable Sealing Materials Compaction Plant (SMCP), capable of producing bentonite-based sealing materials for Used Fuel Container (UFC) placement.

Deliverables

The design and construction of a multi-story structural steel-framed 60m x 50m x 20m high SMC plant building mounted on a reinforced concrete slab. The design to include supply and installation of all building services. The building ventilation system will primarily provide dust suppression within the building operating areas. The design, supply installation of all process equipment. The process equipment within the SMC plant will include:

- Positive displacement blowers (3)
- Conveyors
- 10 x 150 tonne clay materials silos
- 150 tonne modified Granular A silo
- Weigh hoppers (4)
- Dust collector
- Mixers (3)
- Vacuum pump
- HCB press
- Hydraulic power pack for HCB press
- Briquetter
- Vacuum Lifting Device (4)
- Locomotive (2)
- Rail Cars (2)

The provision of detailed engineering, construction and other installation indirect costs (labour and equipment) incurred by the contractor to execute the project have been included.

Assumptions

A combination of database values/vendor budget estimates for fixed plant equipment and factored costs for plant direct (infrastructure) and indirect (engineering, commissioning and construction support) costs have been used to build the estimate. Press, briquetter, vacuum lift and mixer costs were developed from vendor budgetary pricing.

Site geotechnical testing and evaluation will be required to specify support needs/foundation requirements for the hydraulic presses.

580.40.40.20

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2040
Labour Cost	\$2,095	Finish Year	2042
Material Cost	\$98,118	Duration	3 years
Other Cost	\$25,737	WBS Type	Fixed
Subtotal	\$125,951		
Allowance	\$31,488		
Total Cost	\$157,439		

PUMP HOUSE & INTAKE

580.40.50.100

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a water intake of 200 m³/day capacity, pump house and pipeline Including an intake structure with screen

Deliverables

Functioning system to supply water to the surface facilities of the DGR and also provide fire protection for surface facilities for 3 hours.

Components include:

- Pump house building
- Three sets of 15 hp pumps
- 5 km of 150 mm dia. Conveyance pipeline
- 5 km of gravel access road
- 5 km of above-ground 13 kv electrical supply (incl. 200 poles).

Assumptions

Size based on water requirements for fresh water, fire water and potable water.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2034
Labour Cost	\$4,899	Finish Year	2034
Material Cost	\$7,699	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$12,597		
Allowance	\$3,149		
Total Cost	\$15,747		

WATER STORAGE TANK AREA

580.40.50.110

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission fire/raw water tank and potable water storage tanks.

Deliverables

Two field fabricated water storage tanks, one for potable water and one for fire/raw water. Includes:

- 300 mm thick reinforced concrete pad, including sub-grade, lighting, etc.
- Fresh/fire water tank (1500 m3)
- Potable water tank (100 m3)
- Monitoring /isolation equipment/submerged mixers

Assumptions

Potable water tank will hold 24 hours at average hourly flow rate. Fire/raw water tank will hold >3 hours of fire fighting at 340 m3/hour plus 24 hours of raw water demand.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$184	Finish Year	2038
Material Cost	\$873	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,057		
Allowance	\$264		
Total Cost	\$1,322		

WATER TREATMENT PLANT

580.40.50.120

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission a water treatment plant and water treatment plant building.

Deliverables

- Skid mounted water treatment plant (treatment rate of 15 gpm, 3 m3/hr)
- 125 m2 single storey building
- Tie ins

Assumptions

Size based on housing water treatment plants and pumps as listed above. Water Treatment Plant verbal quote from Ecologix System of Georgia; skid-mount package system requires daily checks but not full-time operator.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$74	Finish Year	2038
Material Cost	\$3,392	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$3,466		
Allowance	\$866		
Total Cost	\$4,332		

PROCESS WATER SETTLING POND

580.40.50.130

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construct and commission a Process Water and storm water Settling Pond to hold 2314 m³ storm runoff. Pond size = 36m x 45 m x 4.1m depth with a freeboard of 0.6 m.

Deliverables

Pond for settling of process water, storm water.

Assumptions

Pond to be excavated in soil; no blasting required. Pond to be 3,775 m³. Includes geomembrane.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2034
Labour Cost	\$85	Finish Year	2034
Material Cost	\$169	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$254		
Allowance	\$63		
Total Cost	\$317		

SERVICE SHAFT WATER SETTLING POND

580.40.50.140

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construct and commission a Settling Pond for mine dewatering effluent.

Pond size = 35 m x 80 m x 2.0 m with a freeboard of 0.5 m

Pond volume = 5 500 m³

Pumps and piping included

Piping from Service Shaft to the pond and from the pond to Service Shaft.

Deliverables

Water settling pond for water discharged from Service Shaft.

Assumptions

Effluent will be discharged either to a local drainage course. Excavation in soil; no rock blasting required. 60-mil HDPE liner installed.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2034
Labour Cost	\$150	Finish Year	2034
Material Cost	\$274	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$424		
Allowance	\$106		
Total Cost	\$530		

STORM RUN-OFF POND

580.40.50.150

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construction and commissioning of two equal size stormwater run-off detention ponds to collect surface water runoff from across the DGR site. Ponds nominally designed for a 500-year storm event. For conceptual design, total volume of approximately 25,600 m³ assumed.

Deliverables

Ponds for the collection of stormwater run-off from the DGR site.

Assumptions

Ponds to be designed for 25,600 m³ total stormwater flow over the site. Two ponds to be constructed in soils with no rock excavation. Pricing includes bedding and geomembrane.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$367	Finish Year	2033
Material Cost	\$691	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,058		
Allowance	\$264		
Total Cost	\$1,322		

SEWAGE TREATMENT PLANT

580.40.50.160

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a pre-engineered packaged sewage treatment plant, including sewage pumping station.

Deliverables

Package sewage treatment plant complete with steel tank enclosure comprising primary clarifier, final clarifier, ultra-violet disinfection system, controls, switchgear, piping and pumping station. Costs encompass package sewage treatment plant (4m w x 20 m l x 5 m h), hook-ups, manholes and two 5 hp pumps.

Assumptions

No external building required as facility is unmanned requiring only daily/weekly inspection. Wastewater influent quality up to 400 mg/l of BOD5 and Total Suspended Solids loadings. Treated effluent will meet Ontario Discharge standards with an assumed effluent quality of BOD5 and Total Suspended Solids loadings below 20 mg/l and fecal coliform count of 200 MPN/100 ml before effluent is discharged to a local drainage course. Sewage Treatment Plant Quote from Tiff Corp of Oakdale PA.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$266	Finish Year	2038
Material Cost	\$4,055	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$4,321		
Allowance	\$1,080		
Total Cost	\$5,401		

LOW LEVEL LIQUID WASTE STORAGE BUILDING

580.40.50.170

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: D. Elion

Organization: SNC-Lavalin

Description

Detail design, construction, equipping and commissioning of a single storey low level liquid waste storage building with a total floor area of 500 m².

The building will be steel framed and clad industrial type warehousing mounted on a 1 m thick reinforced concrete base. The concrete area used for tank and drum storage will be sealed using an epoxy resin finish and be graded and bounded to contain and collect active liquid spillages. The building will be heated to help prevent freezing of liquids and drum corrosion/degradation. The building will incorporate a load/unload area and be equipped with radiation monitoring and wash down facilities. Office space will be included for operations personnel.

Deliverables

The provision of all direct and indirect resources for the detail design, construction, supply, installation, testing and commissioning of a fully operable Low Level Liquid Storage Building. These will include:

- Design and Engineering;
- Construction of the building together with all permanent fixtures; and
- Commissioning resources.

Assumptions

The building design and construction will be let on a turnkey contract basis. This contract will include an allowance for ongoing management and co-ordination of all other building plant and equipment installation sub-contracts.

The provision of building services, systems and equipment will be by placement of detail design, supply, installation and testing contracts on individual Mechanical and/or EC&I contractors (or contractor). All commissioning will be placed on an Engineering Commissioning contractor.

Liquid effluent will be generated from decontamination activities within the UFPP, particularly associated with cleaning sealed modules prior to disposal. There will be a small amount of liquid effluent arising from general washdown of active cells.

Building will be only used as an interim storage facility prior to disposal or transfer and treatment of the inventory at the Active Liquid Waste Treatment (ALWT) building.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$1,519
Other Cost	\$2,146
Subtotal	\$3,665
Allowance	\$916
Total Cost	\$4,582

Start Year	2041
Finish Year	2042
Duration	2 years
WBS Type	Step Fixed

ACTIVE LIQUID WASTE TREATMENT (ALWT) SYSTEM

580.40.50.180

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: D. Elion

Organization: SNC-Lavalin

Description

The detail design and construction of an Active Liquid Waste Treatment Building, including the supply and installation of all process equipment and the setting to work and commissioning of the completed facility. The building will be single storey and have an area of 450 m². It will not have a basement. The process within the building include evaporation system and associated tanks.

Deliverables

The provision of all direct and indirect resources for the detail design, construction, supply, installation, testing and commissioning of a fully operable Active Liquid Waste Treatment Building. These will include:

- Design and Engineering;
- Construction of the building together with all permanent fixtures; and
- Commissioning resources.

Assumptions

The building design and construction will be let on a turnkey contract basis. This contract will include an allowance for ongoing management and co-ordination of all other building plant and equipment installation sub-contracts.

The provision of building services, systems and equipment within the ALWT building will be by placement of detail design, supply, installation and testing contracts on individual Mechanical and/or EC&I contractors (or contractor).

All commissioning will be placed on an Engineering Commissioning contractor.

Liquid effluent will be generated from decontamination activities within the UFPP, particularly associated with cleaning sealed modules prior to disposal. There will be a small amount of liquid effluent arising from general wash down of active cells.

Plant is based on the processing of 2,500 m³ of liquid effluent per annum. It is based on using 1 m³ of liquid to decontaminate a module and an equivalent of 1,250 modules per annum. This total is doubled to account for other liquid waste arisings. It is assumed that processing this volume of liquid by evaporation will produce approximately 100, 200-L drums of solid active residues. Following treatment and satisfactory sampling, condensed evaporator overheads (steam) will be recycled or discharged to a local river or lake.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

580.40.50.180

	2020K\$	Start Year	2041
Labour Cost	\$0	Finish Year	2042
Material Cost	\$1,040	Duration	2 years
Other Cost	\$2,483	WBS Type	Step Fixed
Subtotal	\$3,523		
Allowance	\$881		
Total Cost	\$4,404		

WASTE MANAGEMENT AREA

580.40.50.190

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Detail design, construct and commissioning of a Waste Management Area. This area conceptualized as an approximate 10,000m² graveled yard with 2,500m² of concrete hard standing areas, confined by a 2.5 m high perimeter fence. The area will be used to park both on and off-site waste transport vehicles, be the location for the low level waste storage building and for the storage and maintenance of on-site waste transfer casks and equipment. The latter will comprise a 30m x 40m single storey industrial steel framed and clad warehouse type building to accommodate vehicle/cask decontamination and maintenance. The building will be heated and ventilated and will accommodate waste management offices and staff facilities.

Deliverables

The provision of all direct and indirect resources for the detail design, construction, supply, installation, testing and commissioning of a fully operable Waste Management Area. These will include:

- Design and Engineering
- Construction of the area, fencing and building together with all permanent fixtures
- Commissioning resources.

Assumptions

The Waste Management Area design and construction will be let on a turnkey contract basis. This contract will include an allowance for ongoing management and co-ordination of all other building plant and equipment installation sub-contracts. The provision of building services, systems and equipment within the Waste Management Area will be on a turnkey basis.

The Waste Management Area and the vehicle/cask decontamination and maintenance building will be constructed using conventional methods.

Costs include:

- 10,000 m2 graveled yard with 2500 m2 concrete pads
- A 1200 m2, one-storey waste management area building including all equipment for vehicle cask decontamination, waste management offices and staff facilities.
- Area perimeter fence, gates and lighting

The low level waste building is costed in the element 580.40.50.220.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$1,330
Material Cost	\$9,291
Other Cost	\$0
Subtotal	\$10,621
Allowance	\$2,655
Total Cost	\$13,276

Start Year	2042
Finish Year	2042
Duration	1 years
WBS Type	Step Fixed

ADMIN BLDG

580.40.50.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a fully equipped administration building. The administration building will include office space for the administration, management, engineering, maintenance and operation staff. The building will also contain Information Technology (IT) & Communication Centre, Transportation and Logistics Coordination Centre, a Nursing Station and First Aid room, Firehall and a Cafeteria. The various building mechanical and electrical equipment will be located on the main floor.

Deliverables

Fully equipped, 2-storey administration building (2,200 m² foot print providing a total gross floor area of 4,400 m²).

Assumptions

Building size based on space for 200 people. Compliance with National Building Code. Fire trucks quoted by Fenton Fire Equipment of Michigan.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$0	Finish Year	2038
Material Cost	\$9,020	Duration	1 years
Other Cost	\$24,280	WBS Type	Step Fixed
Subtotal	\$33,300		
Allowance	\$8,325		
Total Cost	\$41,625		

LOW LEVEL WASTE STORAGE BUILDING

580.40.50.220

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: D. Elion

Organization: SNC-Lavalin

Description

Detail design, construction, equipment supply, installation and commissioning of a Low Level Radioactive Solid Waste Storage Facility.

Covering an area 1,000 m², the building will be 6 m high, single storey with no basement. The building will be a steel framed and clad structure with no permanent shielding, to accommodate storage of low-level radioactive waste (LLW) and potentially intermediate level waste (ILW). The building will include heating and ventilation, with a load bearing concrete floor suitably sealed using epoxy resin. The building will be seismically qualified to nuclear industry standards and will be served by fork lift truck. The store will be provided with suitable receipt and export areas.

Deliverables

The provision of all direct and indirect resources for the detail design, construction, supply, installation, testing and commissioning of a fully operable Low Level Waste Storage building. These will include:

- Design and Engineering;
- Construction of the building together with all permanent fixtures; and
- Commissioning resources.

Assumptions

The building design and construction will be let on a turnkey contract basis.

All commissioning will be placed on an Engineering Commissioning contractor.

LLW store is provided with forklift truck access.

The LLW store is of conventional construction.

No packaging of materials will be carried out at this facility. It is for interim storage only, prior to dispatch to a separate, off-site processing and disposal facility.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$1,225
Other Cost	\$4,292
Subtotal	\$5,517
Allowance	\$1,379
Total Cost	\$6,896

Start Year	2041
Finish Year	2042
Duration	2 years
WBS Type	Step Fixed

ELECTRICAL SWITCHYARD

580.40.50.230

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construct and commission main electrical switchyard adjacent to the transformer area and powerhouse. Total area required is 40 m x 50 m with concrete pads for switchgear and breakers.

Deliverables

Electrical switchyard grading, surface preparation, concrete pads, switches, controls, breakers and fencing to provide electrical power for entire facility.

Assumptions

2000 m² switchyard including 800 m² of concrete pads .

Estimated cost includes site preparation, fencing and yard foundations.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$1,045	Finish Year	2033
Material Cost	\$798	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,843		
Allowance	\$461		
Total Cost	\$2,303		

TRANSFORMER AREAS

580.40.50.240

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construct and commission transformer area.

Deliverables

Transformers, interconnections, gravel base, concrete pad and protective fencing (integrated with switchyard fence).

Assumptions

Estimated on the basis of 120 m² (10 m by 12 m) area with two transformers.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$204	Finish Year	2033
Material Cost	\$4,540	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$4,744		
Allowance	\$1,186		
Total Cost	\$5,930		

VISITORS CENTRE

580.40.50.250

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a fully equipped visitors' centre. The visitors' centre will include office space for the administration staff, exhibition or display room, photograph areas, meeting rooms for groups, change rooms, cafeteria and operation staff. The various building mechanical and electrical equipment will be located on the main floor.

Deliverables

Fully equipped single storey visitors' centre (1,100 m² foot print).

Assumptions

Building size based on space for 15 staff and 50 visitors in a meeting room and 40 people in small conference rooms. Includes furnishings and equipment for kitchen, theatre, restaurant and exhibition room. Compliance with National Building Code.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$718	Finish Year	2033
Material Cost	\$8,038	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$8,756		
Allowance	\$2,189		
Total Cost	\$10,945		

AUXILIARY OFFICE BUILDING

580.40.50.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of the Auxiliary Building. This facility will include offices, change house and mine dry for DGR personnel, space for campaign mining personnel.

Deliverables

Two-storey Auxiliary Building without basement with 1,140 m² foot print & total floor area of 2,280 m². Based on similar structures for existing and planned/proposed nuclear power facilities in Ontario.

Building composition similar to Administration Building and other surface facilities for personnel.

Roof: Insulated protected membrane roofing on metal deck.

Exterior walls: Preformed insulated wall metal panels. Insulated masonry cavity dado wall to 2.4m above grade.

Internal walls: Concrete block in traffic areas. Gypsum board on metal studs (demountable in office areas)

Floors: Non-dusting hardener treatment applied to areas with exposed concrete. Quarry tile or similar ceramic tile for change rooms, lockers and health physics areas. Vinyl composite tiles in areas requiring higher degree of finish other than exposed concrete. Carpet in office areas.

Ceilings: Exposed structure with fire protection as required in shops area. Suspended gypsum board in areas requiring fire protection and a higher degree of finish other than exposed structure. Suspended acoustic tile in all other areas.

Assumptions

Building size based on assumed occupancy of 80 permanent DGR personnel, and 25 campaign mining personnel on an intermittent basis. Plus 6 crews for remote operation of underground equipment.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$0	Finish Year	2038
Material Cost	\$32,736	Duration	1 years
Other Cost	\$9,563	WBS Type	Fixed
Subtotal	\$42,299		
Allowance	\$10,575		
Total Cost	\$52,874		

QC OFFICES & LABS

580.40.50.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of Quality Control Offices and Laboratory building.

Deliverables

Single-storey building with no basement, 825 m² gross floor area. This facility will include offices and laboratories.

Based on similar structures for existing and planned/proposed nuclear power facilities in Ontario.

Building composition similar to Administration Building and other surface facilities for personnel.

Roof: insulated protected membrane roofing on metal deck.

Exterior walls: Preformed insulated modular metal panels with an integrated curtain wall glazing system.

Internal walls: Concrete block in high traffic areas. Gypsum board on metal studs (demountable type in office areas).

Floors: non-dusting hardener treatment applied to areas with exposed concrete. Quarry tile or similar ceramic tile for washrooms and kitchenette areas. Vinyl composite tiles in areas requiring higher degree of finish than exposed concrete. Carpet in office areas.

Ceilings: Suspended gypsum board in areas requiring fire protection and a higher degree of finish than exposed structure. Suspended acoustic tile in all other areas.

Assumptions

33 m by 25 m; equipment similar to similar existing facilities.

Approximately 45 m² laboratories.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$390
Material Cost	\$5,600
Other Cost	\$0
Subtotal	\$5,990
Allowance	\$1,498
Total Cost	\$7,488

Start Year	2039
Finish Year	2039
Duration	1 years
WBS Type	Step Fixed

GARAGE BUILDING / WAREHOUSE

580.40.50.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a vehicle service garage and warehouse. This facility will include maintenance shops, repair bay, truck wash facility, oil separator and warehouse with a space allocated for hazardous materials storage.

Deliverables

Equipped single storey building, no basement, 1,920 m² total gross floor area.
Garage area of 1024 m² (32 m x 32 m).

Assumptions

Structure to be pre-engineered type steel structure building. Includes garage equipment apportionment for: overhead crane/hoist, vehicle hoist, lube/oil equipment, oil separator, truck wash.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$1,865	Finish Year	2033
Material Cost	\$18,505	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$20,370		
Allowance	\$5,092		
Total Cost	\$25,462		

WALKWAYS/SERVICeways

580.40.50.60

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission covered corridors (all-weather enclosed walkways) 3 m wide and 2.5 m high between specified buildings to facilitate movement of personnel.

Deliverables

Weather protected and fully enclosed grade level pedestrian walkway (corridor).

Assumptions

Composition: steel truss frame system clad with metal siding and roofing to provide weather tight enclosure with fully glazed windows every 15 m and doors with built-in glazing every 50 m.

One Covered Corridor between Administration Building/Cafeteria and Auxiliary Buildings at 30 m.

One Covered Corridor between Auxiliary Building and Used Fuel Packaging Plant at 45 m.

One Covered Corridor between Auxiliary Building and Service Shaft Complex at 90 m.

Includes power, heat-traced water, hose stations, heat and air conditioning, windows, doors.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$1,928	Finish Year	2038
Material Cost	\$1,214	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$3,142		
Allowance	\$785		
Total Cost	\$3,927		

FUEL TANK AREA

580.40.50.70

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of a fuel storage area for two tanks capable of holding a two-week supply for site. Unloading of delivered fuel using fuel transfer pumps, with fuel supply pumps system used to supply end users.

Deliverables

One diesel fuel tank at 105 m3 and one gasoline tank at 25 m3. Diesel tank is field erected. Gasoline tank is horizontal shop fabricated. Containment area will be lined with High Density Polyethylene (HDPE) Liner.

Assumptions

Site designed to NFPA 30 Flammable and Combustible liquids. Diesel tank is 105 m3 and gasoline tank is 25 m3, installed in a high density polyethylene (HDPE) lined containment area of 12 m x 10 m. Includes base, concrete, tanks, two pumping systems, interconnections, piping, heat tracing, manifolds and instrumentation. Pricing developed with input from ZCL Composites.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2041
Labour Cost	\$542	Finish Year	2041
Material Cost	\$628	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,170		
Allowance	\$292		
Total Cost	\$1,462		

SECURITY CHECKPOINTS

580.40.50.80

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construction and commissioning of security buildings and access control points.

This work element was originally referred to as "Fire Hall/Security Building" - Fire hall and equipment is now included in the Administration Building, .40.50.20. Admin building also accommodates central security offices]

Deliverables

Two 8 m x 10 m security buildings (with associated double gates and radiation monitors), one access control point (with gate, biometrics and radiation monitors), two 4 m x 6 m security booths (with gates, biometrics and radiation monitors). Also includes two explosive detectors and four metal detectors as well as a specialized security monitoring room/crisis centre in the Administration Building.

Assumptions

Costing includes turn-key buildings and security monitoring room within administration building. Gates, power, monitoring devices and installation accounted for.

Does not include costing for fence (see .40.20, "Site Improvements") or firehall, fire training facility and fire trucks (.40.50.20, "Administration Building").

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2041
Labour Cost	\$1,340	Finish Year	2041
Material Cost	\$8,238	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$9,578		
Allowance	\$2,394		
Total Cost	\$11,972		

EMERGENCY POWER GENERATION

580.40.50.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Construct and commission a powerhouse building with emergency power generation equipment.

Deliverables

Single story building, 800 m2 area, with 30 m2 fuel storage pad.

Constructed of concrete block with insulation and cladding.

Steel frame roof with insulation.

Three diesel generators

Electrical tie-ins to main camp facilities.

Assumptions

Emergency power requirement based on 10% of anticipated total facility requirements.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$4,668	Finish Year	2033
Material Cost	\$10,735	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$15,404		
Allowance	\$3,851		
Total Cost	\$19,255		

MAIN SHAFT AND HEADFRAME

580.40.60.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Construction and commissioning of a shaft and associated infrastructure to convey transfer package from surface to a depth of 500 m underground.

The work will include the following components: Erection of a permanent headframe, set-up of surface plant, sinking a 7.0 m (finished internal) diameter, concrete lined (0.5 m thick) shaft, change-over from sinking to handling of used fuel in UFCs Waste Shaft hoist installation.

Deliverables

A functional 500 m deep shaft of 7 m finished internal diameter complete with required services and accessories for transfer of used fuel in UFCs.

Assumptions

Shaft sinking will utilize the permanent headframe. The collar is 35 m in depth. The shaft is nominally 500 m in length, however the shaft depth was assumed to be approximately 532 m to allow for the overwind/underwind required for safety concerns.

Exclusive of contingency.

Allowance

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2034
Material Cost	\$0	Duration	2 years
Other Cost	\$137,989	WBS Type	Fixed
Subtotal	\$137,989		
Allowance	\$34,497		
Total Cost	\$172,486		

EXHAUST VENTILATION SHAFT AND HEADFRAME

580.40.60.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Construction and commissioning of the Exhaust Ventilation Shaft to provide the DGR's main ventilation exhaust capacity. To comprise: Erecting a temporary headframe for sinking. Setting up temporary sinking hoists. Sink a 7.0 m internal diameter, concrete lined (0.5 m thick) shaft. Install temporary waste rock skipping facilities for initial 1.5 years, prior to the Service Shaft skipping being available. Install associated equipment.

Deliverables

A functional 512 m deep x 7.0 m finished internal diameter shaft complete with required services and accessories.

Assumptions

The temporary headframe is 30 m in height. The collar is 35 m in depth. The shaft is nominally 512 m in length. The permanent Exhaust Ventilation Shaft Headframe will remain through operations and extended monitoring phases. Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2035
Labour Cost	\$0	Finish Year	2036
Material Cost	\$0	Duration	2 years
Other Cost	\$103,524	WBS Type	Fixed
Subtotal	<i>\$103,524</i>		
Allowance	\$25,881		
Total Cost	\$129,405		

VENTILATION SYSTEM

580.40.60.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

This WBS covers the cost of the primary ventilation system on surface and underground. The cost of the auxiliary systems (2) are covered under WBS 580.40.10.30.20.80 UG Infrastructure Installations & Construction.

Deliverables

The major elements in the deliverables include, fans, major ducting systems, surface standby HEPA filter systems for exhaust airflow, doors, airlock systems, etcetera for the following locations: Surface at Service Shaft - fresh air intake fans and heaters Underground at Exhaust Ventilation Shaft - main exhaust booster fans Booster fans for each of the primary ventilation circuits on the exhaust side: Northeast loop Northwest loop Southwest loop South loop Main UDF Area Services Area circuits: Early UDF / Exhaust Ventilation Shaft to Service Shaft connector tunnel Mobile equipment shop Main Shaft UFC Cask parking area and shaft loop East Access Tunnel (past the main sumps) flow through loop Loading pocket loop Service Shaft bottom

Assumptions

The ventilation system was designed to meet the minimum airflow velocity requirements for battery powered equipment. It was also significantly modified due to the change to the Adaptive Layout versus the Reference Design Layout. Preliminary thermal modeling indicated that a cooling system would not be required for the summer months.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2035
Material Cost	\$0	Duration	3 years
Other Cost	\$79,069	WBS Type	Step Fixed
Subtotal	\$79,069		
Allowance	\$19,767		
Total Cost	\$98,836		

EARLY & MAIN UDF

580.40.60.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Underground excavation to accommodate the early and main Underground Demonstration Facility (UDF). These excavations comprise the following:

Electric Sub-Station
Special Equipment Storage
Instrumentation Shop
Drifts
Early UDF #1 to #5
Early UDF #6, #7 and #8
Drifts to Main UDF area

Deliverables

Excavations to accommodate the early and main Underground Demonstration Facility.

Assumptions

All-inclusive pricing per linear metre of mine development as per Golder costing model. Note that per unit (\$/m) are worked up from individual crew components and are different between crystalline and sedimentary mine development. Pricing includes waste rock delivered and spread at waste rock pile.

Electric Sub-Station (6m x 5m): 15 metres
Special Equipment Storage (7m x 4m): 39 metres
Instrumentation Shop (5m x 4m): 30 metres
Drifts (6.5m x 5m): 122 metres
Early UDF #1 to #5 (3.2m x 2.4m): 136 metres
Early UDF #6, #7 and #8 (3.2m x 2.4m): 115 metres
Drifts to Main UDF area (5m x 5m): 393 metres
Main UDF Tunnel (9m x 4m): 381 metres
Main UDF Rooms (3.2m x 2.4m): 2100 metres

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$12,263
Material Cost	\$5,377
Other Cost	\$1,204
Subtotal	\$18,844
Allowance	\$4,711
Total Cost	\$23,555

Start Year	2036
Finish Year	2038
Duration	3 years
WBS Type	Fixed

ACCESS TUNNELS

580.40.60.60

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavation of the Access Tunnels comprising the DGR's panel access ways. The excavation of these tunnels will be by full face drill and blast technique employing control perimeter blasting to minimize creation of an EDZ. Access Tunnels will be 9.0 m width by 4.0 m height. Cross-cuts and Refuge Stations will be of 5.0 m width by 5.0 m height, and Electrical Substations will be 6.0 m width by 5.0 m height.

Deliverables

12,905 m of new tunnels comprising the DGR's panel access ways. 2,737 m of cross cuts and refuge stations. 437 m of electrical substations.

Assumptions

All-inclusive pricing for per linear meter of mine development as per previous estimate costing model. Note that per unit (\$/m) are worked up from individual crew components and are different between crystalline and sedimentary mine development. Pricing includes waste rock delivered and spread at waste rock pile. Per linear meter costs include conduit, etc. Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$102,073	Finish Year	2041
Material Cost	\$48,834	Duration	4 years
Other Cost	\$8,146	WBS Type	Step Fixed
Subtotal	\$159,053		
Allowance	\$39,763		
Total Cost	\$198,816		

ROOM EXCAVATION PANEL 1 - INITIAL PANEL

580.40.60.70

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the first panel of placement rooms (Panel 1 – 24 placement rooms). Excavation will proceed from the south end of Panel 1 (Arm 'C') towards the north end of the panel.

Deliverables

Construction of 24 placement rooms (6915.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 1 Rooms (3.2 m W x 2.4 m H): 6915 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2040
Labour Cost	\$37,998	Finish Year	2042
Material Cost	\$6,835	Duration	3 years
Other Cost	\$2,073	WBS Type	Step Fixed
Subtotal	\$46,906		
Allowance	\$11,726		
Total Cost	\$58,632		

FACILITY ELECTRICAL DISTRIBUTION

580.40.70.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Design, construction, installation and commissioning of the electrical system throughout the DGR.

Deliverables

Primary distribution , including medium voltage switchgear, power distribution transformers, low voltage switchgears and motor control centres.

Assumptions

Includes:

- On-site power distribution hydro poles every 25 m (200 poles)
- Med voltage 13 kv cabling on site line coverage (5,000 m)
- Step-down 13.8 kv transformers (40 units – pad mounted, incl. enclosures, locks)
- Interconnects, switch gear, finishing, fire extinguishers, etc.

Verbal quote received from America Wire of Michigan for electrical cable.

Main power supply including 25 km O/H transmission line included in .40.20 (Site Improvements). Powerhouse, emergency diesel-generators and associated equipment under 40.50.90. Underground distribution included in per-metre development costs and in outfitting/finishing costs for specific underground components.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2037
Labour Cost	\$3,684	Finish Year	2037
Material Cost	\$8,323	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$12,007		
Allowance	\$3,002		
Total Cost	\$15,009		

580.40.70.10

FACILITY COMMUNICATION SYSTEM(S)

580.40.70.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: W. Palmer

Organization: SNC-Lavalin

Description

Design, installation and commissioning of DGR communication system on surface.
Auxiliary building will require expansion by 200 m2.

Deliverables

Communication system to include: Telephone and radio communication systems. Public address system, Clock system, Security system, Fire alarm system.
Remote operation for underground placement room activities where remote operation is necessary.

Assumptions

All process instrumentation and control systems are included:

- Data communication links and inter connections (5,500 m, incl. shielded cable)
- Full data collection system and phone system
- Miscellaneous boxes and software

Routing of power cable along power pole covered under .40.70.10

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2037
Labour Cost	\$578	Finish Year	2037
Material Cost	\$0	Duration	1 years
Other Cost	\$21,025	WBS Type	Step Fixed
Subtotal	\$21,603		
Allowance	\$5,401		
Total Cost	\$27,004		

FIRE WATER

580.40.70.30.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Install buried high density polyethylene (HDPE) pipeline across DGR site including hydrants and connected to fire water pumps located inside water treatment plant building. Pipes will be buried below the frost line. Hydrants are strategically located around the site to ensure all buildings are provided access and fire protection.

Deliverables

Dedicated fire water pipeline, hydrants, and fire water pump package including electric, diesel, and jockey pumps plus controls and test header.

Assumptions

Fire water will be supplied from raw/fire water tank on DGR site. Frost depth is 2 m. System design based on NFPA guidelines.

Includes:

- Main water distribution pumps (125 HP, 1200 usgpm, electrical and diesel)
- Jockey pump (10 hp)
- Electrical, diesel and water tie-ins
- Diesel day tank (5000 litres)
- Fire hydrants (35)
- Underground pipe (1,500 m)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$844	Finish Year	2038
Material Cost	\$403	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,246		
Allowance	\$312		
Total Cost	\$1,558		

POTABLE WATER

580.40.70.30.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission a potable water system to serve buildings constructed as part of the DGR facility. Potable water will be distributed through buried pipelines to each building. Pipes will be buried below the frost line.

Deliverables

Buried high density polyethylene (HDPE) water main including isolation valves. Main will distribute potable water to surface buildings.

Assumptions

Water will be supplied from a local river or lake upstream from the facility from the surface facility's watershed (see 40.50.100, Pumphouse and Intake). A frost depth of 2 m is assumed.

Includes:

- Electrical water distribution pumps (two 15 HP units)
- Water and electrical tie ins
- Isolation valves
- Underground pipe (1,500 m)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$372	Finish Year	2038
Material Cost	\$165	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$537		
Allowance	\$134		
Total Cost	\$671		

PROCESS WATER

580.40.70.30.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission a raw water system to serve buildings constructed as part of the DGR facility and specifically for truckwash operations, cleaning, landscaping, rock crushing, concrete batching and other fresh water operations. Fresh water will be distributed through buried pipelines to each building as required. Pipes will be buried below the frost line.

Deliverables

Water system to distribute fresh water to surface buildings.

Assumptions

Water taken from Raw Water / Fire Water Storage Tank. A frost depth of 2 m is assumed.

Includes:

- Electrical return water pump (two 10 HP units)
- Water and electrical tie-ins
- Underground pipe (crushing plant, pond: 250 m)
- Underground pipe (rock crushing and cement plants: 700 m)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$273	Finish Year	2038
Material Cost	\$181	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$454		
Allowance	\$114		
Total Cost	\$568		

SEWERAGE

580.40.70.30.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission a sewage collection system to serve buildings on site.

Deliverables

PVC gravity sewer network with manholes from serviced buildings to sewage treatment plant.

Assumptions

No abnormal constructions issues/problems. Designed based on site work force of 500 persons under normal operations with capability to cater for a further 75 persons during campaign mining.

Includes:

- Underground conveyance pipe (1,500 m)
- Manholes (20)
- Tie-ins

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$735	Finish Year	2038
Material Cost	\$175	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$910		
Allowance	\$228		
Total Cost	\$1,138		

STORMWATER AND DRAINAGE

580.40.70.30.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Construct and commission a stormwater collection system to serve buildings and parking areas and facilities on site.

Deliverables

Storm water ditching and culverts under road crossings. Stormwater will be diverted to either of the two storm run-off holding ponds on site.

Assumptions

No abnormal construction issues/problems. Designed based on nominal 500-year storm event.

Includes:

- Drainage ditch (7,400 m)
- Corrugated, galvanized steel culverts (15)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$1,517	Finish Year	2038
Material Cost	\$615	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$2,132		
Allowance	\$533		
Total Cost	\$2,665		

BREATHING AIR

580.40.70.40.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Design, procure, install and commission a compressed air system for breathing air both for surface and underground use.

Deliverables

Breathing compressed air supply and distribution systems to UFPP and other surface facilities. Breathing Air at 0.15 m³ /s (~300 cfm) surface and underground supplied by 2 compressors each supplying 0.15 m³ /s (~300 cfm)@ 700 kPa .

Assumptions

Breathing Air requirements to be at 0.15 m³ /s . Verbal quote received from Atlas Copco Mississauga Ontario. Includes:

- Breathing air supply units (0.15m³/s @ 700 kPa, one on-line, one standby)
- Distribution system (1500 m, includes interconnections, building piping, headers, filtration, manifolds)

Shared service building included under .40.70.40.20 (Service Air).

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$675	Finish Year	2038
Material Cost	\$2,142	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$2,817		
Allowance	\$704		
Total Cost	\$3,521		

SERVICE AIR

580.40.70.40.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Hagen

Organization: SNC-Lavalin

Description

Design, procure, install and commission a compressed air system for service air both for surface and underground use. Work includes building to house both service air and breathing air equipment.

Deliverables

Service compressed air supply and distribution systems to UFPP and other surface facilities. Service compressed air supply and distribution systems to the DGR construction and operation phases. Service Air at 1.0 m³ /s (~2,100 cfm) surface and underground supplied by 3 rotary screw type compressors each supplying 0.5 m³ /s (~1,050 cfm)@ 900 kPa . Concrete block construction with insulation and cladding. Steel frame roof with sprayed insulation.

Assumptions

Service air requirements to be at 1.0 m³ /s . Verbal quotation for equipment received from Atlas Copco of Mississauga Ontario.

Includes:

- One storey 20 m by 15 m building (300 m², furnished and equipped)
- Service air supply units (0.5m³/s @ 900kPa, rotary screw units, two on-line, one on standby)
- Distribution system (1500 m, includes interconnections, building piping, headers, filtration, manifolds)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2038
Labour Cost	\$829	Finish Year	2038
Material Cost	\$5,653	Duration	1 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$6,483		
Allowance	\$1,621		
Total Cost	\$8,103		

DIRECT OPS MANAGEMENT (INC QA)

580.45.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Wilson

Organization: NWMO

Description

Management and administrative functions covering the day-to-day operation of the DGR facility during the operations phase

Deliverables

DGR-based organization which delivers facility engineering, human resources/human development, external affairs, accounting, procurement, security, emergency response, compliance and licensing, conventional health and safety, health physics, quality assurance, information technology and environmental management.

Assumptions

Management numbers determined on the basis of the staffing plan for site (2043 to 2088, inclusive).

Includes management and engineering as follows:

- Senior Management (8FTE)
- Management Staff (12 FTE)
- Support Staffing (90 FTE)

Line staff for procurement, environmental management, security, fire, housekeeping, etc. are included under 580.45.30 (Operations Indirects). Line staff for maintenance are included under 580.45.40.40 (O&M of Auxiliary Surface Facilities).

Mine development, UFC placement, UFPP operations, SMCP, and aggregate plant operations (including supervision and incidental engineering) not included in this element. Such costs are accounted for in, for example, .45.40.10 (UFPP Operation) and .45.50.60.10 (Backfill Material (SMCP & Concrete), 45.50.60.20 (Engineering Barrier Emplacement Equipment) and .45.50.60.30 (Placement Labour).

NWMO burdened labour rates (and available annual hours) used to construct expenditure estimate. Estimated on a labour basis - related building services/equipment, etc., not included in this work element.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$535,854
Material Cost	\$0
Other Cost	\$0
Subtotal	\$535,854
Allowance	\$133,964
Total Cost	\$669,818

Start Year	2043
Finish Year	2088
Duration	46 years
WBS Type	Step Fixed

OPERATIONS INDIRECTS (INC FIRE & SECURITY)

580.45.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Wilson

Organization: NWMO

Description

Indirect labour and equipment required to operate the DGR facility during the Facility Operations phase of the project (2043 to 2088), excluding the indirect labour and equipment provided for during underground excavation, for O&M of auxiliary facilities (580.45.40.40) and during extended operations phase (580.45.50.130).

Deliverables

The provision of the following indirect labour and equipment to operate the DGR facility during the Facility Operation stage:

- Security staff including management, administration, 24 hour cover and armed response capability
- Medical staff including paramedics and nurses
- Cleaning personnel including management, building and infrastructure cleaners, waste collection

Assumptions

Based on staffing as follows:

Visitor Centre Staff (4 FTE)

Management (11 FTE)

Common Services (20 FTE)

Conventional and Radiological Safety (38 FTE)

Fire Response and Security (80 FTE)

Janitorial and Support Services (20 FTE)

Includes allocation for fire and security equipment with on-going refurbishment or replacement.

NWMO staff pay rates include for sickness benefit, pension contributions, holidays and training therefore these items are not considered as indirect overhead costs.

Mine rescue assumed to be covered by other staff with suitable specialist training.

Dedicated firecrew numbers limited with duties to include supervising and training other DGR staff.

Excludes the indirect labour and equipment provided for during underground excavation, for O&M of auxiliary facilities (cf. 45.40.40) and during extended operations phase (cf. 45.50.130). Also excludes taxes (such as HST), heat and power.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

580.45.30

	2020K\$
Labour Cost	\$752,744
Material Cost	\$0
Other Cost	\$4,570
Subtotal	\$757,314
Allowance	\$189,328
Total Cost	\$946,642

Start Year	2043
Finish Year	2088
Duration	46 years
WBS Type	Step Fixed

SUPPLY OF BASKETS AND UFCS

580.45.40.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: C. Boyle

Organization: NWMO

Description

Supply, packaging and delivery of the required number of Used Fuel Containers (UFCs) and UFC baskets during the operational period.

Deliverables

Supply of 2,500 UFCs per year over the 46 year operational period (total ~115,000 UFCs).

- Reusable packaging for UFCs and baskets.
- Transport of UFCs and baskets from assembly plant to DGR facility.

Assumptions

Assume costs distributed uniformly on an annualized basis for a duration of 46 years.

A total cost per UFC of C\$36,224 has been estimated. The UFC is made of a steel vessel and has a 3 mm copper coating over the steel using electro-deposition and cold spray techniques. The steel vessel is made of a steel core, internal baskets, and closure welds. The major cost components are as follows:

Steel Vessel- C\$21,428 per UFC.

Copper Coating- C\$7,544 per UFC.

Transportation- C\$112 per UFC.

Allowance (assumed at 25%)- C\$7,245 per UFC.

The steel core and internal baskets used a median estimate of three commercial estimates to derive the Mark 2 UFC unit cost estimate. Labour, facility and equipment costs associated for the closure weld consumables are accounted for in the Used Fuel Packing Plant (UFPP) estimate (WED# 580.45.40.10).

For copper coating, the estimates assumed a unit cost of \$9.89/kg (2020\$) assumption used for the cost of copper.

Labour, facility and equipment costs associated for the copper cold spray are accounted for in the UFPP estimate (WED# 580.45.40.10).

Transportation costs provided in this UFC cost estimate are all-inclusive for the transportation of the empty UFCs from the site of manufacture to the UFPP located at the APM DGR site using 2014 shipping rates escalated to 2020\$. Transportation does not include any movement of used fuel.

UFCs and baskets will be manufactured and assembled off-site and shipped to the DGR as a completed item.

Licensing and approvals sought from relevant authorities will be obtained without significant delay to the agreed schedule.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2087
Material Cost	\$0	Duration	45 years
Other Cost	\$3,332,594	WBS Type	Variable
Subtotal	\$3,332,594		
Allowance	\$833,148		
Total Cost	\$4,165,742		

O&M OF AUXILIARY SURFACE FACILITIES

580.45.40.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Wilson

Organization: NWMO

Description

Operation and maintenance of all surface buildings and associated facilities for the DGR.

Deliverables

Maintenance staff including civil, mechanical and electrical maintenance.

Annual electrical power, including UFPP (but excluding hoists, ventilation, aggregate plant, concrete plant and SMCP, which are accounted for in mining costs and in UFC placement costs).

Allocation for the maintenance and management of fixed assets not otherwise covered (i.e., other than for mining equipment, UFC placement equipment, SMCP equipment and UFPP equipment).

Assumptions

Staffing includes a maintenance crew of 40. Crew load accounts for general maintenance, water treatment, sewage treatment, switchyard/transformers, active liquid waste treatment, low level waste storage, etc. Electrical includes building HVAC, heat, power and light (47,404,784 KWh). Allocation of \$12M/annum accounts for asset management and maintenance activities and materials.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$174,938	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$681,436	WBS Type	Step Fixed
Subtotal	\$856,374		
Allowance	\$214,094		
Total Cost	\$1,070,468		

HOIST ROPE REPLACEMENT

580.45.50.100

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Replacement of the ropes in the Service Shaft and Main Shaft as often as every three years. Set-aside for replacement of the Exhaust Ventilation Shaft rope (auxiliary hoist) (not scheduled for routine use) as often as every nine years.

Deliverables

Replacement hoist ropes: hoists ready for use.

Assumptions

Stretch and deterioration of the ropes used in hoisting results in the requirement to replace a complete set of ropes every three years. Therefore, an allowance of 33% of the original purchase price of the hoisting ropes for the Main and Service Shafts is applied annually for the hoisting life of the project.

The Exhaust Ventilation Shaft hoist is not scheduled for routine use; emergency hoist capacity in the Exhaust Ventilation Shaft will be maintained.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2035
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	54 years
Other Cost	\$18,700	WBS Type	Step Fixed
Subtotal	<u>\$18,700</u>		
Allowance	<u>\$4,675</u>		
Total Cost	\$23,375		

INDIRECTS FOR FINAL PANEL UFC PLACEMENT

580.45.50.110

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: RPC

Organization: SNC-Lavalin
Nuclear

Description

Underground indirect costs for placement of UFCs in the final panel (Underground indirect costs are built into EPC-basis mine development per metre costs; this work element covers indirects for the brief period of UFC emplacement in the final panel when development is not proceeding on a per metre basis elsewhere in the repository).

Deliverables

Support for underground operations.

Assumptions

Indirects for periods w/o drilling/blasting derived from previous estimate mine development cost model to include:

- Lifts and trucks
- Fuel & Lube Vehicles
- Sanitary Vehicle
- Ventilation and water pumping
- Mine Lights & Chargers
- Shop Tools
- Safety Gear
- Mine Superintendent
- Safety Coordinator
- Administrative functions (Clerk, Shifter etc.)
- Maintenance General Foreman and staff
- Chief Engineer

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$0
Other Cost	\$62,130
Subtotal	\$62,130
Allowance	\$15,533
Total Cost	\$77,663

Start Year	2082
Finish Year	2088
Duration	7 years
WBS Type	Variable

MINING HEAT AND POWER

580.45.50.120

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Mine heating and electrical costs (other mining indirects are incorporated in EPC-basis per metre underground development costs).

Deliverables

Support for underground operations.

Assumptions

Key scope notes:

Ventilation fan power is estimated with the Ventilation scope.

Lateral development mobile equipment power cost is built into the unit advance rate.

Power for UFC Placement Equipment is excluded - Estimate of this is by NWMO.

Note: the following items are estimated for the three major stages of the DGR lifecycle:

Construction

Operations

Monitoring

UG Installed Equipment & General Power Loads:

UG Main Mobile Equipment Maintenance Shop

UG Millwright Shop

UG Electricians Shop

UG Small Battery Repair Shop

UG Main Refuge Station

UG Placement Arm Refuge Stations

UG SA Office & Lunch Room

UDF Area - Lighting

SA Area - Lighting

Placement Arm - Lighting

UG Rock Breaker Station

UG Loading Pocket Installation

Hoisting Equipment Power:

Main Shaft - Main Cage

Service Shaft - Service Cage

Service Shaft - Skips

Service Shaft - Auxiliary Cage

Exhaust Ventilation Shaft - Auxiliary Cage

Main Shaft Headworks - Allowance

580.45.50.120

Service Shaft Headworks - Allowance
 Exhaust Ventilation Shaft Headworks - Allowance

Auxiliary Ventilation Fans:
 Large Heading Development
 Placement Room Header System - Full Panel Development
 Placement Room Individual Fans - Construction Period Boundary Rooms

Battery Powered Mobile Support Equipment:
 Grader - M116
 Personal Carrier - Miller Truck 8200
 Lube Truck - Miller Truck 8200
 Shotcrete Sprayer - 30 cu m/hr (spray ht = 17m)
 Transmixer - TM3
 Boom Truck Shaft Station - A64 Boom 2-1300
 Electricians Truck - Miller Truck 8200 manbasket

Dewatering Power:
 Main Sump - Dewatering Pumps
 Main Sump - Agitators
 Shaft Bottom - Sump Pumps
 Placement Arm - Sump Pumps

Miscellaneous Demand:
 Surface Air Compressors (for UG Supply)
 Allowance for Other Loads

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	56 years
Other Cost	\$639,489	WBS Type	Variable
Subtotal	\$639,489		
Allowance	\$159,872		
Total Cost	\$799,361		

EXTENDED OPERATIONS (INC SUPPORT SERVICES)

580.45.50.130

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Wilson

Organization: NWMO

Description

Operation and management of the DGR facility for 70 years (2089 to 2158, inclusive) following the completion of UFC emplacement operations. Tasks to include monitoring and preservation of key surface and underground facilities, monitoring the geotechnical integrity of the DGR, collection and maintenance of monitoring records, and preparation of the application for regulatory approval to close the DGR.

Deliverables

DGR-based organization which maintains the NWMO structures, facilities, and knowledge base over the extended monitoring period in advance of decommissioning and closure.

Asset management to maintain DGR infrastructure and surface facilities integrity over the 70-year monitoring period.

Assumptions

The DGR site infrastructure, surface buildings and underground works will be held in a care and maintenance regime for 70 years (extended operations) following the completion of UFC emplacement operations.

Staffing assumptions include for the following:

Facility oversight and management (7 FTE)
Conventional and Radiological Safety (7 FTE)
Common Services and Administration (9 FTE)
Engineering and Technical Support (4 FTE)
Maintenance and Janitorial (8 FTE)
Security Guard (20 FTE)

Surface facility maintenance accounted for in an asset management expenditure of \$4.6M/annum.

Power provided at an average annual consumption of 36M KWhr/yr.

Placeholder for annual taxes or payments in lieu of taxes carried at \$300K per annum.

Maintenance crew, hoist rope replacement and associated costs are addressed in element .45.50.140 (EXTENDED OPERATIONS EQUIP REPLACE/REFURB/MAINTAIN)

No specific line items included for other taxes (HST), insurance, engineering and surveying supplies, maintenance supplies, fire protection equipment, safety and first aid equipment, mine rescue supplies, training (rescue, fire, medical.). Operating pickups, loaders, forklifts, small tools and shop supplies. IT systems lease and

580.45.50.130

supply and periodic upgrade, vehicle purchase and leasing, special clothing, stores, spares and consumables including general stores, building materials and plant maintenance spares.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2089
Labour Cost	\$431,760	Finish Year	2158
Material Cost	\$0	Duration	70 years
Other Cost	\$474,459	WBS Type	Step Fixed
Subtotal	\$906,219		
Allowance	\$226,555		
Total Cost	\$1,132,774		

EXTENDED OPERATIONS EQUIP REPLACE/REFURB/MAINTAIN

580.45.50.140

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: L. Hwozdyk

Organization: Hwozdyk Inc.

Description

Maintenance of the DGR facility for 70 years following the completion of UFC emplacement operations in conjunction with the corporate function defined in element 580.45.50.130.

Deliverables

The ongoing maintenance and refurbishment of the DGR infrastructure and surface facilities to ensure their continued operability and integrity against the prevailing environment.

Assumptions

The DGR site infrastructure, surface buildings and underground works will be held in a care and maintenance regime for 70 years (extended operations) following the completion of UFC emplacement operations.

Maintenance functions included in this estimate include 2 full-time (2 shifts) maintenance managers and 12 maintenance personnel. Hoist rope inspection and maintenance for potential use carried forward at 1/10 the applicable rate for the operational period. Small equipment, incidentals and consumables included in the assigned allowance.

580.45.50.130 includes annual asset management allocations for major structural work.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2089
Labour Cost	\$104,791	Finish Year	2158
Material Cost	\$0	Duration	70 years
Other Cost	\$2,274	WBS Type	Step Fixed
Subtotal	\$107,065		
Allowance	\$26,766		
Total Cost	\$133,831		

ROOM EXCAVATION PANEL 5

580.45.50.150

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the eighth panel of placement rooms (Panel 5 – 16 placement rooms). Excavation will proceed from the north end of Panel 5 (Arm 'A') towards the south end of the panel.

Deliverables

Construction of 16 placement rooms (4880.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement. As each room is developed: vent duct, compressed air, water and electrical power will be installed.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 5 Rooms (3.2 m W x 2.4 m H): 4880 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2071
Labour Cost	\$26,816	Finish Year	2074
Material Cost	\$4,823	Duration	4 years
Other Cost	\$1,463	WBS Type	Variable
Subtotal	\$33,102		
Allowance	\$8,275		
Total Cost	\$41,377		

580.45.50.150

ROOM EXCAVATION PANEL 6

580.45.50.160

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the tenth panel of placement rooms (Panel 6 – 15 placement rooms). Excavation will proceed from the north end of Panel 6 (Arm 'A') towards the south end of the panel.

Deliverables

Construction of 15 placement rooms (4575.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 6 Rooms (3.2 m W x 2.4 m H): 4575 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2079
Labour Cost	\$25,140	Finish Year	2082
Material Cost	\$4,522	Duration	4 years
Other Cost	\$1,372	WBS Type	Variable
Subtotal	\$31,033		
Allowance	\$7,758		
Total Cost	\$38,791		

ROOM EXCAVATION PANEL 7

580.45.50.170

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the fourth panel of placement rooms (Panel 7 – 27 placement rooms). Excavation will proceed from the north end of Panel 7 (Arm 'A') towards the south end of the panel.

Deliverables

Construction of 27 placement rooms (7429.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 7 Rooms (3.2 m W x 2.4 m H): 7429 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2053
Labour Cost	\$40,822	Finish Year	2056
Material Cost	\$7,343	Duration	4 years
Other Cost	\$2,227	WBS Type	Variable
Subtotal	\$50,393		
Allowance	\$12,598		
Total Cost	\$62,991		

ROOM EXCAVATION PANEL 8

580.45.50.180

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the eleventh panel of placement rooms (Panel 8 – 25 placement rooms). Excavation will proceed from the north end of Panel 8 (Arm 'B') towards the south end of the panel.

Deliverables

Construction of 25 placement rooms (7475.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 8 Rooms (3.2 m W x 2.4 m H): 7475 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2083
Labour Cost	\$41,075	Finish Year	2086
Material Cost	\$7,388	Duration	4 years
Other Cost	\$2,241	WBS Type	Variable
Subtotal	\$50,704		
Allowance	\$12,676		
Total Cost	\$63,380		

ROOM EXCAVATION PANEL 9

580.45.50.190

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the ninth panel of placement rooms (Panel 9 – 27 placement rooms). Excavation will proceed from the north end of Panel 9 (Arm 'B') towards the south end of the panel.

Deliverables

Construction of 27 placement rooms (8235.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 9 Rooms (3.2 m W x 2.4 m H): 8235 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2075
Labour Cost	\$45,251	Finish Year	2078
Material Cost	\$8,139	Duration	4 years
Other Cost	\$2,469	WBS Type	Variable
Subtotal	\$55,860		
Allowance	\$13,965		
Total Cost	\$69,824		

ROOM EXCAVATION PANEL 10

580.45.50.200

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the seventh panel of placement rooms (Panel 10 – 27 placement rooms). Excavation will proceed from the north end of Panel 10 (Arm 'B') towards the south end of the panel.

Deliverables

Construction of 27 placement rooms (8235.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 10 Rooms (3.2 m W x 2.4 m H): 8235 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2065
Labour Cost	\$45,251	Finish Year	2069
Material Cost	\$8,139	Duration	5 years
Other Cost	\$2,469	WBS Type	Variable
Subtotal	\$55,860		
Allowance	\$13,965		
Total Cost	\$69,824		

ROOM EXCAVATION PANEL 11

580.45.50.210

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the third panel of placement rooms (Panel 11 – 28 placement rooms). Excavation will proceed from the north end of Panel 11 (Arm 'B') towards the south end of the panel.

Deliverables

Construction of 28 placement rooms (7980.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 11 Rooms (3.2 m W x 2.4 m H): 7980 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2047
Labour Cost	\$43,850	Finish Year	2052
Material Cost	\$7,887	Duration	6 years
Other Cost	\$2,393	WBS Type	Variable
Subtotal	\$54,130		
Allowance	\$13,533		
Total Cost	\$67,663		

ROOM EXCAVATION PANEL 12 (ADDITIONAL PANEL)

580.45.50.220

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the twelfth panel of placement rooms (Panel 12 – 6 placement rooms). Location of Panel 12 (Arm) to be determined at a later date. Excavation direction to be determined at a later date.

Deliverables

Construction of 6 placement rooms (1830.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 12 Rooms (3.2 m W x 2.4 m H): 1830 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2083
Labour Cost	\$11,336	Finish Year	2086
Material Cost	\$2,420	Duration	4 years
Other Cost	\$651	WBS Type	Variable
Subtotal	<i>\$14,407</i>		
Allowance	\$3,602		
Total Cost	\$18,009		

ROOM EXCAVATION PANEL 2

580.45.50.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the fifth panel of placement rooms (Panel 2 – 29 placement rooms). Excavation will proceed from the south end of Panel 2 (Arm 'C') towards the north end of the panel.

Deliverables

Construction of 29 placement rooms (8845.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 2 Rooms (3.2 m W x 2.4 m H): 8845 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2057
Labour Cost	\$48,603	Finish Year	2060
Material Cost	\$8,742	Duration	4 years
Other Cost	\$2,652	WBS Type	Variable
Subtotal	\$59,997		
Allowance	\$14,999		
Total Cost	\$74,997		

ROOM EXCAVATION PANEL 3

580.45.50.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the second panel of placement rooms (Panel 3 – 39 placement rooms). Excavation will proceed from the south end of Panel 3 (Arm 'D') towards the north end of the panel.

Deliverables

Construction of 39 placement rooms (11895.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 3 Rooms (3.2 m W x 2.4 m H): 11895 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$65,363	Finish Year	2046
Material Cost	\$11,756	Duration	4 years
Other Cost	\$3,566	WBS Type	Variable
Subtotal	\$80,686		
Allowance	\$20,171		
Total Cost	\$100,857		

ROOM EXCAVATION PANEL 4

580.45.50.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Excavate, furnish and prepare the sixth panel of placement rooms (Panel 4 – 36 placement rooms). Excavation will proceed from the south end of Panel 4 (Arm 'D') towards the north end of the panel.

Deliverables

Construction of 36 placement rooms (10980.0 m in total). Following tunnel excavation the contractor will prepare the floor of the placement rooms to facilitate UFC placement.

Assumptions

The rooms are 3.2 m wide by 2.4 m high, and a maximum 305 m in length. Rooms can be shorter if constrained by offsetting from faults, but shall not be less than a minimum of 150 m in length. The entrance to each room will be perpendicular to the panel access tunnel. The placement rooms will be developed by full face drill and blast techniques, with controlled perimeter blasting to minimize creation of an EDZ. All drilling and muck haulage equipment will be rubber tired. A total of 10 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. Probe drilling will occur every four rounds, and will extend the length of five rounds, creating an overlap of one round. As each room is completed the ventilation fan will be transferred to the next room to be developed.

- Panel 4 Rooms (3.2 m W x 2.4 m H): 10980 metres

Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2061
Labour Cost	\$60,335	Finish Year	2064
Material Cost	\$10,852	Duration	4 years
Other Cost	\$3,292	WBS Type	Variable
Subtotal	\$74,479		
Allowance	\$18,620		
Total Cost	\$93,099		

BACKFILL MATERIAL (SMCP & CONCRETE)

580.45.50.60.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: I. Ahmed

Organization:

Golder
Associates Ltd.

Description

Emplacement of all sealing materials and UFCs within the underground placement rooms, together with the construction of the emplacement room bulkhead seal. This activity also includes the transfers of all personnel and materials to and from the placement rooms.

Deliverables

Material directly relating to the emplacement of UFCs which are involved in such tasks as:
Personnel and material transfers to / from emplacement rooms including main and service shaft operation:
Placement of compacted levelling layer;
Placement of buffer blocks containing the UFCs;
Placement of highly compacted bentonite (HCB) spacer blocks;
Placement of gap fill material (GFM); and
Backfill and re-staging to accept the next UFC.

Assumptions

UFC buffer boxes containing the Mark 2 UFC are placed 90 degrees to the length of the placement room. HCB spacer blocks are placed adjacent the UFC buffer boxes. There are two rows of UFC buffer blocks and these are placed in an alternating pattern with the HCB spacer blocks. The lower layer of HCB spacer blocks and UFC buffer blocks rest on top of a compacted levelling layer. Bentonite GFM is used to fill the remaining voids in the placement room.

Bentonite GFM and HCB spacer blocks for backfilling the placement room and UFC buffer boxes for UFC encapsulation are produced at the SMCP. Bentonite GFM and HCB spacer blocks are then transported to the repository level; UFCs are placed inside the UFC buffer box at the UFPP and then transported to the repository level in a shielded transfer cask.

Placement estimates take into account buffer box rejection. Based on 2500 UFC installations in the DGR annually, a rate of about 50 UFCs installations per week is required. Considering the weekly UFC placement rate, then the rate of placement room advance can be translated to 33 m based on 50 UFCs centre to centre spacing. On a weekly basis, 50 complete UFC buffer boxes, translates to 200 pieces of UFC buffer box components and about 140 tonnes of bentonite GFM.

Following setting up the room for placement of the initial UFC, it has been estimated that the total sequence for placing and backfilling a single UFC will take about 22 hours, including a 20% allowance.

Exclusive of contingency.

580.45.50.60.10

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$1,306,074	WBS Type	Variable
Subtotal	<i>\$1,306,074</i>		
Allowance	\$326,518		
Total Cost	\$1,632,592		

ENGINEERED BARRIER EMPLACEMENT EQUIPMENT

580.45.50.60.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Boyle

Organization: NWMO

Description

Emplacement of all materials into the Placement Room, EDZ Room and Concrete Bulkhead that includes Buffer Boxes containing the UFCs, Spacer Blocks, Bentonite Gap Fill Material, Bentonite Bricks and Concrete. These activities also take account the transfer of all equipment and materials from the UFPP / main hoist surface and underground storage to the placement rooms.

Deliverables

Equipment directly relating to the placement and material handling of Buffer Boxes with Spacer Blocks from the UFPP and main hoist surface to / from the placement rooms and the underground storage. that include:

- Positioning of the Shielding Canopy;
- Transfer of Buffer Box from UFC Transfer Cask to Placement Vehicle;
- Placement of Buffer Box;
- Placement of Bentonite Spacer Block;
- Placement of Bentonite Gap Fill Material, as required;
- Removal of Floor Plates;

These activities are carried out approximately 2,500 times per year, with a total of 115,000 UFCs placed over the 46-year operations period. Further deliverables during UFC emplacement include the supply and installation of major replacement capital equipment and routine maintenance.

Equipment directly relating to the placement and material handling of EDZ Room (Seal Room) with Spacer Blocks and Bentonite Bricks from the main hoist surface to / from the EDZ Room.

Equipment directly relating to the placement and material handling of Concrete Bulkhead from the underground main hoist to / from the Concrete Bulkhead.

Assumptions

Costing is based on full set of UFC Placement Room equipment with a replacement rate of once over 46 years and yearly maintenance rate.

UFC Transfer Cask

Trolley for UFC Transfer Cask

Shielding Canopy

Shielding Canopy Trolley

Hydraulic Cylinder Cart

Placement Vehicle

Bentonite Spacer Block Trolley

Bentonite Gap Fill Material Delivery System

Floor Plate Handling System

580.45.50.60.20

Tow Vehicle
 Concrete Mixer Truck
 Underground Hopper
 Concrete Pump
 Concrete Forms
 Exclusive of contingency

Costing includes a 10% allowance and equipment quantities are based on information currently available and engineering judgement.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2088
Material Cost	\$57,870	Duration	46 years
Other Cost	\$62,693	WBS Type	Step Fixed
Subtotal	\$120,564		
Allowance	\$30,141		
Total Cost	\$150,704		

PLACEMENT LABOUR

580.45.50.60.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: C. Boyle

Prepared by: C. Lee

Organization: NWMO

Description

Labour for the emplacement of all materials into the Placement Room, EDZ Room and Concrete Bulkhead that includes Buffer Boxes containing the UFCs, Spacer Blocks, Bentonite Gap Fill Material, Bentonite Bricks and Concrete. These activities also take into account transfer of all equipment and materials from the UFPP / main hoist surface and underground storage to the placement rooms.

Deliverables

Labour effort for the placement and material handling of Buffer Boxes with Spacer Blocks from the UFPP and main hoist surface to / from the placement rooms and the underground storage that include:

Positioning of the Shielding Canopy;

Transport UFC/Buffer Box Transfer Cask from UFPP to entrance of emplacement room;

Transfer of Buffer Box from UFC Transfer Cask to Placement Vehicle;

Placement of Buffer Box;

Placement of Bentonite Spacer Block;

Placement of Bentonite Gap Fill Material, as required;

Removal of Floor Plates;

Re-staging to accept the next Buffer Box.

These activities are carried out approximately 2,500 times per year, with a total of 115,000 UFCs placed over the 46-year operations period. Further deliverables during UFC emplacement include the supply and installation of major replacement capital equipment and routine maintenance.

Labour effort for the placement and material handling of EDZ Room (Seal Room) with Spacer Blocks and Bentonite Bricks from the main hoist surface to / from the EDZ Room that include:

Transfer of Spacer Block to Placement Vehicle;

Placement of Bentonite Spacer Block;

Placement of Bentonite Gap Fill Material, as required;

Removal of Floor Plates;

Placement of Bentonite Bricks;

Placement of Bentonite Gap Fill Material, as required.

Labour effort for the placement and material handling of Concrete Bulkhead from the underground main hoist to / from the Concrete Bulkhead that include:

Transfer of Concrete Mixer Truck;

Placement of Cement.

Assumptions

Labour effort is based on utilizing the full set of Buffer Box/UFC placement equipment.

UFC Transfer Cask

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Trolley for UFC Transfer Cask
 Shielding Canopy
 Shielding Canopy Trolley
 Hydraulic Cylinder Cart
 Placement Vehicle
 Bentonite Spacer Block Trolley
 Bentonite Gap Fill Material Delivery System
 Floor Plate Handling System
 Tow Vehicle
 Concrete Mixer Truck
 Underground Hopper
 Concrete Pump
 Concrete Forms

Exclusive of contingency

It has been estimated that the total sequence for placing and backfilling a single Buffer Box/UFC will take 4.3 hours, including a 20% labour contingency.
 Total labour effort is based on an all-inclusive per UFC emplacement rate.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$306,861	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$0	WBS Type	Variable
Subtotal	\$306,861		
Allowance	\$76,715		
Total Cost	\$383,577		

ENVIRONMENTAL RESPONSE EQUIPMENT

580.55.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Ahmad

Organization: SNC-Lavalin
Nuclear

Description

Procurement, delivery, installation and commissioning of environmental response equipment

Deliverables

Procurement, installation, and commissioning for the following items:

- Environmental Protection Control System (1)
 - Environmental Protection Control System Software (1)
 - Environmental Protection measuring devices (500)
 - Contamination kits (100)
 - Environmental cleaning kits (50)
 - Mobile rapid response units (6)
 - Environmental assessment laboratory (1)
-

Assumptions

Materials Costs Assumptions:

- The cost of materials is based on past experience with OPG & Bruce Power projects
- Cost Estimates for Environmental Protection Control System and Environmental Assessment Laboratory includes installation
- Operating labour, maintenance, refurbishment and replacement covered under on-going operational costs (operations indirects, etc.)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$6,914
Other Cost	\$0
Subtotal	\$6,914
Allowance	\$1,728
Total Cost	\$8,642

Start Year	2042
Finish Year	2042
Duration	1 years
WBS Type	Fixed

RADIOLOGICAL MONITORING EQUIPMENT

580.55.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Ahmad

Organization: SNC-Lavalin
Nuclear

Description

Procurement, delivery, installation and commissioning of radiological monitoring equipment.

The radiological monitoring system will include:

- Passive (badge) personal dosimeters that will be sent offsite for measuring up to four times annually.
- Personal electronic dosimeters for personnel with high probability of being exposed to radiation sources and download terminals.
- Hand and Foot Monitors for personnel leaving higher level Radiation Defined Zone (RDZ) to a lower RDZ.
- Hand-held radiation monitors ("Friskers") to monitor articles leaving higher level RDZ to a lower RDZ.
- Whole Body Monitors and Small Article Monitors for personnel leaving higher RDZ to a lower RDZ.
- Personal Portable Monitor personnel higher level RDZ to a lower RDZ and for personnel leaving the PA into the Public Domain.
- Whole Body Counter for personnel in the health physics program to use annually or quarterly.
- Fixed Area Gamma Monitors (FAGM) to be located throughout the facility for monitoring the local dose rate at places routinely occupied by operating personnel.
- Air radiation Monitors located throughout the facility for measuring the activity of radioactive substances in the atmosphere.
- Radiation Vehicle Monitor, Whole Body Monitor and Small Article Monitor for personnel to be located at the vehicle access point.
- Radiation Portable Vehicle Monitor to be located at the unloading area.
- Radiation, Chemistry and Health Physics laboratory to be located medium RDZ to help personnel with all radiation related issues.
- Radiation Protection Control System that include connections (wired or wireless) to all monitors, computers and dedicated software to ensure all devices are functioning and all alarms are captured and recorded.
- Gas & Kinetic Sampler Monitors to be placed in vent stack to detect if there is any radiological contamination being exhausted from the facility

(Note that this element was formerly named "RADIOLOGICAL BIOSPHERE MONITORING". However, in the current cost estimate, costs for other cost elements include all necessary radiological monitoring. For example, radiation safety and monitoring staff are included in .45.30, Operations Indirects)

Deliverables

Procurement, installation and commissioning for the following items:

- Radiation Protection Control System and software(1)
- Rock Monitor (for excavated rock out-flow & in-flow of backfill materials: 1)

580.55.50

- Dosimetry device (4 per person/per year, 25 persons: 100)
- Electronic Dosimeter device (50)
- Hand and Foot Monitor (5)
- Whole Body Monitor (6)
- Whole Body Counter (2)
- Frisker (articles scanner) (40)
- Fixed Air Monitor (45)
- Mobile Air Monitor (7)
- Fixed Area Gamma Monitor (25)
- Vehicle Monitor (2)
- Vent Stack Gas Monitor (2)
- Kinetic sampler (2)
- Water Monitors (for water in-flow, out-flow & unloading area water out-flow: (4)
- Out-flow Water Monitor (2)
- Portable Monitor (6)
- Chemistry and Health Physics laboratory (1)

Assumptions

Materials Costs Assumptions:

- The cost of materials is based on past experience with OPG & Bruce Power projects
- Cost Estimates for Chemistry and Health Physics laboratory, and Radiation Protection Control System includes installation
- Operating labour, maintenance, refurbishment and replacement covered under on-going operational costs (operations indirects, etc.)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2042
Labour Cost	\$0	Finish Year	2042
Material Cost	\$7,600	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$7,600		
Allowance	\$1,900		
Total Cost	\$9,500		

NON RADIOLOGICAL MONITORING EQUIPMENT

580.55.60

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Ahmad

Organization: SNC-Lavalin
Nuclear

Description

Procurement, delivery, installation, and commissioning of non-radiological air monitoring equipment.

The Air Quality Monitoring system will detect, monitor and record air quality from various site locations.

Air Quality Monitoring system will include specific measuring detectors installed at various locations in the facility that are capable of detecting specific gases and the concentrations of key analytes. Additional parameters like barometric pressure, air temperature, relative humidity, and air velocity will be continuously monitored. A Central Air Monitoring system will be used to integrate the local air quality information and will identify gas concentrations, temperature, pressure & humidity for each area. Local data loggers can provide output signals to energize a suitable local warning devices if required.

Deliverables

Procurement, installation, and commissioning for the following items:

- Central Air Monitoring System and software (1)
- O2 Detectors (25)
- CO2 Detectors (25)
- CO Detectors (50)
- Radon Detectors (25)
- Explosive Gas Detectors (25)
- H2S Detectors (25)
- Fixed Air Monitors (20)
- N2O Detectors (25)
- NO Detectors (25)
- SO2 Detectors (25)
- Alarm sound amplifiers (25)
- Battery powered emergency lights (25)
- Temperature Monitors (50)
- Pressure Monitors (50)
- Humidity Monitors (50)
- Stack Monitors (3)

Assumptions

Materials Costs Assumptions:

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- The cost of materials is based on past experience with OPG & Bruce Power projects
- Cost estimates for central air monitoring system includes installation
- Operating labour, maintenance, refurbishment and replacement covered under on-going operational costs (operations indirects, etc.)

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2042
Labour Cost	\$0	Finish Year	2042
Material Cost	\$2,166	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$2,166		
Allowance	\$541		
Total Cost	\$2,707		

DECOMMISSIONING MANAGEMENT

580.60.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin
Nuclear

Description

NWMO operation and management of the DGR facility for 10 years following the completion of extended operations/monitoring.

The major function of decommissioning management will be the management of decommissioning contracts for the backfill of remaining mine openings and the demolition/salvage of surface facilities.

Note that this element does not include final closure (Y136 to Y150), the anticipated period between the completion of major decommissioning work and obtaining the facility license to abandon.

Deliverables

DGR-based corporate organisation which applies for necessary instruments, lets contracts and manages contract delivery to decommission underground works and major surface facilities.

Assumptions

Staffing plan includes:

- Management (9 FTE)
- Technical (19 FTE)
- Support Services (39 FTE)

Power and utilities provided as approximately \$820K/annum. Other incidentals and consumables allocated to allowance (25%).

No specific allocation for sales taxes (HST), insurance, engineering and surveying supplies, maintenance supplies, fire protection equipment, safety and first aid equipment, mine rescue supplies, training (rescue, fire, medical.), IT systems lease and supply and periodic upgrade, special clothing, stores, spares and consumables including general stores, building materials and plant maintenance spares.

This element encompasses NMWO's own engineering; contractor engineering is accounted for in turnkey (design-build) pricing for individual decommissioning actions.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

580.60.10

	2020K\$	Start Year	2159
Labour Cost	\$85,537	Finish Year	2168
Material Cost	\$1,418	Duration	10 years
Other Cost	\$8,178	WBS Type	Step Fixed
Subtotal	\$95,133		
Allowance	\$23,783		
Total Cost	\$118,916		

ACCESS TUNNELS AND DRIFTS DECOMMISSIONING

580.60.100.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: J. Carvalho

Organization:

Golder
Associates Ltd.

Description

Decommissioning of access tunnels and drifts, Service Area accesses and rooms/shops etc. to comprise:

- Removal of road bed, etc.
- Removal of rock handling equipment.
- Removal of all fuels and lubricants.
- Removal of personnel and material transporting equipment.
- Removal of all infrastructure.
- Backfilling and sealing of all tunnels, drifts and rooms (not placement rooms) comprising the repository and underground shaft complexes.

Deliverables

Tunnels/rooms backfilled with dense backfill - DBF - (70% crushed granite, 25% glacial lake clay and 5% bentonite – density: 2.28 tonnes/m³) up to 75% of the room height/volume. The upper 25% of the tunnels/rooms, will be filled with Gap Fill (100% bentonite chips – density: 1.439 tonnes/m³). Tunnels to be sealed with an assemblage of sealing material blocks placed in conjunction with a concrete bulkhead at regular intervals and/or at structural discontinuities - a total of 51 seals.

Assumptions

Total length of tunnels and rooms to be backfilled to be 26,675 m. Initially the dense backfill - DBF - will be placed utilizing placement, positioning and compaction utilizing load-haul-dump vehicles with suitable rollers. Gap Fill will be placed by pneumatic or augered insertion placement methods. The combined density of the DBF and the Gap Fill will be 2.07 tonnes/m³. The backfill plant will be expanded to meet drift and tunnel backfilling demands. New slick lines will be installed in the shaft to provide the increased backfill production requirements. Access tunnels and drifts backfilled over a period of 10 years based on multi-face working.

Includes:

Dense backfill - DBF, 70% crushed granite, 25% glacial lake clay and 5% bentonite - 399,462 m³

Gap Fill, 100% bentonite chips - 133,154 m³

Concrete bulkhead in Access Tunnel and drifts - 14,244 m³

Removal of fuels and lubricants

Removal and haulage of rail ballast

Removal and haulage of debris (cables, air ducts, drain pipes, etc.)

Removal and transport of salvageable ferrous and non-ferrous materials

Nonferrous metals credit for salvage

Copper from 4160 V / 13.8 kV cable for salvage

Labour rates used include contractor indirects.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2159
Labour Cost	\$44,677	Finish Year	2163
Material Cost	\$203,599	Duration	5 years
Other Cost	\$33,856	WBS Type	Step Fixed
Subtotal	\$282,133		
Allowance	\$70,533		
Total Cost	\$352,666		

SERVICE SHAFT DECOMMISSIONING

580.60.100.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Strip the operational hoists and install a sinking hoist and refurbish the Service Shaft, as required in preparation for decommissioning and backfilling. Incrementally strip and dismantle the Service Shaft and backfill the shaft in a retreat fashion, including the removal of all concrete and damaged rock annulus, then remove headframe, collar house and hoist room.

Deliverables

A backfilled and sealed Service Shaft.

Assumptions

No further requirement to access the underground facility. Upon removal of the concrete and damaged rock annulus, the shaft will be filled with various backfill materials. A new slick line will be installed in the Service Shaft.

A typical shaft seal consists of:

0 – 20 m Low heat high performance concrete (LHHPC) – concrete cap at surface,
20 – 150 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
150 – 170 m LHHPC for concrete bulkhead keyed into rock / overburden to a distance of 0.5 times the original radius of the shaft
170 – 330 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
330 – 380 m Asphalt seal
380 – 480 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
480 – 500 m Concrete monolith - LHHPC

Estimate includes:

- Shaft lining removal
- Reinforced Low Heat High Performance Concrete (LHHPC) - 11,760 m³
- Bentonite and Sand Seal – 23,819 m³
- Asphalt Seal – 3,053 m³
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 690 tonne
- Non-ferrous credit for salvage - 10 tonne
- Hoist credit for salvage (Credit)
- Dismantling of dewatering, electrical, compressed air, water, alarm and IT systems.
- Dismantling of headframe production hoist, service hoist, auxiliary hoist, service crane and ventilation systems.

580.60.100.20

Labour rates used include contractor indirects.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2163
Labour Cost	\$19,798	Finish Year	2165
Material Cost	\$41,755	Duration	3 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$61,553		
Allowance	\$15,388		
Total Cost	\$76,941		

MAIN SHAFT DECOMMISSIONING

580.60.100.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Strip the operational hoist and install a sinking hoist and refurbish the Main Shaft, as required in preparation for decommissioning and backfilling. Incrementally strip and dismantle the Main Shaft and backfill the shaft in a retreat fashion, including the removal of all concrete and damaged rock annulus, then remove headframe, collar house and hoist room.

Deliverables

A backfilled and sealed Main Shaft.

Assumptions

No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shaft will be filled with various backfill materials.

A new slick line will be installed.

A typical shaft seal consists of:

0 – 20 m Low heat high performance concrete (LHHPC) – concrete cap at surface,
 20 – 150 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 150 – 170 m LHHPC for concrete bulkhead keyed into rock / overburden to a distance of 0.5 times the original radius of the shaft
 170 – 330 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 330 – 380 m Asphalt seal
 380 – 480 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 480 – 500 m Concrete monolith - LHHPC

Estimate includes:

- Shaft lining removal
- Reinforced Low Heat High Performance Concrete (LHHPC) - 6,268.7 m³
- Bentonite and Sand Seal – 23,864.3 m³
- Asphalt Seal – 3,059.6 m³
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 473 tonne
- Non-ferrous credit for salvage - 10 tonne
- Hoist credit for salvage (Credit)
- Dismantling of dewatering, electrical, compressed air, water, alarm and IT systems.

580.60.100.30

- Dismantling of headframe production hoist, service hoist, auxiliary hoist, service crane and ventilation systems.

Labour rates used include contractor indirects.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2164
Labour Cost	\$14,913	Finish Year	2166
Material Cost	\$31,227	Duration	3 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$46,140		
Allowance	\$11,535		
Total Cost	\$57,675		

EXHAUST VENTILATION SHAFT DECOMMISSIONING

580.60.100.50

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: C. Imrie

Organization: Hatch

Description

Install a sinking hoist and refurbish the Ventilation Shaft so that the shaft can be back filled in a retreated fashion, including the removal of all concrete and damaged rock annulus, then remove the sinking hoist and headframe. Install a backfill slick line in the Maintenance Area Ventilation Shaft for shaft sealing.

Deliverables

A backfilled and sealed ventilation shaft.

Assumptions

No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shaft will be filled with various backfill materials.

A new slick line will be installed.

A typical shaft seal consist of:

0 – 20 m Low heat high performance concrete (LHHPC) – concrete cap at surface,
 20 – 150 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 150 – 170 m LHHPC for concrete bulkhead keyed into rock / overburden to a distance of 0.5 times the original radius of the shaft
 170 – 330 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 330 – 380 m Asphalt seal
 380 – 480 m 70/30 bentonite / sand shaft seal compacted in-situ and/or highly compacted bentonite blocks
 480 – 500 m Concrete monolith - LHHPC

Estimate includes:

- Shaft lining removal
- Reinforced Low Heat High Performance Concrete (LHHPC) - 7,431.8 m³
- Bentonite and Sand Seal – 22,949.0 m³
- Asphalt Seal – 2,942.8 m³
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 224 tonne
- Non-ferrous credit for salvage - 10 tonne
- Hoist credit for salvage (Credit)
- Dismantling of dewatering, electrical, compressed air, water, alarm and IT systems.
- Dismantling of headframe production hoist, service hoist, auxiliary hoist, service crane and ventilation

580.60.100.50

systems.

Labour rates used include contractor indirects.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2159
Labour Cost	\$15,595	Finish Year	2161
Material Cost	\$38,649	Duration	3 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$54,244		
Allowance	\$13,561		
Total Cost	\$67,804		

SITE CLEANUP (DECOMM)

580.60.130

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Dismantle and dispose of remaining non-building surface infrastructure as part of the completion of decommissioning and preparation for subsequent closure. This work would be performed during the last two years of the decommissioning period. Only an access road would be left, and only to the extent required to support closure activities such as monitoring.

Deliverables

Restored site surface to a state suitable for public use (with the provision that subsurface use be restricted). If required to support closure, a graveled access road would be left in place to access monitoring and power-related equipment.

Assumptions

Cost estimate uses 1.8 Design-Build Surface Labour Full Time Equivalents over a two-year period. DB07 labour rate includes contractor indirects, including equipment and waste disposal.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2167
Labour Cost	\$991	Finish Year	2168
Material Cost	\$0	Duration	2 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$991		
Allowance	\$248		
Total Cost	\$1,239		

DECOMM INDIRECTS (INC HEAT, CONSUMABLES)

580.60.150

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: K. Hojka

Organization: SNC-Lavalin

Description

This work element covers decommissioning indirects not encompassed in turn-key (design-build) labour rates or NWMO host functions (see, e.g., .60.10 Decommissioning Management), such as major utilities.

Deliverables

Contractor plant indirects for decommissioning.

Assumptions

Estimate based on support costs modified from operations phase as follows:

- Mine Heating - \$1,683,000/ year (escalated from 2010\$)
- Surface Building Heat - \$1,110,000/ year (escalated from 2010\$)
- Electricity - \$1,550,000/year (escalated 2010\$)
- Water and Sewerage - \$10,010/year (escalated 2010\$)

Other work elements and the labour rates used for specific decommissioning tasks include all other contractor indirects, such as:

- Waste Disposal
- Telecom/Office Expenses
- Engineering / Surveying Supplies
- Maintenance Supplies
- Safety and First Aid
- Mine Rescue/Fire Safety Supplies
- Operating Equipment (pick up trucks, forklifts)
- Small Tools Allowance

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$2,895
Other Cost	\$40,659
Subtotal	\$43,555
Allowance	\$10,889
Total Cost	\$54,443

Start Year	2159
Finish Year	2168
Duration	10 years
WBS Type	Step Fixed

DECOMM WASTE DISPOSAL

580.60.160

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: RPC

Organization: SNC-Lavalin

Description

Packaging, transport and disposal of itemised conventional waste, very low level waste (VLLW) and low level waste (LLW) resulting from DGR decommissioning activities.

Deliverables

- Containerisation of decommissioning waste arisings.
- Transport of all decommissioning waste arisings from the DGR to suitable disposal facilities.
- Disposal of all decommissioning waste arisings at suitable disposal facilities.

Assumptions

Waste disposal costs include 1130 m3 of low level radioactive waste at \$1,540/m3 over 10 years from the following sources:

- Waste management area - 750 m3
- Used fuel packaging plant - 375 m3

With regards to LLW, the following has been assumed:

- Concrete volumes based on a 25 mm surface layer of each cell within the UFPP, assumed to be LLW. The remaining concrete assumed to be disposed of as conventional waste.
- All stainless steel cladding within cells regarded as LLW
- All equipment within the Fuel Handling Cells will be treated as LLW for disposal purposes
- All equipment within the Basket Cutting Cells will be treated as LLW for disposal purposes
- All equipment that becomes submerged within the Storage Pool will be treated as LLW, the remainder will be treated as conventional waste
- Equipment in Basket and Module receipt cells will be taken as LLW
- Equipment in the Waste Management facility will be treated as LLW
- Equipment in the UFC Receipt Cells will be treated as LLW
- Equipment in all other cells will be treated as conventional waste

Waste disposal costs include 129,779 tonnes of conventional (free-release) waste at \$220/tonne (load/transport/dispose) over 10 years, from the following sources.

- Main (protected area) fence - 45 tonnes
- Perimeter security fence - 225 tonnes

580.60.160

- Pumphouse and intake - 137.5 tonnes
- Water storage tank area - 400 tonnes
- Water treatment plant - 375 tonnes
- Process water settling pond - 50 tonnes
- Service shaft water settling pond - 25 tonnes
- Storm water run-off ponds - 25 tonnes
- Sewage treatment plant - 1075 tonnes
- Waste management area - 12700 tonnes
- Administration building including firehall / cafeteria - 3872 tonnes
- Switchyard - 620 tonnes
- Transformer areas - 685 tonnes
- Auxiliary building - 1830.4 tonnes
- Quality control offices and laboratories - 726 tonnes
- Garage building/warehouse - 4083.2 tonnes
- Security - 625 tonnes
- Emergency power generation - 1200 tonnes
- Facility communication system (s) - 150 tonnes
- Potable water - 10450 tonnes
- Sewerage - 70.4 tonnes
- Service air - 264 tonnes
- Three headframes for the shafts - 12000 tonnes
- Permanent vent fan removal - 680 tonnes
- Main shaft complex - 5568.75 tonnes
- Vent shaft complex - 4455 tonnes
- Service shaft complex - 3564 tonnes
- Concrete batching plant - 1525 tonnes
- Rock crushing plant - 1650 tonnes
- Used fuel packaging plant - 59300 tonnes
- UFC handling systems - 1400 tonnes

A single waste disposal coordinator (one NWMO FTE) and \$120K/annum (escalated from 2010\$) in ISO containers, re-handling and temporary storage have been assumed.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2159
Labour Cost	\$1,368	Finish Year	2168
Material Cost	\$0	Duration	10 years
Other Cost	\$34,319	WBS Type	Step Fixed
Subtotal	\$35,687		
Allowance	\$8,922		
Total Cost	\$44,609		

FINAL CLOSURE

580.60.170

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: K. Hojka

Organization: SNC-Lavalin

Description

Following the decommissioning and backfilling of all underground tunnels and shafts, and the decommissioning and removal from site of all redundant surface facilities, the DGR will remain under institutional management control until a license to abandon the site is obtained. During this 15 year period site security will remain in place, albeit at reduced levels, with facilities also available to accommodate monitoring personnel and the management and administration infrastructure to support their ongoing activities.

Once a license to abandon the site has been obtained all remaining staff will vacate the site to allow the decommissioning and removal of remaining surface facilities, site fences, utilities and access roads. The site will then be made good to a level consistent with the surrounding environment.

Deliverables

This activity covers all labour, plant, equipment and services required to undertake the final closure phase of the DGR project using a combination of an NWMO corporate structure and turn-key contracts for Site services.

Assumptions

The duration of the Closure Phase is 15 years, and costs are based on working one shift/day, 230 days/year.

The management and operation of the DGR during this phase of the project will be carried out using NWMO staff. It is assumed 13 FTE would be required for this phase.

Other costs include 3rd party contracts for ecological restoration, signage and landmarking, final dismantling, removal, and disposals, security, final sealing of deep boreholes, maintenance, other contracts, equipment, spares, consumables, vehicle leases, and energy consumption, etc.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$28,013
Material Cost	\$0
Other Cost	\$21,698
Subtotal	\$49,711
Allowance	\$12,428
Total Cost	\$62,139

Start Year	2169
Finish Year	2183
Duration	15 years
WBS Type	Fixed

BACKFILL MATERIAL PLANT (SUPPLY AND OPERATE)

580.60.30.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

The design, construction, installation, commissioning and operation of a facility for the handling and preparation of backfill (sealing materials) required to decommission the DGR.

Deliverables

The backfill materials plant includes a steel framed 4,000 m² insulated building with office, process, storage and personnel areas including all services. Also included are the backfill materials processing equipment/plant - silos, rock crusher, mixing and delivery systems. Operating management, engineering, QA, technical support, admin support, operations and maintenance staff are included.

Assumptions

Facility design, construction, installation and commissioning will be on a turnkey contract basis. Management and operation will be done by contract labour with an assumed labour requirement of 70 FTE.

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas incl services - 4000m² (\$8.5M, turn-key)
- Design, supply and install to site new backfill materials processing plant, capacity of 500 tonnes/day (incl. Silos / delivery systems, rock crushing, mixing, processing, delivery systems) (\$35.4M, turn-key).
- Spares and consumables (\$1.4M/year)
- Accommodation, travel and incidentals (\$2.7M/year)

Materials costs and additional operating costs are not included here, but are built into the blended materials costs used for individual backfill/decommissioning work elements.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2159
Labour Cost	\$168,343	Finish Year	2168
Material Cost	\$43,963	Duration	10 years
Other Cost	\$36,734	WBS Type	Step Fixed
Subtotal	\$249,040		
Allowance	\$62,260		
Total Cost	\$311,301		

580.60.30.10

WASTE PROCESSING AND HANDLING FACILITY

580.60.30.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

The design, construction, installation, commissioning and operation of a facility for handling, sorting, volume reduction and packaging of the various waste arisings produced during the decommissioning of the DGR.

Deliverables

The waste processing and handling facility includes an insulated pre-engineered 1,500 m² building with office, process, storage and personnel areas including services. It also includes size reduction equipment, cropping, burning, crushing, compaction, and articulated hammer equipment for use in the plant and on the site. Waste handling and crane equipment, loaders and conveyors are included, as are ventilated enclosures for sorting and packing of waste generated on site during decommissioning. Operating management, QA, admin and technical support, operation and maintenance staff are also covered here.

Assumptions

Facility design, construction, installation and commissioning will be on a turnkey contract basis, with management and operation of the facility carried out with an assumed contract labour requirement of 20 FTE.

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas including services - 1500m² (\$13.3M, turn-key)
- Size reduction equipment (equipment for use within the facility and on site as needed for cropping, burning, crushing and compaction) (\$7.1M, turn-key).
- Materials handling equipment, including building crane, loaders and materials conveyors (\$2.8M, turn-key)
- Ventilated enclosure for the sorting and packing of waste into ISO containers (\$1.1M, turn-key)
- Operating spares and consumable (\$354K/year, 2020\$)
- Accommodation, travel and incidentals (\$500K/year, 2020\$)

Transport, disposal and other operating costs are not included here, but are built into per tonne and per m³ rates for waste disposal line items.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$35,867
Material Cost	\$27,833
Other Cost	\$5,075
Subtotal	\$68,775
Allowance	\$17,194
Total Cost	\$85,969

Start Year	2159
Finish Year	2168
Duration	10 years
WBS Type	Step Fixed

AUXILIARY SURFACE FACILITIES DECOMM

580.60.40

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Decommissioning (demolition and removal) of the auxiliary Surface Facilities. These facilities do not include those facilities which are the subject of other work elements, such as the UFPP, the Waste Processing and Handling facility, the Backfill Materials Plant and the Sealing Materials Compaction Plant. The Waste Storage Areas, the Permanent Vent Fan, and the Decommissioning Facilities put in place specifically for the D&C period are also excluded from this WEDS.

Deliverables

A fully decommissioned DGR site, and a decommissioned off-site Waste Rock Storage/Disposal area. The site will be ready for the beginning of the Closure period, which runs for 15 years after the end of Decommissioning.

Assumptions

Costing is based on a single lump-sum turn-key decommissioning contract assessed as approximately 2.5% of initial costs for items not incorporated in other work elements. Specifically, the total contract value is derived from the following breakout (note that actual per-item costs are likely to vary according to item-specific decommissioning attributes):

- Remaining site improvements
- Pumphouse and intake
- Water storage tank area
- Water treatment plant
- Process water settling pond
- Service shaft water settling pond
- Storm water run-off ponds
- Sewage treatment plant
- Administration building including firewall / cafeteria
- Switchyard
- Transformer areas
- Auxiliary building
- Quality control offices and laboratories
- Garage building/warehouse/hazardous matls storage
- Walkways and serviceways
- Fuel storage tanks
- Fire hall / security
- Emergency power generation
- Facility electrical distribution
- Facility communication system (s)
- Firewater system

580.60.40

- Potable water system
- Process water system
- Sewerage system
- Storm water and drainage system
- Service air system
- Breathing air system
- Camp site remnants

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2159
Labour Cost	\$0	Finish Year	2168
Material Cost	\$0	Duration	10 years
Other Cost	\$6,644	WBS Type	Step Fixed
Subtotal	\$6,644		
Allowance	\$1,661		
Total Cost	\$8,305		

SEALING MATERIAL COMPACTION PLANT DECOMM

580.60.60

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: I. Ahmed

Organization:

Golder
Associates Ltd.

Description

Labour and equipment for the decommissioning, dismantling and removal of the Sealing Materials Compaction Plant.

Deliverables

Sealing Materials Compaction Plant site restored to a "green" state.

Assumptions

There will be no need to decontaminate from a radiological viewpoint.

All equipment and materials will be disposed of as conventional waste.

Volumes of waste emanating from this facility and the cost of waste containers, transport and disposal are covered elsewhere.

On-site managerial team for the decommissioning of the SMCP will comprise a project manager (about 500 hours) supported by a technical specialist (about 1000 hours). Decommissioning will be carried out using approximately 25,000 person-hours, an annual operating spares and consumables budget of about \$130K and an annual allocation for accommodations, incidentals and travel of about \$206k.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2164
Labour Cost	\$3,845	Finish Year	2165
Material Cost	\$284	Duration	2 years
Other Cost	\$454	WBS Type	Fixed
Subtotal	\$4,583		
Allowance	\$1,146		
Total Cost	\$5,728		

580.60.60

ALWT

580.60.70.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Active Liquid Waste Treatment Building.

Deliverables

The return of the ALWT building site to a 'green' state.

Assumptions

It is assumed that POCO (post operation clean out) is done after operations are complete.

Decommissioning is estimated as requiring approximately 780 person-hours for a decommissioning manager. Decommissioning will be carried out with approximately 8,100 person-hours of direct labour. The cost estimate also includes a \$39K annual assignment for operating spares and consumables over a three-year period, as well as a \$53.5K annual assignment for accommodation, incidentals and travel over the same three year period.

It is assumed no ILW will arise due to decommissioning activities, all arisings not LLW will be classified as conventional wastes.

A facility for handling, sorting, volume reduction and packaging of the various waste arisings produced during the decommissioning of the DGR, is to be constructed on site (580.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2160
Labour Cost	\$1,358	Finish Year	2162
Material Cost	\$117	Duration	3 years
Other Cost	\$160	WBS Type	Step Fixed
Subtotal	\$1,635		
Allowance	\$409		
Total Cost	\$2,044		

LLLW STORAGE

580.60.70.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Liquid Waste Storage Building.

Deliverables

The return of the LLLW building site to a 'green' state.

Assumptions

It is assumed that POCO (post operation clean out) is done after operations are complete.

Decommissioning is estimated as requiring approximately 390 person-hours for a decommissioning manager. Decommissioning will be carried out with approximately 3,360 person-hours of direct labour. The cost estimate also includes a \$16.4K annual assignment for operating spares and consumables over a three-year period, as well as a \$20K annual assignment for accommodation, incidentals and travel over the same three year period.

A facility for handling, sorting, volume reduction and packaging of the various waste arisings produced during the decommissioning of the DGR, is to be constructed on site (580.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2160
Labour Cost	\$577	Finish Year	2162
Material Cost	\$50	Duration	3 years
Other Cost	\$61	WBS Type	Step Fixed
Subtotal	\$687		
Allowance	\$172		
Total Cost	\$859		

LLW STORAGE

580.60.70.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Waste (LLW) storage building.

Deliverables

The return of the LLW storage building site to a 'green' state.

Assumptions

It is assumed that POCO (post operation clean out) is done after operations are complete.

Decommissioning is estimated as requiring approximately 780 person-hours for a decommissioning manager. Decommissioning will be carried out with approximately 8,160 person-hours of direct labour. The cost estimate also includes a \$39K (escalated from \$33K 2010\$) annual assignment for operating spares and consumables over a three-year period, as well as a \$53.8K (escalated from \$45K 2010\$) annual assignment for accommodation, incidentals and travel over the same three year period.

A facility for handling, sorting, volume reduction and packaging of the various waste arisings produced during the decommissioning of the DGR, is to be constructed on site (580.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2160
Labour Cost	\$1,367	Finish Year	2162
Material Cost	\$117	Duration	3 years
Other Cost	\$161	WBS Type	Step Fixed
Subtotal	\$1,646		
Allowance	\$411		
Total Cost	\$2,057		

UFC HANDLING SYSTEMS

580.60.80

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: A. Gaensbauer

Organization:

Palladium
Product
Development &
Design

Description

Labour and equipment for the decontamination, decommissioning, dismantling and removal of UFC Transfer Cask, Shielding Canopy, Hydraulic Cylinder Cart, Placement Vehicle, Floor Plate Handling System, Bentonite Gap Fill Delivery System, Tow Vehicles, Floor Plate Placement System, Concrete Mixer Truck, Underground Hopper, Concrete Pump, Concrete Forms

Deliverables

The removal from site of UFC Transfer Cask for Buffer Box, Shielding Canopy, Hydraulic Cylinder Cart, Placement Vehicle, Floor Plate Handling System, Bentonite Gap Fill Delivery System, Tow Vehicles, Floor Plate Placement System, Concrete Mixer Truck, Underground Hopper, Concrete Pump, Concrete Forms

Assumptions

Estimate is based on the following actions:

- Decontaminate 15 UFC Transfer Casks
- Decontaminate 12 Placement Vehicles
- Size reduction and load for disposal - 15 UFC Transfer Casks
- Size reduction and load for disposal - 15 trolley for UFC Transfer Casks
- Size reduction and load for disposal - 9 Shielding Canopy's
- Size reduction and load for disposal - 9 Shielding Canopy Trolley's
- Size reduction and load for disposal - 12 Hydraulic Cylinder Cart
- Size reduction and load for disposal - 12 Placement Vehicles
- Size reduction and load for disposal - 12 Floor Plate Handling System
- Size reduction and load for disposal - 12 Bentonite Spacer Block Trolley
- Size reduction and load for disposal - 12 Bentonite Gap Fill Delivery System
- Size reduction and load for disposal - 15 Tow Vehicles
- Size reduction and load for disposal for 6 Floor Plate Placement System
- Size reduction and load for disposal for 8 Concrete Mixer Truck
- Size reduction and load for disposal for 4 Underground Hopper
- Size reduction and load for disposal for 4 Concrete Pump
- Size reduction and load for disposal for 4 Concrete Forms
- Material for disposal- 560 tonne
- Scrap metal credit for salvage - 2,240 tonne

Components will be size reduced and packaged in a form suitable for transport from site, to a facility for final

disposal.

A total of 125 m³ produced from decommissioning these items will be conventional waste. Conventional waste will be transported 200 km by road in 30 tonne loads to a disposal facility. The cost of waste containers, transport and disposal is covered included.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2160
Labour Cost	\$0	Finish Year	2160
Material Cost	\$657	Duration	1 years
Other Cost	\$366	WBS Type	Step Fixed
Subtotal	\$1,023		
Allowance	\$256		
Total Cost	\$1,278		

PERM VENT FAN REMOVAL (DECOMMISSIONING)

580.60.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: A. Lee

Prepared by: B. Brewer

Organization: SNC-Lavalin

Description

Temporary ventilation as required during shaft back-filling operations as well as decommissioning aspects of ventilation equipment, accessories, heating penthouses, HEPA units and associated electrical gear not encompassed in shaft decommissioning work elements.

Deliverables

Complete (greenfield) decommissioning of ventilation systems.

Assumptions

Costs estimated as 4000 hours of direct labour and a \$57K (escalated from \$48K 2010\$) allocation for special materials and equipment.

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2160
Labour Cost	\$594	Finish Year	2160
Material Cost	\$57	Duration	1 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$650		
Allowance	\$163		
Total Cost	\$813		

GOVERNANCE STRUCTURE

580.80

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Gibson

Organization: NWMO

Description

Activities in support of Governance include:

Convene meetings of NWMO Members, Board, Board Committees and Advisory Council as required in the respective charters.

Ensure membership of Advisory Council is updated as required to reflect expertise and representation required by the Nuclear Fuel Waste Act (NFWA).

Coordinate annual technical program reviews.

Interact with the Canadian Nuclear Safety Commission on APM in the pre-project period consistent with the agreed project agreement terms relating to provision of regulatory information and reviews.

Maintain certification to ISO 9001:2008 and conformance with the requirements of CSA N286-12 as it applies to the development of a DGR.

On an annual basis, report on plans and progress through publication of APM Implementation Plans and NWMO Annual Reports.

Submit to government and make public NWMO's triennial report on APM implementation as required by NFWA.

Deliverables

None

Assumptions

Annual 3rd party contract costs are as per the 2021 – 2025 business plan and carried through to the end of operations at \$620K/year.

Staffing for the construction and operations period (2033 – 2172) are not included as it is assumed that this would be undertaken by the Common Services during construction and DGR operations staff during operations.

Allowance

An overall allowance of 10% has been included for 2026 - 2032; an allowance of 25% has been included starting in 2033. No additional allowance has been included in the years prior to 2026.

	2020K\$	Start Year	2020
Labour Cost	\$3,397	Finish Year	2088
Material Cost	\$0	Duration	69 years
Other Cost	\$42,688	WBS Type	Fixed
Subtotal	\$46,085		
Allowance	\$9,395		

580.80

Total Cost **\$55,480**

ENVIRONMENTAL MONITORING

580.85.10

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

Environmental monitoring will start following receipt of the CNSC Licence to Prepare Site and continue until closure of the facility. Environmental monitoring information will be used to support the licensing by providing site specific information which can be used as the basis for predicting anticipated effects of the APM Project activities throughout the life of the project. The results of the environmental monitoring program will be published annually and provided to the CNSC, other federal and provincial regulatory authorities, and the surrounding communities.

For each licence application to the CNSC and periodically during the licence periods, the environmental monitoring information will be used to conduct an Ecological Risk Assessment and an Environmental Risk Assessment. These will be performed to support the initial CNSC Licence to Prepare Site, updated for the Licence to Construct and the initial Licence to Operate, and thereafter renewed every 5 years in accordance with the requirements of the applicable CSA standards.

Deliverables

Environmental Risk Assessment (ERA) Report and Ecological Risk Assessment (EcoRA) Report at each licensing and at a 5 year renewal phase once operations commences until closure.
Annual Baseline Environmental Monitoring Reports.

Assumptions

NWMO environmental monitoring staffing costs are included in WEDS 580.85.90
For the baseline monitoring program annual reports, the scope of the environmental monitoring program will be expanded upon receipt of the CNSC Licence to Operate in 2043 to include the Radiological Environmental Monitoring Program (REMP) (estimated at \$1,000,000 per year).

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2027
Labour Cost	\$0	Finish Year	2183
Material Cost	\$0	Duration	157 years
Other Cost	\$63,200	WBS Type	Fixed
Subtotal	\$63,200		
Allowance	\$15,500		
Total Cost	\$78,700		

580.85.10

HUMAN HEALTH MONITORING

580.85.20

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

Human Health monitoring will start in advance of the initial regulatory approvals and continue until closure of the facility has occurred. Baseline information will be used to support the IA by providing site specific information which can be used as the basis for predicting anticipated effects of the APM Project activities throughout the life of the project.

For each licence application to the CNSC and periodically during the licence periods, NWMO will perform a Human Health Risk Assessment. These will be performed to support the initial CNSC Licence to Prepare Site, updated for the Licence to Construct and the initial Licence to Operate, and thereafter renewed every 5 years in accordance with the requirements of the applicable CSA standards.

To conduct the Human Health Risk Assessment, NWMO will collect dietary and epidemiological information in the siting area. The Human Health Risk Assessment will also be used in the analysis models for pre-closure and post-closure safety analysis.

Types of data include samples from plants, soil, and locally grown or harvested food (such as garden vegetables, fruits and berries, eggs, milk and meat). Published reports on incidence rates of illnesses within the local population are evaluated to confirm consistency with regional incidence rates.

This work will draw from the field work and analyses completed for WED 580.85.10 (Environmental Monitoring)

Deliverables

Human Health Risk Assessment reports.

Assumptions

NWMO environmental monitoring staffing costs are included in the WED 580.85.90.

Human Health Risk Assessment reports are assumed to be prepared for the CNSC Licence to Prepare Site, the Licence to Construct, the initial Licence to Operate, and thereafter once every 5 years until decommissioning and closure have been completed, at a cost of \$500,000 for field studies in the siting area and preparation of report.

Allowance

An overall allowance of 10% has been included for 2024 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$
Labour Cost	\$0
Material Cost	\$0
Other Cost	\$50,463
Subtotal	\$50,463
Allowance	\$3,931
Total Cost	\$54,394

Start Year	2020
Finish Year	2182
Duration	163 years
WBS Type	Fixed

SOCIAL AND ECONOMIC MONITORING

580.85.30

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

Follow-up Monitoring of the results of the commitments made by the NWMO or the conditions imposed through the regulatory approvals process is expected to occur through the site preparation and construction periods up to the first renewal of the Licence to Operate (2027 to 2052).

Deliverables

Annual Reports on the achievement of the Social and Economic commitments and resulting effects on the local communities (Follow-up Monitoring Reports).

Assumptions

This does not include the cost of any commitments the NWMO makes with respect to social programs, community infrastructure, pre-hiring job or skills training programs, or local procurement initiatives. These costs are assumed to be included in the partnership costs.

Staffing costs of the Follow-up Monitoring Program report are included in the Licensing Staffing WED 580.35.90.

Allowance

An overall allowance of 10% has been included for 2024 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2027
Labour Cost	\$0	Finish Year	2052
Material Cost	\$0	Duration	26 years
Other Cost	\$2,655	WBS Type	Fixed
Subtotal	\$2,655		
Allowance	\$572		
Total Cost	\$3,227		

ENVIRONMENTAL - STAFFING

580.85.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: A. Webster

Organization: NWMO

Description

Staffing related to Environmental Monitoring (WED# 580.85.10) and Human Health Monitoring (WED# 580.85.20)

Deliverables

Includes an average of 6 FTE from 2020 through 2042.

Environmental staffing from 2043 to 2183 covered by WBS 580.45.20 (Direct Operations Management) and WBS 580.45.30 (Operations Indirect), WBS 580.60.10 (Decommissioning Management), and WBS 580.60.170 (Final Closure).

Assumptions

None.

Allowance

An overall allowance of 10% has been included for 2024 - 2032; and an allowance of 25% has been included, starting in 2033.

	2020K\$	Start Year	2020
Labour Cost	\$27,126	Finish Year	2042
Material Cost	\$0	Duration	23 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$27,126		
Allowance	\$3,411		
Total Cost	\$30,538		

COMMON SERVICES

580.90

Case 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: D. Wilson

Prepared by: D. Gibson

Organization: NWMO

Description

An overall business, administrative and management function that will provide the necessary backoffice support to the project including the provision and or management of finances, systems, people, infrastructure, supplies and includes:

- Finance, Pension Administration and Business Services: Account management, reporting, invoicing, contract payments, staff payments, buyer and IT support.
- Human Resources: Recruitment, staff management, purchase of payroll services, general support.
- Legal, Procurement and Insurance – Internal and external legal counsel, procurement services and conventional insurance coverage for work during the pre-operations phase.
- Office and IT costs, office accommodation, supplies and staff expenses.
- Quality services: internal audit and governance.
- President's office

Deliverables

None

Assumptions

Costs include internal NWMO headcount of an average of 57 FTE as well as other costs such as pension administration fees, office rent, purchase and maintenance of IT infrastructure, etc.

Allowance

An overall allowance of 10% has been included for 2026 - 2032; and an allowance of 25% has been included, starting in 2033. No additional allowance has been included in the years prior to 2026.

	2020K\$	Start Year	2020
Labour Cost	\$218,076	Finish Year	2042
Material Cost	\$0	Duration	23 years
Other Cost	\$301,928	WBS Type	Fixed
Subtotal	\$520,004		
Allowance	\$71,077		
Total Cost	\$591,081		

PROJECT MANAGEMENT/BUILDING DESIGN AND CONSTRUCTION OF UFPP

580.40.40.10.10

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

All activities associated with project management, design, procurement, and construction of the UFPP building.

Deliverables

UFPP building designed and installed.

1. The following deliverables are included:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

The UFPP will process approximately 5,500,000 CANDU fuel bundles (120,000 per year).

The facility and equipment will be constructed to comply with the nuclear standards, specified in the design requirement documents.

The UFPP will be a building on the larger DGR Site. The larger DGR Site will include all supporting facilities such as, site security, repository sealing material, administrative building, power and water sources, sewage treatment plant, etc.

The UFPP will be a single story, ground level, reinforced concrete structure.

The building shall be designed to withstand a National Building Code of Canada (NBCC) seismic event. Major earthquake is not considered for UFPP design.

Construction worker rates will be impacted by location. Assumed northern Ontario.

Hot cell walls will be 7.0 m high.

Transfer Hall walls will be 30 m high.

Fuel handling cell walls will be reinforced concrete, 1.2 m thick. The rest of the walls will be 0.3-0.5 m thick.

Adjacent administrative building will be 8 m high (total for two levels) of standard commercial building construction.

Foundation budget assumptions are site-specific and actual values will depend on geotechnical parameters.

Estimate Assumptions:

Cost of UFPP licensing is not included.

Excludes contingency.

Installation labour costs are estimated as a percentage of material cost, with the percentage varying depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before building permit, EPC fees, and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	<u>\$40,408</u>	Finish Year	2040
Material Cost	<u>\$44,049</u>	Duration	3 years
Other Cost	<u>\$24,704</u>	WBS Type	Fixed
Subtotal	<u>\$109,161</u>		
Allowance	<u>\$27,290</u>		
Total Cost	\$136,452		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (RECEIPT OF UFTPS)

580.40.40.10.20.10

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization:

AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to:

- Receive and inspect truck with Used Fuel Transportation Packages (UFTPs).
- Survey UFTP.
- Unload UFTP from truck and transfer to laydown area.
- Remove impact limiters and IAEA seal, transfer UFTP to vent hall and vent/sample UFTP.
- Remove lid and modules from UFTP.
- Decontaminate and load empty modules and UFTPs on the truck.

Deliverables

UFPP Receipt Systems designed and installed.

1. The following Systems deliverables are included:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

UFTP will be received at UFPP site loaded with CANDU used fuel bundles.

Fuel bundles have been discharged from reactors for long enough and have a low enough burn-up rate to be handled safely with shielding and sorting assumed.

Fuels other than CANDU fuel bundles will be managed in the UFPP if they have similar characteristics.

Estimate Assumptions:

UFTP design and transportation logistics are not part of this project.

The requirements and provisions for dispatch of the UFTPs that do not pass inspection before being opened are not included.

Provision for surge storage is not part of this project.

580.40.40.10.20.10

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2039
Labour Cost	\$10,458	Finish Year	2041
Material Cost	\$55,255	Duration	3 years
Other Cost	\$17,459	WBS Type	Fixed
Subtotal	\$83,172		
Allowance	\$20,793		
Total Cost	\$103,965		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (TRANSFER BASKETED FUEL INTO MODULES)

580.40.40.10.20.15

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to

- receive Basket Transportation Packages (BTPs);
- remove the baskets from BTPs; and
- transfer fuel bundles from baskets into modules.

Deliverables

System for transferring basketed fuel into modules designed and installed.

1. The following systems deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

BTP received at UFPP will be filled with CANDU fuel bundles.

Fuel bundles have been discharged from reactors for long enough and have a low enough burn-up rate to be handled safely with shielding and sorting assumed.

Fuels other than CANDU fuel bundles will be managed in the UFPP if they have similar characteristics.

Estimate Assumptions:

BTP design and transportation logistics is not part of this project.

Provisions for dispatch of the BTPs that do not pass inspection before being opened are not included.

Provisions for surge storage are not included.

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Installation labour cost is 19.8% of material cost

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$1,865	Finish Year	2041
Material Cost	\$9,413	Duration	4 years
Other Cost	\$2,997	WBS Type	Fixed
Subtotal	\$14,275		
Allowance	\$3,569		
Total Cost	\$17,844		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (INSPECTION)

580.40.40.10.20.20

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to inspect and classify used fuel bundles prior to transfer from fuel modules into UFC inserts.

Deliverables

Bundle Inspection Systems designed and installed.

1. The following systems deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

The inspection and classification system will process used fuel modules as well as adapted fuel modules (containing canned defective/damaged fuel bundles/packages).

The fuel modules (standard and adapted) will be full of CANDU fuel bundles.

The target inspection time for a fuel bundle/package in the fuel loading cell is 2 minutes.

Estimate Assumptions:

0.1% of all fuel bundles are assumed defective or damaged and will go to the contingency cell from inspection and classification area for canning.

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

215

	2020\$K
Labour Cost	\$488
Material Cost	\$2,450
Other Cost	\$781
Subtotal	\$3,719
Allowance	\$930
Total Cost	\$4,649

Start Year	2039
Finish Year	2041
Duration	3 years
WBS Type	Fixed

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (UFC FUEL LOADING)

580.40.40.10.30.10

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to:

- transfer fuel bundles into UFC.
- install UFC hemispherical head to lower assembly when fully loaded with fuel bundles; and
- inspect hemispherical head installation on lower assembly.

Deliverables

System for loading fuel bundles into UFCs and loading UFCs into transfer flasks designed and installed.

1. The following deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

The system will be capable of unloading and retract a fuel bundle from the UFC insert or canned fuel bundle from the adapted UFC insert.

The fuel modules (standard and adapted) will arrive fully loaded with fuel bundles.

The target time for loading a fuel bundle/package into UFC after completion of inspection will be 1 minute.

Recovery system for mechanical failure will be provided by a backup, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator.

Estimate Assumptions:

0.1% of all fuel bundle/package will need to be removed from the inspection port and transferred to the contingency cell instead of the normal transfer into a UFC.

0.1% UFCs that fail hemispherical-head fit-up inspection go to the contingency cell for repairs.

Major equipment will be replaced or refurbished one time during UFPP operations.

580.40.40.10.30.10

Excludes contingency.

Installation labour cost is 19.8% of material cost.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$7,926	Finish Year	2041
Material Cost	\$39,826	Duration	4 years
Other Cost	\$12,687	WBS Type	Fixed
Subtotal	\$60,439		
Allowance	\$15,110		
Total Cost	\$75,549		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD UFC)

580.40.40.10.30.30

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to:

- preheat the closure zone for welding the UFC hemispherical head to the UFC lower assembly.
- weld the UFC hemispherical head to the UFC lower assembly; and
- prepare the welded closure zone for weld cap removal.

Deliverables

System for welding UFC Hemispherical Head to Lower Assembly designed and installed.
System for welding UFC hemispherical head to UFC lower assembly designed and installed.

Procurement and installation, including:

Development of specifications

Preparation of tendering documentation and issue of Requests for Proposals (RFPs)

Selection of contractors

Placing of orders/letting of contracts

Review of contractor engineering documentation & engineering drawings

Supervision/inspection of installation

Assumptions

Design Assumptions:

Post weld heat treatment (PWHT) is not required.

Weld preheat duration is 30 min.

Single pass circumferential closure weld will secure the UFC hemispherical head to the UFC lower assembly.

After completion of the welding, ambient air cooling will take 20 min followed by 50 min of forced air cooling

Weld repair, if required, will be performed after the weld NDE, and followed by weld machining.

Two (2) minutes will be allotted for the pre-weld inspection.

Recovery system for mechanical failure will be provided by a backup, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator.

Major equipment will be replaced or refurbished once during UFPP operations.

Estimate Assumptions:

Major equipment will be replaced or refurbished one time during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$5,308	Finish Year	2041
Material Cost	\$38,129	Duration	4 years
Other Cost	\$11,541	WBS Type	Fixed
Subtotal	\$54,977		
Allowance	\$13,744		
Total Cost	\$68,721		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD CAP REMOVAL)

580.40.40.10.30.40

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization:

AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to remove excess weld material after closure and welding of UFC.

Deliverables

System for weld cap removal designed and installed.

1. The following deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

'0-degree' marking on the UFC will be used to identify where defects are located for machining and for weld repair processing.

Weld machining can be achieved without the need for liquid coolant.

Recovery system for mechanical failure will be provided by a backup, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator (WBS 580.40.40.10.30.30).

Estimate Assumptions:

Major equipment will be replaced or refurbished one time during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

580.40.40.10.30.40

	2020\$K	Start Year	2038
Labour Cost	\$749	Finish Year	2041
Material Cost	\$5,064	Duration	4 years
Other Cost	\$1,544	WBS Type	Fixed
Subtotal	\$7,357		
Allowance	\$1,839		
Total Cost	\$9,196		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (WELD NDE)

580.40.40.10.30.50

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to perform examination of the UFC closure weld.

Deliverables

System for weld NDE designed and installed.

1. The following deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
 - Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
 - Selection of contractors
 - Placing of orders/letting of contracts
 - Review of contractor engineering documentation & engineering drawings
 - Supervision/inspection of installation
-

Assumptions

Design Assumptions:

One scan of the UFC weld (or calibration block) and NDE data acquisition will be completed within 15 minutes. Analysis of the NDE data (i.e. Primary, Secondary and Resolution) for one UFC will be completed within 240 minutes from the completion of data acquisition.

UFC rotation surface speed will be in range of 10 to 20 mm/sec.

There will be three data analysis workstations provided for each NDE method utilized for the examination: two workstations for Primary and Secondary analysis and one workstation for Resolution analysis.

Weld repair and weld cutting requires intra-process transfer capability of the UFC between the weld system, weld machining system and the weld NDE system.

Recovery system for mechanical failure will be provided by a back up, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator (WBS 580.40.40.10.30.30).

Estimate Assumptions:

0.1% of all UFCs will need weld repair at the contingency cell.

Major equipment will be replaced or refurbished one time during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

580.40.40.10.30.50

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$620	Finish Year	2041
Material Cost	\$4,137	Duration	4 years
Other Cost	\$1,264	WBS Type	Fixed
Subtotal	\$6,021		
Allowance	\$1,505		
Total Cost	\$7,526		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER COLD SPRAY)

580.40.40.10.30.60

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to:

- perform surface and heat treatment of the exposed steel surface of the UFC;
- apply a copper coating to the exposed steel surface of the UFC; and
- for re-application of copper coating.

Deliverables

System for Copper Cold Spray designed and installed.

1. The following systems deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation; engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

The '0-degree' marking on the UFC will be used to identify where defects are located to apply copper coating and for repair.

The cold copper tooling will be used to clean the weld closure zone to prepare the surface of weld closure zone for copper spray.

Recovery system for mechanical failure will be provided by a back up, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator.

Estimate Assumptions:

0.05% of all UFCs will be transferred to the contingency cell from copper cell for repairs.

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

580.40.40.10.30.60

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$6,679	Finish Year	2041
Material Cost	\$48,069	Duration	4 years
Other Cost	\$14,546	WBS Type	Fixed
Subtotal	\$69,295		
Allowance	\$17,324		
Total Cost	\$86,618		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER MACHINING)

580.40.40.10.30.70

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization:

AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to conduct copper machining for preparing the copper surface for NDE.

Deliverables

System for Copper Machining designed and installed.

1. The following deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

The machining process will meet the required surface finish and thus a visual inspection for gross defects would suffice.

The '0-degree' marking on the UFC will be used to identify where defects are located for machining.

Copper machining will be completed without the need for liquid coolant.

A power-manipulator gantry crane will be utilized to address in-cell remote handling issues (580.40.40.10.30.80).

Estimate Assumptions:

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$1,856	Finish Year	2041
Material Cost	\$11,895	Duration	4 years
Other Cost	\$3,653	WBS Type	Fixed
Subtotal	\$17,404		
Allowance	\$4,351		
Total Cost	\$21,755		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (COPPER NDE)

580.40.40.10.30.80

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to conduct non-destructive examination of the UFC closure zone copper coating.

Deliverables

System for Copper NDE designed and installed.

1. The following deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
 - Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
 - Selection of contractors
 - Placing of orders/letting of contracts
 - Review of contractor engineering documentation & engineering drawings
 - Supervision/inspection of installation
-

Assumptions

Design Assumptions:

The reference NDE process for copper coating examination will utilize 0-degree ultrasonic examination and eddy current examination technique.

NDE data acquisition will be completed within 2 minutes.

Analysis of the NDE data (i.e. Primary, Secondary and Resolution) for one UFC will be completed within 120 minutes from the completion of data acquisition.

UFC rotation surface speed will be in a range of 10 to 20 mm/sec.

There will be three data analysis workstations provided for each NDE method utilized for the examination: two workstations for primary and secondary analysis and one workstation for resolution analysis.

Intra-process transfer systems will support movement between the UFC between the Copper Application System, Copper Machining System, Copper Annealing System, and the Copper Coating NDE System for copper re-application, as necessary.

Recovery system for mechanical failure will be provided by a back up, in-cell overhead crane with 3,000 kg capacity and remote handling telescopic manipulator.

Estimate Assumptions:

0.1% of all UFCs will need copper repair in the Contingency Cell.

580.40.40.10.30.80

Major equipment will be replaced or refurbished one time during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% or 19.8% of material cost, depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$6,938	Finish Year	2041
Material Cost	\$49,656	Duration	4 years
Other Cost	\$15,036	WBS Type	Fixed
Subtotal	\$71,630		
Allowance	\$17,907		
Total Cost	\$89,537		

UFPP EQUIPMENT DESIGN, SUPPLY AND INSTALL (BUFFER BOX ASSEMBLY)

580.40.40.10.45

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization:

AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of systems required to transfer completed UFC into bentonite buffer boxes, including loading and handling.

Deliverables

System for Buffer Box Assembly designed and installed.

1. The following system deliverables are required:

- Completed design basis documentation.
- Completed detailed design.

2. Procurement and installation, including:

- Development of specifications
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs)
- Selection of contractors
- Placing of orders/letting of contracts
- Review of contractor engineering documentation & engineering drawings
- Supervision/inspection of installation

Assumptions

Design Assumptions:

Short-term climate-controlled bentonite buffer box storage area will be provided within the UFPP
Buffer boxes filled with a UFC will be transferred to the DGR without further need to provide a controlled humidity environment.

Includes final inspection cell for completed UFC.

Estimate Assumptions:

Buffer box design and transportation logistics are not part of this project.

Provisions for dispatch of the buffer boxes that do not pass inspection before being loaded are not included.

Buffer box manufacturing flaws will be investigated in the buffer box manufacturing facility.

Major equipment will be replaced or refurbished one time during UFPP operations.

Excludes contingency.

Installation labour cost is 13.8% of material cost.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2040
Labour Cost	\$3,340	Finish Year	2041
Material Cost	\$24,105	Duration	2 years
Other Cost	\$7,292	WBS Type	Fixed
Subtotal	\$34,736		
Allowance	\$8,684		
Total Cost	\$43,421		

BUILDING SERVICES DESIGN, SUPPLY AND INSTALLATION (UFPP)

580.40.40.10.50

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

The design, procurement, supply, and installation of building services, including:

Utilities.

Instrumentation and Control.

Data Logging.

Receipt of empty UFCs.

Equipment Repair and Maintenance Shop.

Contingency Cell.

Fuel Canning Cell

UFC Decontamination Cell

Waste Management systems.

Radiation Protection systems.

Systems required to transfer used fuel within UFPP.

Office/Admin building.

Control room.

HVAC.

Plumbing.

Fire protection.

Liquid Drainage.

Deliverables

Systems for Building Services designed and installed.

The following deliverables are required:

Completed design basis documentation.

Completed detailed design.

2. Procurement and installation, including:

Development of specifications

Preparation of tendering documentation and issue of Requests for Proposals (RFPs)

Selection of contractors

Placing of orders/letting of contracts

Review of contractor engineering documentation & engineering drawings

Supervision/inspection of installation

Assumptions

Design Assumptions:

The UFPP fire protection design is in accordance with CSA N393 standard.

UFPP contingency cell and canning cell will be designated as radiologically hazardous zones.

Canning cell and equipment will be used for fuel canning.

Contingency cell and equipment will be used for major UFC weld or copper application repairs.

Air radiation monitors are installed in the UFPP exhausts of the active ventilation system and radiologically hazardous areas.

Personnel contamination monitoring stations are provided for personnel movement from a higher to a lower radiological zone.

Active waste, general decontamination areas and active machine shop are designed as radiologically hazardous zones.

The UFPP active waste are transferred for processing to the DGR complex waste management area.

The ventilation system for the radiological hazardous areas will be a single active ventilation system. The zones will be set up to ensure airflow only from lower to higher zones.

Estimate Assumptions:

Volume of activities in the contingency cell will be less than 1% of the plant throughput.

Major equipment will be replaced or refurbished once during UFPP operations.

Excludes contingency.

Nuclear safeguards (relating to nuclear material accountancy) are not included.

Installation labour costs for mechanical and electrical services are based on detailed estimates of labour hours for each activity.

Installation labour costs for other items are estimated as a percentage of material cost, with the percentage varying depending on the material.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2038
Labour Cost	\$57,179	Finish Year	2041
Material Cost	\$259,897	Duration	4 years
Other Cost	\$84,244	WBS Type	Fixed
Subtotal	\$401,320		
Allowance	\$100,330		
Total Cost	\$501,650		

COMMISSIONING (UFPP)

580.40.40.10.60

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

UFPP commissioning to assure that all systems and components of a building or industrial plant are designed, installed, tested, operated, and maintained according to the operational requirements.

Deliverables

UFPP commissioned, including:

Commissioning specification and plan issued.

The following systems commissioned: a) Architectural and structural; b) Mechanical, and; c) Electrical.

Pre-commissioning activities.

Schedule of commissioning of integrated systems

Identification system

Commissioning specifications

Installation and start-up checklists

Performance verification

Commissioning report

Assumptions

Design Assumptions:

Filters and sampling point will be included for commissioning purpose.

Instrument calibration will be done before commencing the commissioning.

During commissioning temporary sensors and instrumentation will be used.

Specialized software will allow for configuring parameters to suit each specific process be commissioned.

Individual information chains will be commissioned as part of their process or safety system.

Estimate Assumptions:

Commissioning specification will be prepared for the UFPP before commencing commissioning.

Equipment factory acceptance test will be available.

The UFPP and its systems will be commission with the use of non-radioactive materials.

Excludes contingency.

Commissioning for items under 580.40.40.10.50 is 7% of subtotal costs (before allowance) for 580.40.40.10.50 for labour plus 20% of that for accommodation & travelling expenses.

Commissioning for items under 580.40.40.10.20 is 10% of subtotal costs (before allowance) for 580.40.40.10.20 for labour plus 20% of that for accommodation & travelling expenses.

Commissioning for items under 580.40.40.10.30 is 5% of subtotal costs (before allowance) for 580.40.40.10.30 for labour plus 20% of that for accommodation & travelling expenses.

Commissioning for items under 580.40.40.10.45 is 10% of subtotal costs (before allowance) for 580.40.40.10.45 for labour plus 20% of that for accommodation & travelling expenses.

Preliminaries (including mobilization and demobilization) are 20% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2042
Labour Cost	\$56,039	Finish Year	2042
Material Cost	\$0	Duration	1 years
Other Cost	\$29,373	WBS Type	Fixed
Subtotal	\$85,412		
Allowance	\$21,353		
Total Cost	\$106,765		

OPERATIONS (UFPP)

580.45.40.10

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

Operation and maintenance of UFPP.

Deliverables

- 5,500,000 used fuel bundles safely transferred from UFTPs and BTPs into UFC and placed within bentonite boxes, ready for disposal.
- Operational reports

Assumptions

Design Assumptions:

The service life of the UFPP considering maintenance and refurbishment will be 50 years.
Major equipment will be replaced or refurbished once during UFPP operations.
The plant will be operational 250 days per year and two 8-hr shifts.

Estimate Assumptions:

Periodic inspection per current code and regulations have not been accounted for as the list has not been fully established at this time.

The cost of transportation, processing and disposal of radioactive waste is not included (the UFPP is only a processing facility).

Excludes contingency.

Operations start in 2043 and finish in 2088.

Transportation Package Shipping, Receiving, and Handling requires 14 Operators (for shipping, receiving, and material handling) and 2 Radiation Technicians (to facilitate the acceptance of transportation packages and prepare incoming / outgoing surveys).

Fuel Handling and UFC Handling Cells require 8 Operators (for supervisory operation) and 2 First Line Managers (to oversee processing operations).

UFC Processing requires 18 Operators (to act as the designated individuals for overseeing automated processes), 20 Technical Specialists / Engineers (for in-depth process knowledge and decision making), and 2 First Line Managers (to oversee processing operations and personnel).

Empty UFC Receiving and Preparation requires 10 Operators (for shipping, receiving, and handling).

UFC Decontamination requires 2 Operators (to perform the decontamination operations) and 2 Radiation Technicians (to provide the necessary evaluation / surveys for the decontaminated UFCs).

UFC Buffer Box Dispatch requires 6 Operators (to pre-assemble the buffer box components and transfer the buffer box to and from each location), 2 First Line Managers (to oversee these operations and assist with overseeing decontamination operations).

Active Maintenance Shop requires 4 Operators and 2 First Line managers.

Waste Management Facility requires 6 Operators and 2 Radiation Technicians to perform the operations required for contaminated waste removal.

Support functions require 6 Civil Specialists, 8 Mechanical Specialists, 6 Control Specialists, 2 Radiation Technicians, 4 Operators (custodians) and 6 Technical Specialists (2 Health Physicists and 4 Health Technicians).

Costs for replacement/refurbishment of capital equipment under 580.40.40.10.10, 580.40.40.10.20, 580.40.40.10.30, and 580.40.40.10.50 are equivalent to 35% of the initial material cost, plus 15% of that for labour, all divided equally over the operating years.

Costs for replacement/refurbishment of capital equipment under 580.40.40.10.45 are equivalent to 40% of the initial material cost, plus 4% of that for labour, all divided equally over the operating years.

Costs for routine maintenance per year are equivalent to 1% of the initial material cost.

Routine maintenance is a contracted service requiring no additional NWMO labour.

Operating costs do not depend on the proportion of used fuel received in UFTPs vs. BTPs.

For LLRW management:

Waste volume is 100 m³ per year.

Waste is transported in consumable 2 m³ containers that can go directly into storage.

Packaging efficiency of waste in containers is 60%.

Each waste shipment consists of 8 containers.

Same transport cost per shipment as used for decommissioning, which assumes 1700-mile trip to the waste disposal site, and is a combination of highway and rail rates.

Same unit cost (per m³ of waste) for disposal (and processing) as used for decommissioning, which was based on inside industry knowledge of the actual LLRW disposal costs from the US Department of Energy for disposing "government" equivalent waste at actual near surface disposal facilities in the US. Canada does not have such facilities.

Disposal (and processing) costs include volume reduction, conditioning, decontamination, and secondary waste.

LLRW disposal facilities will be available at the time that LLRW from the UFPP is generated. Costs to temporarily store the waste if this assumption is invalidated are excluded.

For ILRW management:

Waste volume is 6 m³ per year.

Waste is transported in reusable containers with consumable liners. The liners can hold 1 m³ of waste and can go directly into storage.

6 containers are needed.

Each waste shipment consists of 2 containers.

Same transport cost per shipment as LLRW.

Unit costs for ILRW disposal (and processing) will be 3 times higher than for LLRW.

Disposal (and processing) costs include volume reduction, conditioning, decontamination, and secondary waste.

ILRW includes waste material that will be suitable for near-surface disposal based on Performance Assessment for a future Canadian repository.

Given the above, and considering other contributing WEDS where there have been assumptions for the technical, operational and maintenance labour requirements, the labour estimate has been adjusted by the NWMO to avoid duplication of staffing.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K
Labour Cost	\$709,826
Material Cost	\$0
Other Cost	\$532,314
Subtotal	\$1,242,140
Allowance	\$310,535
Total Cost	\$1,552,675

Start Year	2043
Finish Year	2088
Duration	46 years
WBS Type	Variable

DECOMMISSIONING (UFPP)

580.60.50

Case UFPP, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner: H. Guo

Prepared by: O. Jouavel

Organization: AECOM Canada
Nuclear Services

Description

UFPP decommissioning to assure that the facility and all systems are dismantled to the point that it no longer requires measures for radiation protection and all licensed activities cease, which will allow the removal of regulatory control.

Deliverables

UFPP decommissioned. Decommissioning documentation, including

- a) Decommissioning Plan
- b) Decommissioning Design
- c) Licensing Submissions
- d) Final report and drawings documenting end state

Assumptions

Estimate Assumptions:

Decommissioning starts 70 years after operations finish and takes 2 years.

Assumes Hot Demo Crew of 10 over 9 months at 2080 hours/year.

Assumes Clean Crew of 12 over 3 months at 2080 hours/year.

Assumes Hazardous Waste Crew of 6 over 10 months at 2080 hours/year.

Assumes Clean Waste Crew of 6 over 9 months at 2080 hours/year.

Assumes Site Restoration Crew of 4 over 10 months at 2080 hours/year.

Assumes Scabbling Crew of 4 over 3 months at 2080 hours/year.

Assumes Supervision of 148 person-months at 2080 hours/year.

5% of 15,900 m³ concrete structure will be radioactive waste.

Assumes transportation of 2700 km to a radioactive waste disposal site and of less than 160 km to a clean waste landfill.

Pricing for transportation is a combination of highway and rail rates.

Assumes disposal of only concrete debris with average density of 1.05 tons/CY.

Includes allowances for materials, temporary equipment, and waste tent.

Assumes other indirect costs at 28% of total non-supervision labour cost.

Assumes contractor overhead at 10% of total decommissioning costs excluding WBS allowance, subcontractor overhead, and subcontractor profit.

Assumes contractor profit at 10% of total decommissioning costs excluding WBS allowance and subcontractor profit.

Cost of delicensing is not included.

The detention, demurrage, and any specialty permit costs are not included.

Excludes contingency.

Preliminaries (including mobilization and demobilization) are 15% of total costs before EPC fees and allowance.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020\$K	Start Year	2157
Labour Cost	\$12,016	Finish Year	2158
Material Cost	\$0	Duration	2 years
Other Cost	\$19,500	WBS Type	Fixed
Subtotal	\$31,516		
Allowance	\$7,879		
Total Cost	\$39,394		

TRANSPORTATION ANALYSES AND ASSESSMENTS

680.20

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by G. Cheema

Organization: NWMO

Description

This task is for performing assessments supporting the development and eventual implementation of the transportation program.

Deliverables

- Identification and assessment of preferred and alternative road routes between each of the interim sites and the repository site.
- Identification and design of the necessary transportation equipment and facilities, including local access infrastructure, transportation packages (including package optimizations of the UFTP and BTP), trailers and security escort vehicles.
- Transportation risk assessment including public and worker dose assessments.

Assumptions

Development and implementation of programs supporting the Used Fuel Transportation System (UFTS) in the following areas:

- UFTS Development,
- Package and conveyance design,
- Risk Assessment,
- Dose Assessment,
- Security Planning,
- Emergency Response,
- Hot cell Analysis,
- Input to Impact Assessment,
- Bundle integrity during Transportation,
- Basket dry storage and used fuel transfer system,
- Rail transport development (if required),
- Engagement support, and
- Miscellaneous costs, including asset insurance, industry organization memberships, etc.

Staffing requirements (all FTEs at 1470 hours per year) for the development and execution of these activities:

Pre Site Selection (2020 - 2022)

- 2020 to 2022 - 1 FTE
- 2020 - 2 FTE
- 2021 - 3 FTE
- 2022 - 4 FTE

Site License Preparation (2023 - 2024)

680.20

- 2023 to 2024 - 1 FTE
- 2023 - 4 FTE
- 2024 - 5 FTE

Site Construction Application (2025 - 2027)

- 2025 to 2027 - 1 FTE
- 2025 to 2027 - 5 FTE

Preparation for Operations (2028 - 2042)

- 2028 to 2032 - 1 FTE (years 2033 to 2042 are covered in 680.90).
- 2028 to 2032 - 5 FTE
- 2033 to 2042 - 1 FTE
- 2035 to 2038 - 1 FTE
- 2041 to 2042 - 1 FTE

Exclusive of contingency.

Allowance

Allowance of 25% added to costs to reflect the level of design and uncertainties.

Allowance is not added to costs incurred during business plan period (2020 - 2024).

	2020K\$	Start Year	2020
Labour Cost	\$15,711	Finish Year	2042
Material Cost	\$0	Duration	23 years
Other Cost	\$76,821	WBS Type	Fixed
Subtotal	\$92,532		
Allowance	\$15,198		
Total Cost	\$107,730		

TRANSPORT LICENSING

680.25

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by G. Cheema

Organization: NWMO

Description

To obtain required certifications for transport package designs, registrations and licenses to transport from the competent authority.

Deliverables

- Certificate for transport package design for UFTP and BTP including recertification of both package certificates every 5 years,
- Registered user certificates for UFTP and BTP prior to commencement of transport operations, renewed with each package certificate recertification, and
- License to transport category II nuclear material for UFTP and BTP prior to commencement of transport operations, renewed annually.

Assumptions

Labour:

- 2036 to 2037 - 1 FTE preparing UFTP SAR and certification.
- 2038 to 2039 - 1 FTE preparing UFTP fleet registration.
- 2040 to 2088 - 0.5 FTE preparing UFTP certificate renewals and SAR updates.
- 2043 to 2044 - 1 FTE preparing BTP SAR and certification.
- 2045 to 2046 - 1 FTE preparing BTP fleet registration.
- 2047 to 2068 - 0.5 FTE preparing BTP certificate renewals and SAR updates.
- 2041 to 2042 - 2 FTE preparing License to Transport Category II Nuclear Material.
- All FTEs are 1470 hours per year.

Other:

UFTP - Initial certificate fee (2033): \$29,136.80.

UFTP Certificate renewal: \$1040.60 every 5 years starting in 2037 through 2088.

BTP - Initial certificate fee (2033): \$29,136.80.

BTP Certificate renewal: \$1040.60 every 5 years starting in 2037 through 2068.

Exclusive of contingency.

Allowance

Allowance of 15% added to travel and certificate and licence fees and allowance of 25% added to labour costs to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$7,499
Material Cost	\$0
Other Cost	\$181
Subtotal	\$7,680
Allowance	\$1,902
Total Cost	\$9,581

Start Year	2033
Finish Year	2088
Duration	56 years
WBS Type	Fixed

TRANSPORTATION VEHICLES - NON-SITE-SPECIFIC

680.40.10.10

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

The design, procurement, testing and commissioning of transportation vehicles for transportation campaign readiness.

Deliverables

UFTS Transport Vehicles

For the tractor-trailer (consisting of 1 tractor and 1 trailer), the following deliverables are required:

- Completed design basis documentation to support the transport of one UFTP or one BTP by road.
- Completed detailed design of the transport vehicles and/or technical specification for commercially available vehicles.
- Completed testing and licensing documentation, safety analysis documentation for submission to the Competent Authority.
- Licenced transport vehicle system and approved commissioning plans for the UFTS.

UFTS Escort Vehicles

For the Escort Vehicle the following deliverables are required:

- Completed design basis documentation.
- Completed detailed design of the transport vehicles and/or technical specification for commercially available vehicles.
- Completed testing and licensing documentation, safety analysis documentation for submission to the Competent Authority.
- Licensed transport vehicle system and approved commissioning plans for the UFTS.

Assumptions

For UFTP Vehicle Fleet Mockups:

- Requires one NWMO Engineering/Technical Specialist/Advisor FTE over 3 years at 1,470 hours per FTE per year for tractors, trailers, and escort vehicles combined, finishing 3 years before the first UFTP shipments.
- Requires 1 mockup each of the tractor, trailer, and escort vehicle, the costs for which are incurred over 1 year starting 3 years before the first UFTP shipments.

For BTP Vehicle Fleet Mockups:

- Requires one NWMO Engineering/Technical Specialist/Advisor FTE over 1 years at 1,470 hours per FTE per year for tractors and trailers combined, finishing 3 years before the first BTP shipments.
- Requires 1 mockup each of the tractor and trailer, the costs for which are incurred over 1 year starting 3 years before the first UFTP shipments.

- The UFTS transport vehicles and UFTS escort vehicles will be used for testing and commissioning to ensure

transportation campaign readiness.

- The total cost of the UFTS transport vehicles and UFTS escort vehicles (for testing/commissioning) is not specific to Reactor Storage Facility.
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2037
Labour Cost	\$631	Finish Year	2047
Material Cost	\$1,139	Duration	11 years
Other Cost	\$0	WBS Type	Step Fixed
Subtotal	\$1,771		
Allowance	\$443		
Total Cost	\$2,213		

TRANSPORTATION VEHICLES FOR BRUCE

680.40.10.30

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Bruce site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of UFTP tractors and trailers and security escort vehicles for transport from the Bruce Site.

Assumptions

- All used fuel shipments from the Bruce site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one UFTP, accompanied by one security escort vehicle.
- The UFTP vehicle fleet consists of 11 tractors, 11 trailers, and 11 security escort vehicles (9 of each for transport operations plus 2 of each as spares).
- The UFTP vehicle fleet replacement intervals are as follows (and continued until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The UFTP vehicle fleet is shared between all OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the UFTP evenly across the axles.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$38,791
Other Cost	\$0
Subtotal	\$38,791
Allowance	\$13,577
Total Cost	\$52,368

Start Year	2042
Finish Year	2086
Duration	45 years
WBS Type	Step Fixed

TRANSPORTATION VEHICLES FOR PICKERING

680.40.10.40

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Pickering site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of UFTP tractors and trailers and security escort vehicles for transport from the Pickering site.

Assumptions

- All used fuel shipments from the Pickering site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one UFTP, accompanied by one security escort vehicle.
- The UFTP vehicle fleet consists of 11 tractors, 11 trailers, and 11 security escort vehicles (9 of each for transport operations plus 2 of each as spares).
- The UFTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The UFTP vehicle fleet is shared between all OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the UFTP evenly across the axles.
- Includes one-time security deposit per toll transponder, prorated by the number of packages shipped from interim storage facilities that use toll roads, assuming 1 transponder for each tractor and each escort vehicle, no replacement, and security deposit is not returned.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2042
Labour Cost	\$0	Finish Year	2086
Material Cost	\$12,211	Duration	45 years
Other Cost	\$2	WBS Type	Step Fixed
Subtotal	\$12,213		
Allowance	\$4,274		
Total Cost	\$16,487		

TRANSPORTATION VEHICLES FOR DARLINGTON

680.40.10.50

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Darlington site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of UFTP tractors and trailers and security escort vehicles for transport from the Darlington site.

Assumptions

- All used fuel shipments from the Darlington site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one UFTP, accompanied by one security escort vehicle.
- The UFTP vehicle fleet consists of 11 tractors, 11 trailers, and 11 security escort vehicles (9 of each for transport operations plus 2 of each as spares).
- The UFTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The UFTP vehicle fleet is shared between all OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the UFTP evenly across the axles.
- Includes one-time security deposit per toll transponder, prorated by the number of packages shipped from interim storage facilities that use toll roads, assuming 1 transponder for each tractor and each escort vehicle, no replacement, and security deposit is not returned.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

680.40.10.50

	2020K\$	Start Year	2042
Labour Cost	\$0	Finish Year	2086
Material Cost	\$16,771	Duration	45 years
Other Cost	\$9	WBS Type	Step Fixed
Subtotal	\$16,780		
Allowance	\$5,873		
Total Cost	\$22,653		

TRANSPORTATION VEHICLES FOR POINT LEPREAU

680.40.10.60

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Point Lepreau site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of BTP tractors and trailers and security escort vehicles for transport from the Point Lepreau site.

Assumptions

- All used fuel shipments from the Point Lepreau site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one BTP, accompanied by one security escort vehicle.
- The BTP vehicle fleet consists of 6 tractors, 6 trailers, and 6 security escort vehicles (5 of each for transport operations plus 1 of each as spares).
- The BTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The BTP vehicle fleet is shared between all non-OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the BTP evenly across the axles.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$9,383
Other Cost	\$2
Subtotal	\$9,384
Allowance	\$3,285
Total Cost	\$12,669

Start Year	2049
Finish Year	2065
Duration	17 years
WBS Type	Step Fixed

TRANSPORTATION VEHICLES FOR CHALK RIVER

680.40.10.70

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Chalk River site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of BTP tractors and trailers and security escort vehicles for transport from the Chalk River site.

Assumptions

- All used fuel shipments from the Chalk River site will be transported by road mode. All used fuel currently located at the Whiteshell site is assumed to have been transported to the Chalk River site prior to the start of DGR operations.

- Each shipment consists of one tractor-trailer carrying one BTP, accompanied by one security escort vehicle.

- The BTP vehicle fleet consists of 6 tractors, 6 trailers, and 6 security escort vehicles (5 of each for transport operations plus 1 of each as spares).

- The BTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):

- Tractors replaced every 7 years,
- Trailers replaced every 10 years, and
- Escort vehicles replaced every 4 years.

- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.

- The BTP vehicle fleet is shared between all non-OPG used fuel origin sites.

- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.

- Tractor fleet unit costs and/or allowances include the following:

- a) speed limiter to meet provincial regulations;
- b) radar-based collision mitigation system to assist drivers with collision avoidance;
- c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
- d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).

- Trailer fleet allowances include custom-designed mounting frames to spread the load of the BTP evenly across the axles.

- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$450
Other Cost	\$0
Subtotal	\$450
Allowance	\$157
Total Cost	\$607

Start Year	2049
Finish Year	2065
Duration	17 years
WBS Type	Step Fixed

TRANSPORTATION VEHICLES FOR GENTILLY 1

680.40.10.80

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Gentilly site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of BTP tractors and trailers and security escort vehicles for transport from the Gentilly site.

Assumptions

- All used fuel shipments from the Gentilly 1 site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one BTP, accompanied by one security escort vehicle.
- The BTP vehicle fleet consists of 6 tractors, 6 trailers, and 6 security escort vehicles (5 of each for transport operations plus 1 of each as spares).
- The BTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The BTP vehicle fleet is shared between all non-OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the BTP evenly across the axles.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$175
Other Cost	\$0
Subtotal	\$175
Allowance	\$61
Total Cost	\$237

Start Year	2049
Finish Year	2065
Duration	17 years
WBS Type	Step Fixed

TRANSPORTATION VEHICLES FOR GENTILLY 2

680.40.10.90

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Gentilly 2 site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of BTP tractors and trailers and security escort vehicles for transport from the Gentilly 2 site.

Assumptions

- All used fuel shipments from the Gentilly 2 site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one BTP, accompanied by one security escort vehicle.
- The BTP vehicle fleet consists of 6 tractors, 6 trailers, and 6 security escort vehicles (5 of each for transport operations plus 1 of each as spares).
- The BTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The BTP vehicle fleet is shared between all non-OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the BTP evenly across the axles.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$4,349
Other Cost	\$1
Subtotal	\$4,350
Allowance	\$1,523
Total Cost	\$5,873

Start Year	2049
Finish Year	2065
Duration	17 years
WBS Type	Step Fixed

TRANSPORTATION VEHICLES FOR DOUGLAS POINT

680.40.10.100

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the vehicle fleet required to facilitate transport of used fuel by road from the Douglas Point (Bruce) site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the fleet of BTP tractors and trailers and security escort vehicles for transport from the Douglas Point (Bruce) site.

Assumptions

- All used fuel shipments from the Douglas Point (Bruce) site will be transported by road mode.
- Each shipment consists of one tractor-trailer carrying one BTP, accompanied by one security escort vehicle.
- The BTP vehicle fleet consists of 6 tractors, 6 trailers, and 6 security escort vehicles (5 of each for transport operations plus 1 of each as spares).
- The BTP vehicle fleet replacement intervals are as follows (and replacements continue until completion of transport campaign):
 - Tractors replaced every 7 years,
 - Trailers replaced every 10 years, and
 - Escort vehicles replaced every 4 years.
- No allowance is given for the remaining useful life, salvage value, or disposal cost of vehicle fleet at time of replacement or retirement.
- The BTP vehicle fleet is shared between all non-OPG used fuel origin sites.
- Fleet costs are prorated by interim storage facility based on the share of the total shipments using these vehicles.
- Tractor fleet unit costs and/or allowances include the following:
 - a) speed limiter to meet provincial regulations;
 - b) radar-based collision mitigation system to assist drivers with collision avoidance;
 - c) anti-theft electronic immobilizer system (e.g. biometric or handprint scanner), and;
 - d) passenger mounted LCD touch screen computer with GPS interface for communications with the security escort vehicle and the Communication & Control Centre (C&CC).
- Trailer fleet allowances include custom-designed mounting frames to spread the load of the BTP evenly across the axles.
- See 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$1,035
Other Cost	\$0
Subtotal	\$1,035
Allowance	\$362
Total Cost	\$1,397

Start Year	2049
Finish Year	2065
Duration	17 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES - NON-SITE-SPECIFIC

680.40.20.10

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Design, procurement, testing, and commissioning of the transportation packages required to facilitate transport campaign readiness for the transport of used fuel by road.

Deliverables

For each of the following transportation package types:

- a) Used Fuel Transportation Package (UFTP)
- b) HI-STAR 63 Package (BTP)

the following deliverables are required:

- Completed design basis documentation.
- Certificate for Transportation Package Design issued by the Competent Authority.
- An approved transportation system utilizing the UFTP and BTP system and the approved commissioning plans.
- Marking, labelling and placarding of transportation system components.
- Real time tracking system.
- Design features for repeated use, as required.
- Design features for mounting and securing packages on transport conveyance.

Assumptions

- Requires one NWMO Engineering/Technical Specialist/Advisor FTE over 3 years at 1,470 hours per FTE year for UFTPs starting 4 years before the first UFTP shipments.
- Requires one NWMO Engineering/Technical Specialist/Advisor FTE over 3 years at 1,470 hours per FTE year for BTPs starting 4 years before the first BTP shipments.
- One UFTP mockup and one BTP mockup for demonstration of transportation campaign readiness.
- Transportation packages (including impact limiters) are allocated to the certification requirement for services and testing.
- For both the UFTP and the BTP, the design life is assumed to be 50 years from initial service date.
- The total cost of the transportation packages (including the impact limiter) is not specific to Reactor Storage Facility.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$947
Material Cost	\$4,007
Other Cost	\$0
Subtotal	\$4,955
Allowance	\$1,239
Total Cost	\$6,193

Start Year	2039
Finish Year	2048
Duration	10 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR BRUCE

680.40.20.30

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Bruce site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel from the Bruce site.

Assumptions

- All used fuel in modules at Bruce site will be transported in UFTPs. Douglas Point fuel in baskets is covered in WEDS 680.40.20.100.
- Each UFTP consists of a cask body and lid plus an impact limiter that attaches to the top of the lid. The cask is designed to accommodate two fuel modules stacked on top of each other and can contain a total of 192 CANDU-style used fuel bundles. Costs of UFTPs include cask body, lid, and impact limiter, but exclude modules.
- The UFTP package fleet consists of 21 UFTPs.
- The same UFTPs will be used to ship used fuel from the Bruce, Pickering, and Darlington sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of UFTPs shipped.
- Empty UFTPs containing empty modules will be returned to interim storage facilities. The returned UFTPs will be reused for future shipments. Reuse or disposal of the returned modules is the responsibility of the fuel waste owner.
- Replacement interval for UFTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of UFTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of UFTP retirement. Decommissioning of UFTP fleet is assessed in WEDS 680.60.
- The entire UFTP fleet is purchased, tested, and commissioned prior to the start of transport operations.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$16,115
Other Cost	\$0
Subtotal	\$16,115
Allowance	\$5,640
Total Cost	\$21,755

Start Year	2039
Finish Year	2042
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR PICKERING

680.40.20.40

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Pickering site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel from the Pickering site.

Assumptions

- All used fuel from Pickering site will be transported in UFTPs.
- Each UFTP consists of a cask body and lid plus an impact limiter that attaches to the top of the lid. The cask is designed to accommodate two fuel modules stacked on top of each other and can contain a total of 192 CANDU-style used fuel bundles. Costs of UFTPs include cask body, lid, and impact limiter, but exclude modules.
- The UFTP package fleet consists of 21 UFTPs.
- The same UFTPs will be used to ship used fuel from the Bruce, Pickering, and Darlington sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of UFTPs shipped.
- Empty UFTPs containing empty modules will be returned to interim storage facilities. The returned UFTPs will be reused for future shipments. Reuse or disposal of the returned modules is the responsibility of the fuel waste owner.
- Replacement interval for UFTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of UFTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of UFTP retirement. Decommissioning of UFTP fleet is assessed in WEDS 680.60.
- The entire UFTP fleet is purchased, tested, and commissioned prior to the start of transport operations.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$4,999
Other Cost	\$0
Subtotal	\$4,999
Allowance	\$1,750
Total Cost	\$6,749

Start Year	2039
Finish Year	2042
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR DARLINGTON

680.40.20.50

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Darlington site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel from the Darlington site.

Assumptions

- All used fuel from Darlington site will be transported in UFTPs.
- Each UFTP consists of a cask body and lid plus an impact limiter that attaches to the top of the lid. The cask is designed to accommodate two fuel modules stacked on top of each other and can contain a total of 192 CANDU-style used fuel bundles. Costs of UFTPs include cask body, lid, and impact limiter, but exclude modules.
- The UFTP package fleet consists of 21 UFTPs.
- The same UFTPs will be used to ship used fuel from the Bruce, Pickering, and Darlington sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of UFTPs shipped.
- Empty UFTPs containing empty modules will be returned to interim storage facilities. The returned UFTPs will be reused for future shipments. Reuse or disposal of the returned modules is the responsibility of the fuel waste owner.
- Replacement interval for UFTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of UFTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of UFTP retirement. Decommissioning of UFTP fleet is assessed in WEDS 680.60.
- The entire UFTP fleet is purchased, tested, and commissioned prior to the start of transport operations.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$7,033
Other Cost	\$0
Subtotal	\$7,033
Allowance	\$2,461
Total Cost	\$9,494

Start Year	2039
Finish Year	2042
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR POINT LEPREAU

680.40.20.60

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Point Lepreau site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel in baskets from the Point Lepreau site.

Assumptions

- All used fuel from the Point Lepreau site will be transported in BTPs.
- Each BTP consists of a cask body and lid plus top and bottom impact limiters. The cask is designed to accommodate two fuel baskets stacked on top of each other and can contain a total of 120 CANDU-style used fuel bundles. Costs of BTPs include cask body, lid, and impact limiters, but exclude baskets.
- The BTP package fleet consists of 12 BTPs.
- The same BTP fleet will be used to ship used fuel from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of BTPs shipped.
- Empty BTPs containing empty baskets will be returned to interim storage facilities. The returned BTPs will be reused for future shipments. Reuse or disposal of the returned baskets is the responsibility of the fuel waste owner.
- Replacement interval for BTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of BTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of BTP retirement. Decommissioning of BTP fleet is assessed in WEDS 680.60.
- The entire BTP fleet is purchased, tested, and commissioned prior to the start of transport operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$15,829
Other Cost	\$0
Subtotal	\$15,829
Allowance	\$5,540
Total Cost	\$21,369

Start Year	2046
Finish Year	2049
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR CHALK RIVER

680.40.20.70

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Chalk River site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel in baskets from the Chalk River site.

Assumptions

- All used fuel from the Chalk River site will be transported in BTPs.
- Each BTP consists of a cask body and lid plus top and bottom impact limiters. The cask is designed to accommodate two fuel baskets stacked on top of each other and can contain a total of 120 CANDU-style used fuel bundles. Costs of BTPs include cask body, lid, and impact limiters, but exclude baskets.
- The BTP package fleet consists of 12 BTPs.
- The same BTP fleet will be used to ship used fuel from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of BTPs shipped.
- Empty BTPs containing empty baskets will be returned to interim storage facilities. The returned BTPs will be reused for future shipments. Reuse or disposal of the returned baskets is the responsibility of the fuel waste owner.
- Replacement interval for BTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of BTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of BTP retirement. Decommissioning of BTP fleet is assessed in WEDS 680.60.
- The entire BTP fleet is purchased, tested, and commissioned prior to the start of transport operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$660
Other Cost	\$0
Subtotal	\$660
Allowance	\$231
Total Cost	\$892

Start Year	2046
Finish Year	2049
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR GENTILLY 1

680.40.20.80

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Gentilly 1 site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel in baskets from the Gentilly 1 site.

Assumptions

- All used fuel from the Gentilly 1 site will be transported in BTPs.
- Each BTP consists of a cask body and lid plus top and bottom impact limiters. The cask is designed to accommodate two fuel baskets stacked on top of each other and can contain a total of 120 CANDU-style used fuel bundles. Costs of BTPs include cask body, lid, and impact limiters, but exclude baskets.
- The BTP package fleet consists of 12 BTPs.
- The same BTP fleet will be used to ship used fuel from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of BTPs shipped.
- Empty BTPs containing empty baskets will be returned to interim storage facilities. The returned BTPs will be reused for future shipments. Reuse or disposal of the returned baskets is the responsibility of the fuel waste owner.
- Replacement interval for BTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of BTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of BTP retirement. Decommissioning of BTP fleet is assessed in WEDS 680.60.
- The entire BTP fleet is purchased, tested, and commissioned prior to the start of transport operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$316
Other Cost	\$0
Subtotal	\$316
Allowance	\$110
Total Cost	\$426

Start Year	2046
Finish Year	2049
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR GENTILLY 2

680.40.20.90

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Gentilly 2 site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel in baskets from the Gentilly 2 site.

Assumptions

- All used fuel from the Gentilly 2 site will be transported in BTPs.
- Each BTP consists of a cask body and lid plus top and bottom impact limiters. The cask is designed to accommodate two fuel baskets stacked on top of each other and can contain a total of 120 CANDU-style used fuel bundles. Costs of BTPs include cask body, lid, and impact limiters, but exclude baskets.
- The BTP package fleet consists of 12 BTPs.
- The same BTP fleet will be used to ship used fuel from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of BTPs shipped.
- Empty BTPs containing empty baskets will be returned to interim storage facilities. The returned BTPs will be reused for future shipments. Reuse or disposal of the returned baskets is the responsibility of the fuel waste owner.
- Replacement interval for BTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of BTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of BTP retirement. Decommissioning of BTP fleet is assessed in WEDS 680.60.
- The entire BTP fleet is purchased, tested, and commissioned prior to the start of transport operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$0
Material Cost	\$7,947
Other Cost	\$0
Subtotal	\$7,947
Allowance	\$2,782
Total Cost	\$10,729

Start Year	2046
Finish Year	2049
Duration	4 years
WBS Type	Step Fixed

TRANSPORTATION PACKAGES FOR DOUGLAS POINT

680.40.20.100

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- Procurement, testing, and commissioning of the transportation package fleet required to facilitate transport of used fuel by road from the Douglas Point site over the duration of the transport campaign.

Deliverables

- Procurement, testing and commissioning of the transportation package fleet for transport of used fuel in baskets from the Douglas Point site.

Assumptions

- All used fuel from the Douglas Point site will be transported in BTPs.
- Each BTP consists of a cask body and lid plus top and bottom impact limiters. The cask is designed to accommodate two fuel baskets stacked on top of each other and can contain a total of 120 CANDU-style used fuel bundles. Costs of BTPs include cask body, lid, and impact limiters, but exclude baskets.
- The BTP package fleet consists of 12 BTPs.
- The same BTP fleet will be used to ship used fuel from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are prorated by interim storage facility based on the share of BTPs shipped.
- Empty BTPs containing empty baskets will be returned to interim storage facilities. The returned BTPs will be reused for future shipments. Reuse or disposal of the returned baskets is the responsibility of the fuel waste owner.
- Replacement interval for BTPs is assumed to be 50 years, greater than the shipping duration, so a replacement fleet of BTPs is not required.
- No allowance for remaining useful life or salvage value is assumed at time of BTP retirement. Decommissioning of BTP fleet is assessed in WEDS 680.60.
- The entire BTP fleet is purchased, tested, and commissioned prior to the start of transport operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- Fleet procurement costs are incurred over 4 years.
- Costs are incurred during the 4 years prior to transportation operations from the Chalk River, Douglas Point, Gentilly, and Point Lepreau sites.
- See WEDS 680.40.40.10 Equipment for Transportation Logistics for Real Time Tracking for acquisition of satellite phone and GPS systems.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

280

	2020K\$
Labour Cost	\$0
Material Cost	\$1,519
Other Cost	\$0
Subtotal	\$1,519
Allowance	\$532
Total Cost	\$2,051

Start Year	2046
Finish Year	2049
Duration	4 years
WBS Type	Step Fixed

EQUIPMENT FOR TRANSPORTATION LOGISTICS FOR REAL TIME TRACKING

680.40.40.10

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario
WBS Owner G. Cheema Prepared by K. Rijleh Organization: AECOM

Description

The development, procurement, testing, and commissioning of the Real-Time Tracking System.

Deliverables

Complete system design for the Real-Time Tracking System including:

- Development of specifications,
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs),
- Selection of contractors,
- Placing of orders/letting of contracts,
- Review of contractor engineering documentation & engineering drawings,
- Supervision/inspection of equipment installation, and
- Preparation, supervision and performance of tests and commissioning.

At the DGR, the following equipment or equivalent (where * denotes equipment that is assumed to be captured in allowances):

- Surge protection and emergency power,
- Central GPS tracking system,
- 5 Workstations*,
- Multifunction Display Screens*,
- Communication System*, and
- Tracking System Software.

For each tractor and UFTP, the following equipment or equivalent:

- GPS unit for remote real-time tracking of the location (assumed included in carrier fees).

For each tractor:

- Passenger-mounted LCD touch screen computer with GPS interface for communications with the C&CC (assumed factory or dealer installed and captured in allowances and/or vehicle cost).

For each escort vehicle:

- GPS unit for remote real-time tracking of the location (assumed included in carrier fees),
- Dashboard Camera,
- Dashboard Camera Recorder,
- Communication Equipment (satellite telephone, cellular telephone with carrier, CB radio, and CB Antenna), and
- Passenger-mounted LCD touch screen computer with GPS interface for communications with the C&CC (assumed factory or dealer installed and captured in allowances and/or vehicle cost).

Assumptions

- NWMO development, procurement, testing, and commissioning effort equivalent to 1 contract Engineering/Technical Specialist/Advisor FTE over 1 year at 1,856 hours per year starting 2 years before the first year of transportation.

- Per-vehicle equipment purchased in year needed for transportation.
- Replacement/repurchase interval of per-vehicle equipment varies. See worksheets referenced in Rationale for details. In summary:
 - a) every 1 year -- GPS carrier monthly system access fees per year;
 - b) every 2 years -- communication equipment for escort vehicles (satellite telephone, cellular telephone with carrier, CB radio, and CB antenna);
 - c) every 3 years -- surge protection and emergency power; central GPS tracking system; dashboard camera, and; dashboard camera recorder; and
 - d) every 10 years -- tracking system software.
- Design is conceptual: minor and incidental costs not specifically identified are included in "Allowance".
- Other assumptions (including the timing and duration of shipments) as detailed in the Used Fuel Transportation System Reference Scenario: Design and Logistics Final Report.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2041
Labour Cost	\$245	Finish Year	2088
Material Cost	\$5,948	Duration	48 years
Other Cost	\$3,522	WBS Type	Fixed
Subtotal	\$9,715		
Allowance	\$3,400		
Total Cost	\$13,115		

EQUIPMENT FOR TRANSPORTATION LOGISTICS FOR EMERGENCY RESPONSE

680.40.40.20

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario
WBS Owner G. Cheema Prepared by K. Rijleh Organization: AECOM

Description

The development, procurement, testing, and commissioning of the Emergency Response System.

Deliverables

Complete system design for the Emergency Response System including:

- Development of specifications,
- Preparation of tendering documentation and issue of Requests for Proposals (RFPs),
- Selection of contractors,
- Placing of orders/letting of contracts,
- Review of contractor engineering documentation & engineering drawings,
- Supervision/inspection of equipment installation, and
- Preparation, supervision and performance of tests and commissioning.

Conveyance recovery equipment and services are addressed in 680.50.40.10 (Transportation Logistics DGR Emergency Response).

For each UFTP tractor, the following equipment or equivalent:

- 2 Rados Rad 60 Electronic Dosimeters,
- 2 MSAS-Cap Hood - Emergency full-face respirators,
- 1 First Aid Kit, and
- 1 Fire Extinguisher (small fires).

For each UFTP escort vehicle, the following equipment or equivalent:

- 1 ERK-506 Plus Emergency Response Kit,
- 2 Rados Rad 60 Electronic Dosimeters,
- 2 MSAS-Cap Hood - Emergency full-face respirators,
- 1 Yellow and magenta durable polyethylene rope,
- 1 First Aid Kit, and
- 1 Fire Extinguisher (small fires).

Assumptions

- Development, procurement, testing, and commissioning effort equivalent to 1 contract Engineering/Technical Specialist/Advisor FTE over 2 years, at 1,856 hours/year, beginning 2 years before the start of transportation.
- Conveyance recovery equipment and services to be provided by contractor(s) as an operating cost per 680.50.40.10.
- Per-vehicle equipment purchased in year needed for transportation.
- Replacement interval of per-vehicle equipment as specified in Table 18 of the Used Fuel Transportation System

Reference Scenario: Design and Logistics Final Report. See "Emergency Response Equipment" worksheet referenced in Rationale for details.

- Design is conceptual: minor and incidental costs not specifically identified are included in "Allowance".
- Other assumptions (including the timing and duration of shipments) as detailed in the Used Fuel Transportation System Reference Scenario: Design and Logistics Final Report.
- Exclusive of contingency.

Allowance

Allowance of 35% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2041
Labour Cost	\$490	Finish Year	2088
Material Cost	\$1,414	Duration	48 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$1,904		
Allowance	\$666		
Total Cost	\$2,570		

PROJECT MANAGEMENT

680.50.10

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by G. Cheema

Organization: NWMO

Description

Management of UFTS components and reporting on progress, including:

- Preparation of project management documentation.
- Interfacing with engineering, procurement, operations and contractors to ensure that milestones are met as planned.
- Project Close Out

Deliverables

Management of UFTS and reporting on progress, including:

- Project management documentation (Project Charters, Project Execution Plans, Business Case Summaries, Release Quality Estimates, Scope Sheets, Change Control Forms and Schedules),
- Approved project schedules and information on the project costs throughout its duration.
- Regular Project Meetings to discuss schedule, project status, issues, and cash flows.
- Reporting to Program Management on the project's progress.

Assumptions

- Project management is carried out by a core team including one project manager and one contract administrator at 1470 FTE hours per year and one scheduler/cost controller at 1680 FTE hours per year beginning in 2033 and continuing until the end of the transportation campaign in 2088.
- Also subject to overall UFTS assumptions. Major assumptions table attached as "Multi Element Supporting Documentation".

Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$34,469	Finish Year	2088
Material Cost	\$0	Duration	56 years
Other Cost	\$0	WBS Type	Variable
Subtotal	\$34,469		
Allowance	\$8,617		
Total Cost	\$43,087		

TRANSPORTATION LOGISTICS FROM BRUCE TO DGR

680.50.30.20

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from the Bruce to the DGR using the UFTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in UFTPs from the Bruce to the DGR site.

Assumptions

- All used fuel transport logistics between the Bruce and the DGR will be by road mode.
- One way distance from the Bruce to DGR: 1,778 km
- Labour hours per return trip: 137 hours
- Number of UFTP return shipments: 15,147 (2,907,650 bundles)
- UFTP Capacity: 2 modules
- Module Capacity: 96 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$217,786
Material Cost	\$0
Other Cost	\$61,443
Subtotal	\$279,228
Allowance	\$41,884
Total Cost	\$321,113

Start Year	2050
Finish Year	2088
Duration	39 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM PICKERING TO DGR

680.50.30.30

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Pickering to the DGR using the UFTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in UFTPs from Pickering to the DGR site.

Assumptions

- All used fuel transport logistics between Pickering and the DGR will be by road mode.
- One way distance from Pickering to DGR: 1,715 km
- Labour hours per return trip: 133 hours
- Number of UFTP return shipments: 4,699 (902,148 bundles)
- UFTP Capacity: 2 modules
- Module Capacity: 96 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$65,590
Material Cost	\$0
Other Cost	\$18,243
Subtotal	\$83,833
Allowance	\$12,575
Total Cost	\$96,408

Start Year	2043
Finish Year	2050
Duration	8 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM DARLINGTON TO DGR

680.50.30.40

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Darlington to the DGR using the UFTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in UFTPs from Darlington to the DGR site.

Assumptions

- All used fuel transport logistics between Darlington and the DGR will be by road mode.
- One way distance from Darlington to DGR: 1,726 km
- Labour hours per return trip: 134 hours
- Number of UFTP return shipments: 6,610 (1,268,801 bundles)
- UFTP Capacity: 2 modules
- Module Capacity: 96 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$92,958
Material Cost	\$0
Other Cost	\$26,496
Subtotal	\$119,455
Allowance	\$17,918
Total Cost	\$137,373

Start Year	2050
Finish Year	2088
Duration	39 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM POINT LEPREAU TO DGR

680.50.30.50

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Point Lepreau to the DGR using the BTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in BTPs from Point Lepreau to the DGR site.

Assumptions

- All used fuel transport logistics between Point Lepreau and the DGR will be by road mode.
- One way distance from Point Lepreau to DGR: 2,888 km
- Labour hours per return trip: 227 hours
- Number of BTP return shipments: 2,157 (258,820 bundles)
- BTP Capacity: 2 baskets
- Basket Capacity: 60 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$51,388
Material Cost	\$0
Other Cost	\$14,580
Subtotal	\$65,967
Allowance	\$9,895
Total Cost	\$75,862

Start Year	2054
Finish Year	2066
Duration	13 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM CHALK RIVER TO DGR

680.50.30.60

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Chalk River to the DGR using the BTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in BTPs from Chalk River to the DGR site.

Assumptions

- All used fuel transport logistics between Chalk River and the DGR will be by road mode.
- One way distance from Chalk River to DGR: 1,598 km
- Labour hours per return trip: 125 hours
- Number of BTP return shipments: 90 (7,187 bundles)
- BTP Capacity: 2 baskets
- Basket Capacity: 40 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$1,181
Material Cost	\$0
Other Cost	\$462
Subtotal	\$1,643
Allowance	\$246
Total Cost	\$1,889

Start Year	2068
Finish Year	2068
Duration	1 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM GENTILLY 1 TO DGR

680.50.30.70

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Gentilly 1 to the DGR using the BTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in BTPs from Gentilly 1 to the DGR site.

Assumptions

- All used fuel transport logistics between Gentilly 1 and the DGR will be by road mode.
- One way distance from Gentilly 1 to DGR: 2,138 km
- Labour hours per return trip: 169 hours
- Number of BTP return shipments: 43 (3,213 bundles)
- BTP Capacity: 2 baskets
- Basket Capacity: 38 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$763
Material Cost	\$0
Other Cost	\$209
Subtotal	\$971
Allowance	\$146
Total Cost	\$1,117

Start Year	2050
Finish Year	2050
Duration	1 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM GENTILLY 2 TO DGR

680.50.30.80

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Gentilly 2 to the DGR using the BTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in BTPs from Gentilly 2 to the DGR site.

Assumptions

- All used fuel transport logistics between Gentilly 2 and the DGR will be by road mode.
- One way distance from Gentilly 2 to DGR: 2,138 km
- Labour hours per return trip: 169 hours
- Number of BTP return shipments: 1,083 (129,925 bundles)
- BTP Capacity: 2 baskets
- Basket Capacity: 60 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$19,209
Material Cost	\$0
Other Cost	\$5,456
Subtotal	\$24,664
Allowance	\$3,700
Total Cost	\$28,364

Start Year	2050
Finish Year	2054
Duration	5 years
WBS Type	Variable

TRANSPORTATION LOGISTICS FROM DOUGLAS POINT TO DGR

680.50.30.90

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Transport of used fuel inventory from Douglas Point to the DGR using the BTP.

Deliverables

Operation of the transportation vehicle fleet for the transport of used fuel in BTPs from Douglas Point to the DGR site.

Assumptions

- All used fuel transport logistics between Douglas Point and the DGR will be by road mode.
- One way distance from Douglas Point to DGR: 1,778 km
- Labour hours per return trip: 137 hours
- Number of BTP return shipments: 207 (22,256 bundles)
- BTP Capacity: 2 baskets
- Basket Capacity: 54 used fuel bundles
- Fuel consumption: tractor-trailer: 45 litres per 100 km, security escort vehicle: 11.3 litres per 100 km
- Fuel cost: \$1.31 per litre
- Insurance, licensing, and permit costs: \$66,598 per tractor per year, \$6,972 per security escort vehicle per year.
- Insurance, licensing, and permit costs for trailers are captured in allowances.
- Costs based on average shipment effort.
- Includes labour costs for NWMO personnel that operate the truck and escort vehicle.
- See 680.50.10 for Transportation Project Management
- See 680.50.50 for Transportation Vehicle and Package Maintenance.
- See 680.50.40.10 for Transportation Logistics DGR Emergency Response.
- See 680.50.40.20 for Transportation Logistics DGR Real Time Tracking.
- Exclusive of contingency.

Allowance

Allowance of 15% added to reflect the level of design and uncertainties.

301

	2020K\$
Labour Cost	\$2,976
Material Cost	\$0
Other Cost	\$1,176
Subtotal	\$4,152
Allowance	\$623
Total Cost	\$4,775

Start Year	2067
Finish Year	2068
Duration	2 years
WBS Type	Variable

TRANSPORTATION LOGISTICS DGR EMERGENCY RESPONSE

680.50.40.10

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

The implementation and maintenance of the Emergency Response System, including communications, operations, and documentation for the duration of the transportation campaign.

Deliverables

- An ongoing Emergency Response System ready to respond to any accident or incident for the duration of transport campaign (i.e., transportation operations).

- Operation of the Emergency Response System includes:

a) Completed emergency response plan with all the necessary documentation (i.e., references to applicable regulations, emergency procedures, maps, safety files, Transport Emergency Response Plan, Emergency Response Assistance Plan, as required).

b) Staffed Emergency Response System ready to raise alarm, conduct situation analysis, activate response agencies, notify authorities, activate part-time personnel and deploy a recovery system.

- When required core staff will activate emergency response teams, such as:

a) Command and Decision Team – Team roles/responsibilities may include logistics and technical assistance to Authorities, decision on proper technical means to be implemented; and management of other teams.

b) Technical Analysis Team – Team roles/responsibilities may include estimation of the technical state of the packaging and of associated impacts; and proposition of technical emergency and assistance solutions.

c) Mobile Command Team – Team roles/responsibilities may include: implementation of command, information and expertise near the incident; and first intervention equipment (satellite communication system, radio or chemical protection, equipment, camera, and computers). This team implements processes to minimize consequences or to bring a solution to the situation.

d) Communications Team – Team roles/responsibilities may include: preparation and development of crisis communication especially dedicated to the media situation; provision of specific communication plan; provide incident information for the press and for other communication entities; accept information from the press.

Assumptions

- One annual emergency exercise/year (600 person-hours).

- One actual emergency exercise/year (600 person-hours).

- Two full-time equivalent (FTE) Operators at 1,680 hours per FTE per year to maintain and operate the Emergency Response System.

- Assumes an annual fee over the transportation campaign for contracting emergency response services to be available in the event of an incident, as reflected in 'Other Costs'. It does not include the capital, labour and/or other costs associated with responding to an actual incident or event as response costs will depend on type of incident/event and severity.

- Minor incidentals, including working area services, consumables, conventional and radiological waste handling, etc., accommodated in "Allowance".

680.50.40.10

- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$22,014	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$4,600	WBS Type	Variable
Subtotal	\$26,614		
Allowance	\$6,654		
Total Cost	\$33,268		

TRANSPORTATION LOGISTICS DGR REAL TIME TRACKING

680.50.40.20

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

The implementation and maintenance of the Real Time Tracking System for the duration of the transport campaign (i.e., transportation operations).

Deliverables

- Secure, real-time tracking and reporting on the current position of the UFTS components.
- Operation of the Real Time Tracking System includes:
 - a) Real time information on UFTS components (transportation packages, conveyances, escort vehicles),
 - b) Provision of progress information for transport operations, and
 - c) Maintaining security of transmitted information.

Assumptions

- Real Time Tracking System operates 24 hours per day, 7 days a week (8760 hours per year).
- Equipment for Real Time Tracking System is captured under 680.40.40.10.
- Real Time Tracking System requires two Controllers present 24 hours per day, 7 days a week (17,520 hours per year). Assuming each Controller FTE works 1680 hours, approximately 10.4 FTEs are required per year over the duration of the transportation campaign.
- Real Time Tracking System management requires one FTE supervisor/manager and one FTE administration per year over the duration of the transportation campaign.
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$100,831	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$0	WBS Type	Variable
Subtotal	<i>\$100,831</i>		
Allowance	\$25,208		
Total Cost	\$126,038		

TRANSPORTATION VEHICLES MAINTENANCE

680.50.50

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Maintenance of transportation vehicle fleet.

Deliverables

Perform preventive maintenance of transportation vehicle fleet, including UFTP tractors, trailers, and escort vehicles.

Assumptions

- The maintenance of the transportation vehicle fleet is contracted to a third party specializing in maintenance of transportation vehicles.
- The annual maintenance cost of transportation vehicles is equivalent to 10% of the purchase cost and is incurred only in the years that the vehicles are being used for transportation.
- Incidental maintenance of low-mileage non-fleet vehicles (e.g., mock-ups) accounted for under "allowance".
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$44,841	WBS Type	Variable
Subtotal	\$44,841		
Allowance	\$11,210		
Total Cost	\$56,051		

TRANSPORTATION PACKAGES MAINTENANCE

680.50.60

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

Maintenance of transportation packages.

Deliverables

Perform annual preventive maintenance of UFTP and BTP transportation package fleets.

Assumptions

- The annual maintenance cost for transportation packages is equivalent to 4% of the purchase cost and is incurred only in the years that the packages are being used for transportation.
- Incidental maintenance of low-mileage non-fleet packages (e.g., mock-ups) accounted for under "allowance".
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2043
Labour Cost	\$0	Finish Year	2088
Material Cost	\$0	Duration	46 years
Other Cost	\$71,757	WBS Type	Variable
Subtotal	\$71,757		
Allowance	\$17,939		
Total Cost	\$89,696		

ENVIRONMENTAL MANAGEMENT

680.55

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

The set-up, and monitoring, of transportation operations within an Environmental Management System (EMS) for NWMO in accordance with ISO 14001, including:

- a) Auditing of supplier EMSs, and review of proposals,
- b) Liaison with regulators regarding environmental and other regulatory requirements,
- c) Assistance with transportation aspects related to environmental management,
- d) Planning of environmental monitoring activities, as required, and
- e) Ensuring that all environmental requirements are met by the UFTS.

Deliverables

- Input to NWMO EMS.
- Communications with regulators.
- Plans, audits and reports as required by the EMS.

Assumptions

- Site Preparation & Construction Period: 2 FTEs per year at 1,470 hours per year per FTE over the 9 years leading up to the first year of shipments to support the development of an EMS for transport operations.
- Operations Period: 0.5 FTEs per year at 1,470 hours per year per FTE over the shipment years to support environmental management activities and monitoring.
- Post Operations: 0.5 FTEs per year at 1,470 hours per year per FTE over the 3 years following the last year of shipments to support environmental management activities and monitoring after operations.
- Expenses and incidentals are included in "Allowance".
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$	Start Year	2034
Labour Cost	\$6,709	Finish Year	2091
Material Cost	\$0	Duration	58 years
Other Cost	\$0	WBS Type	Fixed
Subtotal	\$6,709		
Allowance	\$1,677		
Total Cost	\$8,386		

DECOMMISSIONING

680.60

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by K. Rijleh

Organization: AECOM

Description

- The development and implementation of plans to decommission the UFTS.
- Decommissioning includes:
 - a) Decommissioning the UFTS.
 - b) Consigning controlled decommissioning waste to a suitable waste management/disposal facility.

Deliverables

- A deactivated and decommissioned UFTS.
- Decommissioning includes:
 - a) An approved plan for decommissioning the UFTS and associated loading equipment.
 - b) Dismantled and decommissioned UFTS and associated loading equipment.
 - c) Decommissioning waste stored in an owner management/disposal facility.

Assumptions

- It is assumed that the UFTS vehicle fleet (tractors, trailers and escort vehicles) have been maintained according to procedures and will be disposed of without need for decommissioning.
- No credit is assumed for remaining useful life or salvage value of the UFTS vehicle fleet at time of decommissioning.
- Package mockups are decommissioned at the cost as production packages.
- The BTP package fleet (including mockup) will be decommissioned at rate of 4 packages per year over a 3-year span immediately after the basket shipments are complete (years 2069 to 2072).
- The UFTP package fleet (including mockup) will be decommissioned at a rate of 4 packages per year over a 5-year span immediately after the module shipments are complete (years 2089 to 2093).
- Contractor, non-permanent equipment and non-permanent material costs (i.e., "Other Costs") of decommissioning are estimated as 10% of the capital cost sum of the UFTS package fleet (including mockups). An allowance for waste management/disposal operation cost of decommissioning waste is included in this sum.
- "Labour Costs" are assumed to be 30% of the "Other Costs", and labour hours are estimated by dividing the Labour Costs by the hourly rate of a "Radiation Technician".
- Exclusive of contingency.

Allowance

Allowance of 25% added to reflect the level of design and uncertainties.

	2020K\$
Labour Cost	\$1,753
Material Cost	\$0
Other Cost	\$5,843
Subtotal	\$7,595
Allowance	\$1,899
Total Cost	\$9,494

Start Year	2069
Finish Year	2094
Duration	26 years
WBS Type	Variable

PROGRAM MANAGEMENT

680.90

Case 680 ALL ROAD TRANSPORTATION SYSTEM, 5.5 Million Fuel Bundles, Crystalline Scenario

WBS Owner G. Cheema

Prepared by G. Cheema

Organization: NWMO

Description

This task is to establish the organizational structure to support and manage the transportation program.

Deliverables

Establishment and operation of the following transportation related programs:

- Training/Certification/Licensing Program for Staff (Drivers)
- Safeguards Program
- Emergency Management Program
- Radiation Protection Program
- Aging Management Program
- Security Program
- Reporting Program
- Conventional Health and Safety Program
- Waste Management Program
- Environmental Monitoring Program

Procurement and Commissioning of:

- Transportation package fleet (UFTPs and BTPs)
- Transportation package conveyance fleet (tractors and trailers)
- Escort vehicle fleet
- Supporting Equipment

Management and Operations

- Operation, management and administration the Used Fuel Transportation System
- Shipment/Resource scheduling for transportation operations
- Management of engineering design changes to system

Exclusive of contingency.

Assumptions

Labour - 2033 to 2088:

- 1 FTE Management/Executive (1,470 hours per FTE per year)
- 1 FTE Administration (1,470 hours per FTE per year)
- 9 FTE Engineering/Technical Specialist/Advisor (1,470 hours per FTE per year)
- 2 FTE Operator (1,680 hours per FTE per year)
- 2 FTE Mechanical Maintainer (1,680 hours per FTE per year)

Other:

- Supporting program operations, 10 trips annually to DGR site & manufacturing/vendor sites & interim storage

680.90

areas & CNSC at \$3,121.80 per trip.

Allowance

Allowance of 15% added to travel.

Allowance of 25% added to labour costs to reflect the level of design and uncertainties.

	2020K\$	Start Year	2033
Labour Cost	\$137,958	Finish Year	2088
Material Cost	\$0	Duration	56 years
Other Cost	\$1,748	WBS Type	Variable
Subtotal	\$139,706		
Allowance	\$34,752		
Total Cost	\$174,457		