

# APM Conceptual Design and Cost Estimate Update Deep Geological Repository Lifecycle Cost and Schedule Report Crystalline Rock Environment Copper Used Fuel Container

APM-REP-00440-0003

August 2011

**SNC-Lavalin Nuclear Inc.**  
SLN Report No. 020606-5100-REPT-0001



**SNC-LAVALIN**  
**Nuclear**

**nwmo**

NUCLEAR WASTE  
MANAGEMENT  
ORGANIZATION

SOCIÉTÉ DE GESTION  
DES DÉCHETS  
NUCLÉAIRES

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# NWMO APM Conceptual Design and Cost Estimate Update

020606-5100-REPT-0001

DEEP GEOLOGICAL REPOSITORY  
LIFECYCLE COST AND SCHEDULE REPORT  
CRYSTALLINE ROCK ENVIRONMENT  
COPPER CONTAINER

Submission to  
Nuclear Waste Management Organization

August 2011

SNL 020606 / GAL 0911170032



**SNC-LAVALIN  
Nuclear**



Title

**Report**

**Deep Geological Repository Lifecycle Cost and Schedule – Crystalline Rock, Copper Container**

Project

**APM Conceptual Design and Cost Estimate Update**

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RA	01	GWS		JR	August 2011	Revised

Issue Codes: RC = Released for Construction, RD = Released for Design, RF = Released for Fabrication, RI = Released for Information, RP = Released for Purchase, RQ = Released for Quotation, RR = Released for Review and Comments.

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## EXECUTIVE SUMMARY

The Nuclear Waste Management Organization (NWMO) has been directed by the Government of Canada to implement Adaptive Phased Management (APM), Canada's plan for the long-term management of its used nuclear fuel. The APM approach includes centralized long-term management of used fuel in a Deep Geological Repository (DGR) constructed within a suitable crystalline or sedimentary rock formation.

In 2009 and 2010, the NWMO updated the previous conceptual design for the APM program. Based on the updated conceptual design for the DGR, this report, the "*Deep Geological Repository Lifecycle Cost and Schedule Report, Crystalline Rock Environment, Copper Container*", presents cost and schedule estimates for a crystalline rock DGR design that comprises a feasible configuration of required facilities and infrastructure to safely receive, re-package and place used nuclear fuel delivered from source reactor storage sites.

This report specifically addresses the estimated costs and scheduling from construction through decommissioning. The design basis for the estimate is as presented in the report "*Deep Geological Repository Design Report – Crystalline Rock Environment*" submitted to NWMO by SNC-Lavalin Nuclear (SLN 020606-6100-REPT-0001).

Two used nuclear fuel inventory scenarios are considered in this analysis. Under the Base Case, 3.6 million used CANDU fuel bundles will be directed to the DGR over a 30 year placement period. The Alternate Case, which assumes (in part) the construction of new nuclear reactors, sees this quantity increased to 7.2 million bundles delivered to the DGR over a 60 year period. This fuel is repackaged into copper IV-25 Used Fuel Containers (UFCs) for emplacement underground.

### Methodology

For each case (identified as '560', the Base Case, and '561', the Alternate Case), the scope of the DGR project was systematically divided into separate areas of effort to create a project Work Breakdown Structure (WBS). Many of these areas were subsequently broken down into sub-tasks of increasing detail to allow formulation of reasonable cost and schedule estimates. The full structures of the 560 and 561 WBSs are presented in Appendix A, the two WBSs are based on the same structure to facilitate comparison. Appendix B includes summary descriptions (Work Element Description Sheets, or 'WEDS') for each of the populated WBS nodes.

The WBS used in this report was specifically developed to facilitate estimate development by the 2009/2010 APM design update and cost estimation team and to allow comparison with earlier (2003) estimates of DGR costs and schedule.

Elements of the DGR scope within the WBS were subject to cost and schedule analysis by the project team. The team evaluated components of the WBS related to construction, operation and decommissioning, with an emphasis on the use of contemporary turn-key ('engineer-procure-construct', EPC) delivery practices and existing/conventional technologies. Select components of the WBS were reserved by NWMO for internal evaluation.

Please note that the NWMO subsequently developed an improved WBS that encompasses and extends beyond the WBS elements assumed in this report for “Siting”, “Repository System Development”, “Safety Assessment”, “Licensing and Approvals”, “Public Affairs” and “Program Management”. This alternate WBS, which has not been used in the current estimate, includes aspects such as “Building Relationships”, “Adapting to Change”, “Research and Confidence Building”, etc. Where overlap exists, the NWMO WBS supersedes and supplants the WBS and data presented herein.

Each of the evaluated work elements from the WBS has been assessed in terms of required labour, permanent materials/equipment and other costs. WBS components are scheduled in project years, with Year 1 currently held to be 2010. Costs are stated in constant 2010 Canadian dollars.

A Microsoft Access database and sets of Microsoft Excel workbooks accompany, and form part of, this cost and schedule report. These files are intended to provide additional supporting information. A variety of quotes, notes, calculations and additional supporting material are contained within the database.

An initial draft of this report (which used a 100 year long extended operations period) was submitted to NWMO in December 2010. Based on comments received from the NWMO in January 2011, the estimate was revised to incorporate a 70 year extended operations period. Attachments and inclusions have been regenerated to reflect the current project schedule.

### Bounds of Study

Work related to the following DGR components, although plotted on the estimated DGR schedule for context, have been independently estimated and are not included in this cost estimate:

- Siting;
- Repository System Development;
- Safety Assessment;
- Licensing and Approvals;
- Public Affairs; and
- Program Management.

As discussed in later sections of this report, costs presented in this report include an allowance to accommodate expected cost items not explicitly encompassed in estimate line items. Contingency has been added to the estimate at the direction of the NWMO to reflect NWMO's understanding of risk and uncertainty.

## Schedule

The overall schedule for the Base and Alternate Cases is as depicted below:

### Base Case

Phases		Item	(Y)ear	
Siting & Licensing		Complete Feasibility Studies (3)	Y3	(December)
		Complete Subsurface Investigations (2)	Y8	(December)
		Select Site	Y9	(January)
		End Siting & Licensing Process	Y15	(December)
Construction		Obtain Construction Licence/Begin Construction	Y16	(January)
		End Construction	Y25	(December)
Operation	Major Operations	Obtain Operations License/Begin Operations	Y26	(January)
	Extended Operations	Complete Loading Fuel/End Operations	Y55	(December)
		Begin Extended Operations (Monitoring)	Y56	(January)
Closure and Decommissioning	Major Decommissioning	Complete Extended Operations (70 yrs)	Y125	(December)
		Obtain Decommissioning Licence/Begin Decommissioning	Y126	(January)
	Final Closure	End Major Decommissioning (10 yrs)	Y135	(December)
		Begin Final Closure Period	Y136	(January)
		Abandonment Licence/End Final Closure (15 yrs)	Y150	(December)

### Alternate Case

Phases		Item	(Y)ear	
Siting & Licensing		Complete Feasibility Studies (3)	Y3	(December)
		Complete Subsurface Investigations (2)	Y8	(December)
		Select Site	Y9	(January)
		End Siting & Licensing Process	Y15	(December)
Construction		Obtain Construction Licence/Begin Construction	Y16	(January)
		End Construction	Y25	(December)
Operation	Major Operations	Obtain Operations License/Begin Operations	Y26	(January)
	Extended Operations	Complete Loading Fuel/End Operations	Y85	(December)
		Begin Extended Operations (Monitoring)	Y86	(January)
Closure and Decommissioning	Major Decommissioning	Complete Extended Operations (70 yrs)	Y155	(December)
		Obtain Decommissioning Licence/Begin Decommissioning	Y156	(January)
	Final Closure	End Major Decommissioning (10 yrs)	Y165	(December)
		Begin Final Closure Period	Y166	(January)
		Abandonment Licence/End Final Closure (15 yrs)	Y180	(December)

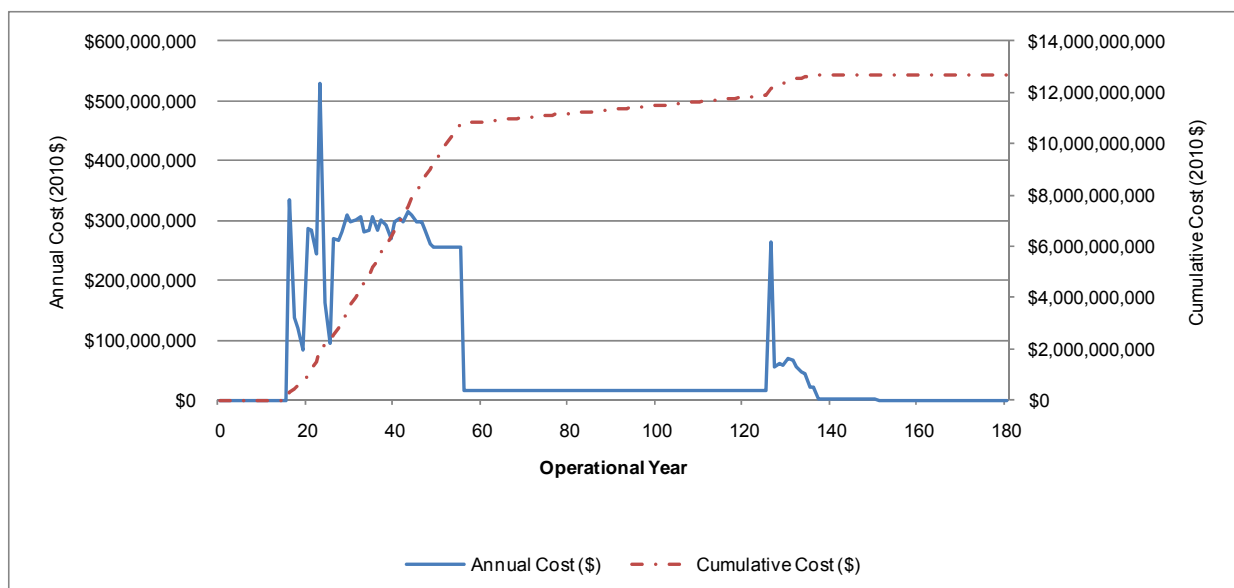
## Estimated Costs

Estimates have been prepared for labour, permanent material and equipment, other costs and an allowance ('allowance' is a percentage-based sum to cover the cost of known but presently undefined requirements for each work element; as noted previously. Contingency has been added to the estimate at the direction of the NWMO to reflect NWMO's understanding of risk and uncertainty.

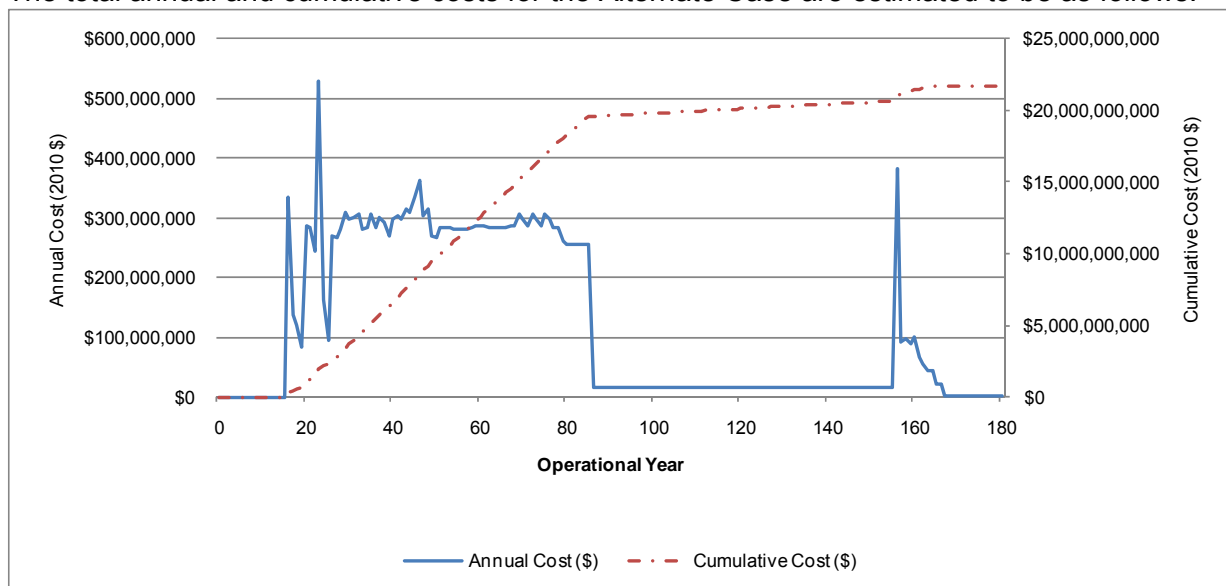
Subject to the inclusions/exclusions, assumptions and limitations presented in this report, the estimated total cost of a crystalline rock DGR (in constant 2010 Canadian dollars) for the subject cases is as follows:

- Base Case (3.6 million used fuel bundles, exclusive of contingency): \$12.7 billion; and
- Alternate Case (7.2 million used fuel bundles, exclusive of contingency): \$21.7 billion.

Given the input years for each cost item, and the overall start and finish years for each work element, total annual costs are presented below for the Base Case in conjunction with the cumulative cost incurred over time.



The total annual and cumulative costs for the Alternate Case are estimated to be as follows:





Costs by phase for the Base Case (not including costs separately estimated by NWMO) are estimated as follows:

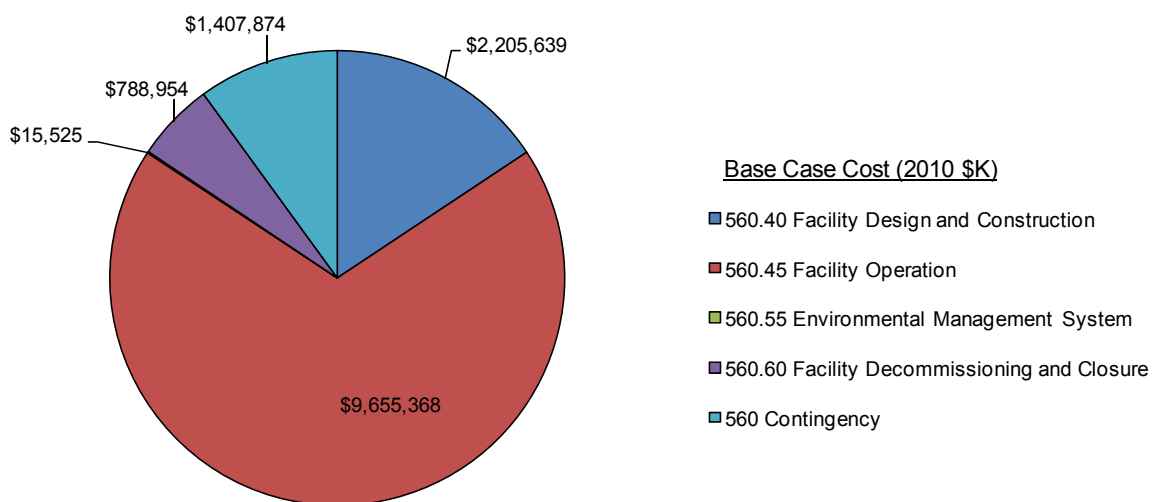
Project Phase		Base Case (2010 \$K)
Siting & Licensing (Y1-Y15)		\$0
Construction (Y16-Y25)		\$2,275,290
Operation	Major Operation (Y26-Y55)	\$8,507,637
	Extended Operation (Y56-Y125)	\$1,093,605
	<i>Operation Subtotal</i>	\$9,601,243
Closure & Decommissioning	Major Decommissioning (Y126-Y135)	\$740,484
	Final Closure (Y136-Y150)	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	\$788,954
<b>560 Subtotal</b>		<b>\$12,665,487</b>
Contingency		\$1,407,874
<b>560 Total</b>		<b>\$14,073,360</b>

Costs by phase for the Alternate Case (not including costs separately estimated by NWMO) are estimated as follows:

Project Phase		Alternate Case (2010 \$K)
Siting & Licensing (Y1-Y15)		\$0
Construction (Y16-Y25)		\$2,275,290
Operation	Major Operation (Y26-Y85)	\$17,290,755
	Extended Operation (Y86-Y155)	\$1,093,957
	<i>Operation Subtotal</i>	\$18,384,712
Closure & Decommissioning	Major Decommissioning (Y156-Y165)	\$997,820
	Final Closure (Y166-Y180)	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	\$1,046,290
<b>561 Subtotal</b>		<b>\$21,706,291</b>
Contingency		\$2,212,981
<b>561 Total</b>		<b>\$23,919,272</b>

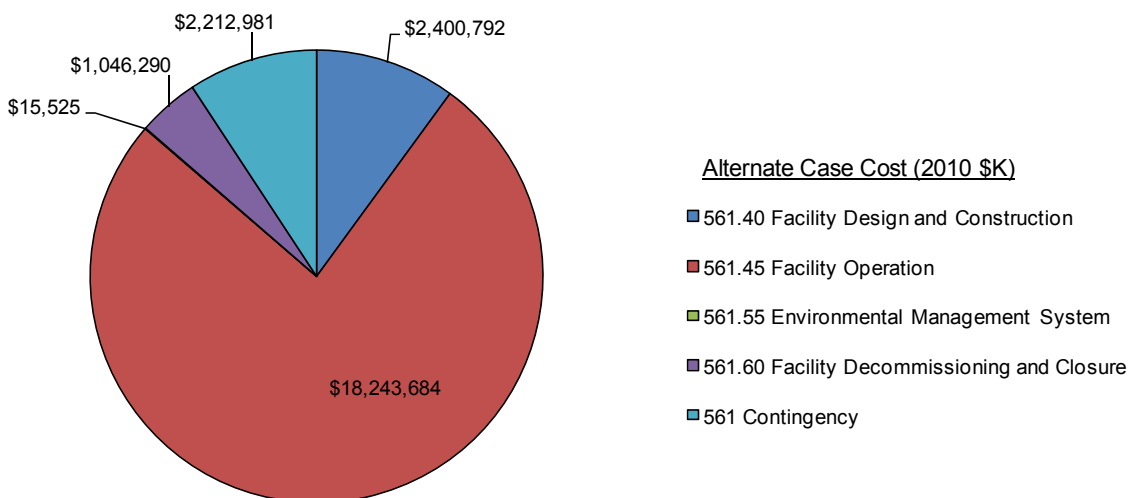
Based on calculations for each of the populated work elements in the work breakdown structure, estimated costs for the Base Case (560) are as follows:

WBS	Title (Base Case)	Estimate (2010 \$K)
560.40	Facility Design and Construction	\$2,205,639
560.45	Facility Operation	\$9,655,368
560.55	Environmental Management System	\$15,525
560.60	Facility Decommissioning and Closure	\$788,954
<b>560 Subtotal</b>		<b>\$12,665,487</b>
	Contingency	\$1,407,874
<b>560 Total</b>		<b>\$14,073,360</b>



Estimated costs for the Alternate Case (561) are as follows:

WBS	Title (Alternate Case)	Estimate (2010 \$K)
561.40	Facility Design and Construction	\$2,400,792
561.45	Facility Operation	\$18,243,684
561.55	Environmental Management System	\$15,525
561.60	Facility Decommissioning and Closure	\$1,046,290
<b>561 Subtotal</b>		<b>\$21,706,291</b>
	Contingency	\$2,212,981
<b>561 Total</b>		<b>\$23,919,272</b>



Comparing the Base Case and Alternate Case estimates demonstrates that preparatory and surface facility decommissioning works are substantially similar between the two cases, as facilities and equipment for both cases are sized for the same annual throughput (120,000 used fuel bundles per year). The primary cost differences between the Base Case and Alternate Case stem from increasing the years of operation (used fuel emplacement) in the Alternate Case, which incurs additional labour, maintenance and project support costs, as well as equipment replacement/refurbishment requirements.

## Estimate Accuracy

The characteristics of the Base and Alternate Case estimates have been examined with regard to contemporary practice in cost engineering, including the following:

- Association for the Advancement of Cost Engineering International (AACE International). 2003. *Cost Estimate Classification System*. AACE International Recommended Practice No. 17R-97; and
- Association for the Advancement of Cost Engineering International (AACE International). 2005. *Cost Estimate Classification System - As Applied in Engineering, Procurement and Construction for the Process Industries*. AACE International Recommended Practice No. 18R-97.

Accepting the design basis (including the postulated used fuel inventories), the conceptual design can be considered a 'Study' or 'Conceptual' cost estimate. Semi-detailed unit costs with assembly level line items dominate the estimate, as do item costs based on existing, available applications. Overall, the estimate can be considered as AACE 'Class 4' for the specific design basis/project scope.

In deference to a lack of benchmark cost data for a similar overall facility, technological risk, project complexity and the relatively long period before commissioning, the anticipated accuracy of the Base and Alternate Case estimates is on the low side of Class 4 norms, potentially on the order of -30% to +50% per AACE RP18R-97, after allowing for the inclusion of contingency by NWMO.

## Limitations

The current revision of this report was developed for submission to NWMO. It should not be referenced in published reports or papers without the express consent of NWMO. This estimate reflects a specific conceptual design, which is subject to further development. Cost and schedule estimates reported in this document are therefore subject to change; readers are cautioned to confer with NWMO to verify that the estimate herein has not been superseded. Any reference to a specific firm, commercial entity, consultant, commercial product, material, process or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or preference.

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## DEFINITIONS AND ACRONYMS

The major terms used in this document and its attachments are described below:

AACE	Association for the Advancement of Cost Engineering International
AECL	Atomic Energy of Canada Ltd.
ALARA	As Low As Reasonably Achievable
APM	Adaptive Phased Management
Backfill	An engineered mixture (solid or loose) designed to infill a void
Basket	Container to maintain the geometry of a used fuel bundle inside a UFC
Bentonite	A clay material used as a sealing material
Borehole	A vertical, horizontal or angled hole drilled into rock
Bulkhead	A concrete stopping / plug
CANDU	Canadian Deuterium and Uranium (a type of fission power reactor)
Cask	Mobile container for used-fuel storage or transport (also 'Flask')
Cluster Drill	Two or more drills combined to establish a larger diameter hole
CNSC	Canadian Nuclear Safety Commission
Collar	The shaft opening at surface and the structure that supports the top of shaft
COTS	Commercial, Off-The-Shelf
Crosscut	A tunnel driven at right angles or near right angles to an access tunnel
D&C	Decommissioning and closure
DB	Design Build
DBF	Dense backfill
DGR	Deep Geological Repository
Drift	Underground tunnel
Drill and Blast	Rock excavation by loading and detonating drill holes with explosive
EAP	"Everything according to plan"
EBW	Electron beam welding
EDZ	Excavation damage zone
EPC	Engineer – Procure - Construct
EPSCA	Ontario Electrical Power Systems Construction Association
ERT	Emergency Response Team
Flask	Mobile container for used fuel storage or transport
FTE	Full Time Equivalent
Geosphere	The rock environment the DGR will be located within
GF	Gap Fill
Grizzly	Heavy duty grate to stop oversize rock from falling into a muck pass



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HCB	Highly compacted bentonite
HDZ	Heavily Damaged Zone (see also: EDZ, Excavation Damage Zone)
Head frame	Tower structure that supports a hoisting operation, situated above the shaft
Heading	A tunnel that is being developed
HEPA	High efficiency particulate air filter
Hot Cell	Isolated shielded room for radioactive, contaminated material and equipment
HR	Human resources
HVAC	Heating, ventilation and air conditioning
IAEA	International Atomic Energy Agency
IFTC	Irradiated fuel transport cask
ILW	Intermediate-level waste
IT	Information technology
Jumbo	A mechanized drilling machine
kV	Kilovolts
km	Kilometre
kWhr	Kilowatt - hour
L & ILW	Low and intermediate level waste
LBF	Light Backfill
LHD	Load/haul/dump unit (low-profile version of a surface front end loader)
LHHPC	Low heat high performance concrete
LLW	Low-level waste
Locomotive	Rail mounted diesel or electric vehicle to move transported equipment
M	Metre(s)
mm	Millimetre(s)
Mbgs	Metres below ground surface
Module	Rack system holding used fuel bundles within a rectangular framework
MSM	Master slave manipulator for remote handling in radiation shielded areas
Muck	n. Broken rock, <i>i.e.</i> , produced by blasting; <i>v.i.</i> to remove blasted rock
NATO	North Atlantic Treaty Organisation
NBC	National Building Code
NDT	Non-destructive testing
NEW	Nuclear Energy Worker
NFC	National Fire Code
NFPA	National Fire Protection Agency
NFWA	Nuclear Fuel Waste Act
NWMO	Nuclear Waste Management Organization

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O&M	Operations and Maintenance
OPG	Ontario Power Generation
OPSS	Ontario Provincial Standard Specifications
OSHA	Occupational, Safety and Health Act
OTC	Overhead travelling crane
PA	Protected Area
PFD	Process Flow Diagram
P&ID	Piping & Instrument Diagram
Placement Room	Tunnel used for vertical placement of UFCs in boreholes along tunnel floor
PPE	Personnel protective equipment
QA/QC	Quality Assurance / Quality Control
Raise	Vertical excavation used for ventilation, or to move personnel via ladders
Rock Bolt	Inserted into a hole and tightened to hold rock around opening in place
RP	Recommended Practice
Safety Bays	Cut-out in side of tunnel for people to stand when equipment is passing
SAVH	Sickness, Accident, Vacation and Holiday Benefit. May include training
Scissor lift	Working platform that can be raised and lowered
Shaft	Vertical excavation for the hoisting of personnel, materials and rock
Shotcrete	Concrete sprayed on tunnel surfaces for ground support
SKB-IC	Svensk Kambranslehantering AB
SMCP	Sealing Materials Compaction Plant
TBD	To be determined
TBM	Tunnel boring machine
TC	Transport cask (intra-site)
Transfer Flask	Mobile container enclosing the UFC when transported underground
Trolley	A portable transportation platform used to move equipment on rails
TRUE	Transportation Risk and Uncertainty Evaluation
UDF	Underground Demonstration/Development Facility
UFC	Used-fuel container (holds the used-fuel bundles in repository)
UFD	Utility Flow Diagrams
UFPP	Used Fuel Packaging Plant
UFTS	Used Fuel Transportation System
USACE	United States Army Corp of Engineers
Used Fuel	Irradiated fuel bundles removed from a CANDU nuclear fission reactor
VBA	Visual Basic for Applications
WBS	Work Breakdown Structure

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WEDS	Work Element Definition Sheet(s)
Wi-Fi	Trademark for wide local area network
Working Face	The front end of a tunnel that is being developed



## 1. INTRODUCTION

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 long-term management of used fuel in a Deep Geological Repository (DGR) constructed within a suitable crystalline or sedimentary rock formation.

In 2009 and 2010, the NWMO undertook an update of the previous conceptual design for the APM program, including DGR design. Based on the updated conceptual design for the DGR, this report, the "*Deep Geological Repository Lifecycle Cost and Schedule Report, Crystalline Rock Environment, Copper Container*", presents cost and schedule estimates for a crystalline rock DGR design that comprises a feasible configuration of facilities and infrastructure to safely receive, re-package and place used nuclear fuel delivered from source reactor storage sites.

Two used nuclear fuel inventory scenarios are considered in this analysis. Under the Base Case, 3.6 million used CANDU fuel bundles will be directed to the DGR over a 30 year placement period. The Alternate Case, which assumes (in part) the construction of new nuclear reactors, sees this quantity increased to 7.2 million bundles delivered to the DGR over a 60 year period. Base and Alternate Case fuel is repackaged into copper IV-25 Used Fuel Containers (UFCs) at the DGR for placement underground.

A main repository level approximately 500 m below grade is envisaged, wherein used fuel containers are placed in vertical boreholes arranged along the floor of placement rooms excavated with conventional mining techniques. As explained in the companion design report, this repository configuration is realistic and achievable using currently available technology.

This report presents preliminary cost and schedule estimates for the lifecycle of such a DGR within the APM context. This report does not include or address transportation costs (which have been described in a stand-alone report) or NWMO corporate functions, including site selection, investigation, acquisition, licensing, safety assessment and specific aspects of long-term environmental monitoring and management.

Report contents include the following:

- An executive summary, presenting an overview of methodology and findings;
- Section 1, which identifies the study purpose, objectives and key companion documents;
- Section 2, which sets out the conceptual design basis for cost and schedule estimation, including descriptions of major scope components;
- Section 3, which describes the basis of the estimate, for example, the methodology, key assumptions, inclusions and exclusions for the cost and schedule estimate process;
- Section 4, which presents the current results for the cost model;
- Section 5, which includes the Base and Alternate Case schedules in Gantt chart form;
- Section 6; which discusses the formulation, use and limitations of a scalable estimate tool derived from the Base and Alternate Cases;
- Section 7, which reviews results and considerations such as the estimate class;
- Section 8, which documents the contributors to the estimate;
- Section 9, which discusses important limitations this study and its use, risks management and opportunities for cost optimization; and
- Section 10, which lays out the contents of the accompanying electronic deliverable.

## 1.1 Purpose of Estimate

The purpose of the current lifecycle cost and schedule estimate for a crystalline rock DGR is to allow NWMO to examine the financial implications of the current DGR design and to engage stakeholders, including waste owners, in consultation. The estimate is a 'study' or 'conceptual' cost estimate for a specific conceptual repository configuration in a hypothetical crystalline rock geosphere.

Depending on specific user requirements, this estimate may be appropriate for strategic planning, business development, alternative analysis, confirmation of feasibility and/or preliminary approvals to proceed.

Users must understand that the estimate is for a specific, conceptual scope of work, subject to a number of important assumptions and exclusions. It is not intended to be a 'definitive', 'detailed' or 'control' estimate.

## 1.2 Objectives of Report

The purpose of this report is the presentation of the current cost and schedule estimate (discussed above) to design, construct, operate, and decommission a DGR for the APM approach assuming:

- A crystalline host rock formation;
- Vertical, in-floor borehole used fuel container (UFC) placement; and
- A copper-clad IV-25 UFC design.

This report is intended to document the DGR cost and schedule estimate in a transparent and concise fashion, enabling decision making, consultation and/or third party validation. In support of this objective, and in conjunction with estimated costs and durations, the report presents:

- Estimate class;
- Estimated accuracy;
- Standards used in the development of the estimate;
- Deviations from the standards;
- Documentation in support of the estimate;
- Explanation of how documentation is interrelated (the 'document trail'); and
- The structure and methodology of the estimate.

To the extent feasible using the methodologies and resources employed, the cost estimate (including its attachments) is intended to function as a stand-alone guide to the current estimate, sufficient to allow review by a third party given access to supporting documentation, such as companion reports, but without access to the original estimators.

### 1.3 Companion Reports

A Microsoft Access database and sets of Microsoft Excel workbooks accompany, and form part of this cost and schedule report. These files are intended to provide additional supporting information. A variety of quotes, notes, calculations and additional supporting material are contained within the database.

This cost and schedule report is related to a number of companion studies, including those documented in the following reports:

- “*Deep Geological Repository Design Report – Crystalline Rock Environment*” submitted to NWMO by SNC Lavalin Nuclear (SLN 020606-6100-REPT-0001) which describes the crystalline rock DGR conceptual design for the Base and Alternate Cases;
- “*Transportation Design Report*” submitted to NWMO by SNC Lavalin Nuclear (SLN 020606-4200-REPT-0001), which describes the current used fuel transportation system conceptual design for the Base and Alternate Cases; and
- “*Life Cycle Cost Estimate for Used Fuel Transportation System*” submitted to NWMO by SNC Lavalin Nuclear (SLN 020606-4200-REPT-0001), which presents the current used fuel transportation system lifecycle cost and schedule estimate for the Base and Alternate Cases.

These companion studies are subject to revision and update; this estimate has been developed to reflect the design status as of January 2011.

Note that a separate, stand-alone conceptual design has been developed for a DGR in sedimentary rock using the horizontal placement of used fuel containers in horizontal tunnels (‘in-room placement’). This approach has been documented in the report “*Deep Geological Repository Design Report - Sedimentary Rock Environment*” submitted to NWMO by SNC Lavalin Nuclear (SLN 020606-6200-REPT-0001) and the associated lifecycle cost and schedule estimate.

## 2. DESIGN BASIS

The following sections review the design basis for the lifecycle cost and schedule estimate. The estimates have been constructed by dividing the overall scope into a Work Breakdown Structure (WBS) for the Base and Alternate Cases. Aspects of the WBS were then subdivided into tasks of sufficient detail for the assessment of cost and schedules.

The following sections on the design basis for the estimate describe the structure of the WBS (the scope breakdown), project phasing, facility throughput and relevant design requirements. This is followed by a discussion of scope, deliverables and assumptions for each of the major divisions of the WBS.

### 2.1 Scope Breakdown

For each case (identified as '560', the Base Case, and '561', the Alternate Case), the scope of the DGR project was systematically divided into separate areas of effort to create a project WBS. Many of these areas were subsequently broken down into sub-tasks of increasing detail to allow formulation of reasonable cost and schedule estimates.

Each of the major divisions of the WBS is described in later sections of this report. In aggregate, the described work elements comprise the design upon which the estimate is based. The full structure of the 560 and 561 WBSs is presented in Appendix A (the two WBSs are based on the same structure to facilitate comparison). Appendix B includes summary descriptions (Work Element Description Sheets, or 'WEDS') for each of the populated WBS nodes.

The parallel 560/561 WBS for the current analysis was derived from the WBS used in previous conceptual cost estimates (CTECH, 2003) to facilitate backwards comparison. This WBS was then modified in collaboration with NWMO as the design update progressed.

Elements of the DGR scope within the WBS were subject to cost and schedule analysis by the project team. The team evaluated components of the WBS related to construction, operation and decommissioning, with an emphasis on the use of contemporary turn-key ('engineer-procure-construct', EPC) delivery practices and existing/conventional technologies. Select components of the WBS were reserved by NWMO for internal evaluation. The major WBS divisions are as indicated in Table 1 (below), which also indicates the WBS inclusions and exclusions for the estimated costs reported herein.

Each of the evaluated work elements from the WBS has been assessed in terms of required labour, permanent materials/equipment and other costs. Summary Excel-format workbooks showing detailed assignments are provided in conjunction with this report.

WBS components are scheduled in project years, with Year 1 currently held to be 2010. Costs are stated in constant 2010 Canadian dollars.



Table 1: Summary Estimate Work Breakdown Structure

Included in this Report	Planned WBS Number	Title
n	56X.15 to 56X.35	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
partial	56X.40.10	Preferred Site Confirmation
n	56X.40.10.10	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
n	56X.40.10.20	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
y	56X.40.10.30	Underground Development Facility (UDF) Design and Construction
y	56X.40.10.30.10	UDF Equipment
y	56X.40.10.30.20	UDF Construction (Incl. Concrete Plant, Crushing Plant, Camp, Service Shaft, Service Area)
y	56X.40.20	Site Improvements
y	56X.40.30	Construction Phase Indirects (Incl. Fire & Security)
y	56X.40.40	Surface Process Facilities (Used Fuel Packaging Plant and Sealing Materials Compaction Plant)
y	56X.40.50	Surface Auxiliary Facilities
y	56X.40.60	Underground Facilities (Incl. Main Shaft, Ventilation Shaft, Perimeter Drifts, Placement Panel 'A')
y	56X.40.70	Common Services
y	56X.45	Facility Operation
y	56X.45.10	Operations Program Management
y	56X.45.20	Direct Operations Management (Incl. Quality Assurance)
y	56X.45.30	Operations Indirects (Includes Fire & Security)
y	56X.45.40	Aboveground (A/G) Operations
y	56X.45.50	Underground (U/G) Operations
y	56X.45.50.30	Room/Tunnel/Borehole Excavation (Second Stage) Panel B
y	56X.45.50.40	Room/Tunnel/Borehole Excavation (Third Stage) Panel C
y	56X.45.50.50	Room/Tunnel/Borehole Excavation (Fourth Stage) Panel D
y	56X.45.50.60	Used Fuel Container (UFC) Transport & Place
y	56X.45.50.100	Hoist Rope Replacement
y	56X.45.50.110	Indirects for Final Panel UFC Placement
y	56X.45.50.120	Mining Heat and Power
y	56X.45.50.130	Extended Operations (Incl. Support Services)
y	56X.45.50.140	Extended Operations Equip Replace/Refurbish/Maintain
y	56X.45.50.150 to 180	Room/Tunnel/Borehole Excavations (Fifth to Eighth Stages), Panels E through H
y	561.45.50.190 to 260	<b>[ALTERNATE CASE]</b> Room/Tunnel/Borehole Excavations (Ninth to Sixteenth Stages), Panels I to P
partial	56X.55	Environmental Management System
n	56X.55.10	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
n	56X.55.20	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
n	56X.55.30	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>
y	56X.55.40	Environmental Response Equipment
y	56X.55.50	Radiological Monitoring Equipment
y	56X.55.60	Non-Radiological Monitoring Equipment
y	56X.60	Decommissioning and Closure
y	56X.60.10	Decommissioning Management
y	56X.60.30	Decommissioning Facilities (Construction & Operation)
y	56X.60.30.10	Backfill Materials Plant (Supply and Operate)
y	56X.60.30.20	Waste Processing and Handling Facility
y	56X.60.40	Auxiliary Surface Facilities Decommissioning
y	56X.60.50	Used Fuel Packaging Plant (UFPP) Decommissioning
y	56X.60.60	Sealing Materials Compaction Plant (SMCP) Decommissioning
y	56X.60.70	Ancillary Radiation Area Decommissioning
y	56X.60.80	UFC Handling Systems
y	56X.60.90	Permanent Vent Fan Removal (Decommissioning)
y	56X.60.100	U/G Decommission and Seal (Incl. Access Tunnels, Drifts, Service Shaft, Main Shaft and Ventilation Shaft)
y	56X.60.110	In-Town Decommissioning
y	56X.60.120	Crusher Plant Demolition (Decommissioning)
y	56X.60.130	Site Clean-up (Decommissioning)
y	56X.60.150	Decommissioning Indirects (Incl. Heat, Consumables)
y	56X.60.160	Decommissioning Waste Disposal
y	56X.60.170	Final Closure
n	56X.90	<i>Superseded by Separate NWMO WBS and Related Cost Estimate(s)</i>

## 2.2 Phases

For the purposes of schedule development, activities for both the Base Case and Alternate Case can be conceptualized as belonging to one of four project phases, as presented below in Table 2.

**Table 2: Project Phases**

Phases		Item
Siting & Licensing		Complete Feasibility Studies
		Complete Subsurface Investigations
		Select Site
		End Siting & Licensing Process
Construction		Obtain Construction Licence/Begin Construction
		End Construction
Operation	Major Operations	Obtain Operations License/Begin Operations
		Complete Loading Fuel/End Operations
	Extended Operations	Begin Extended Operations (Monitoring)
		Complete Extended Operations (70 yrs)
Closure and Decommissioning	Major Decommissioning	Obtain Decommissioning Licence/Begin Decommissioning
		Complete Major Decommissioning (10 yrs)
	Final Closure	Begin Final Closure Period (15 yrs)
		Abandonment Licence/End Final Closure

## 2.3 Used Fuel Inventory and Throughput

As mentioned, the Base Case assumes 3.6 million CANDU fuel bundles arriving over a span of 30 years. The Alternate Case allows for 7.2 million bundles over 60 years. An annual facility throughput (to receive and place) of 120,000 fuel bundles is assumed for both the Base and Alternate Cases.

Facilities and equipment are sized for this throughput, although they do include buffer mechanisms to allow efficient operation through unforeseen interruptions in shipping, repackaging or placement. The Used Fuel Packaging Plant (UFPP), for example, incorporates provisions to hold up to a three-month supply of fuel in water-shielded storage. Buffers and storage points, however, are not intended for use under normal conditions.

Overall, an increase in bundle count is taken to increase the duration of repackaging and placement operations, with no requirement for increasing the capacity or size of fixed plant and equipment.

## 2.4 Applicable Standards

As described in the companion design report, various regulations, codes and standards were referenced in the completion of the supporting project work to this report. Cost estimates reflect the design team's understanding of the substantive requirements of these regulations, codes and standards. Of these, which included both domestic and international sources, the following took priority for the design described herein:

- General Nuclear Safety and Control Regulations (2000). Registration SOR/2000-202, Canada Gazette Part II, Vol. 134, No. 13;
- Class I Nuclear Facilities Regulations (2000). Registration SOR/2000-204, Canada Gazette Part II, Vol. 134, No. 13;
- Radiation Protection Regulations (2000). Registration SOR/2000-202, Canada Gazette Part II, Vol. 134, No. 13;
- Nuclear Security Regulations, SOR/2000-209 plus amendments SOR/2006-191;
- Canadian Nuclear Safety Commission (CNSC) (2004). Keeping Radiation Exposures and Doses 'As Low as Reasonably Achievable (ALARA)'. CNSC G-129 Revision 1;
- CNSC Regulatory Guide G-208 Transportation Security Plans for Category I, II or III Nuclear Material, March 2003 Transport Canada;
- CNSC Regulatory Guide G-219 Decommissioning Planning for Licensed Activities, June 2000;
- IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised);
- Transportation of Dangerous Goods Act (1992), including Amendment SOR/2008-34, Department of Transport, Government of Canada;
- Ontario Mining Regulations (Occupational Health and Safety Act, R.R.O. 1990, Regulation 854, Mines and Mining Plants);
- National Fire Code, as set out in the National Building Code and National Fire Protection Association 801;
- Ontario Provincial Standard Specifications (OPSS) for particle size distribution; and
- The National Building Code of Canada (NBC).

## 2.5 Design Components

The project scope is summarized in the following sections for each of the major divisions of the WBS. To eliminate redundancy and simplify this presentation, elements that apply to both the Base (560) and Alternate (561) Cases are denoted with the generic prefix '56X' (e.g., code '56X.15' refers to both 560.20 and 561.20).

## 2.5.1 NWMO Elements

The following elements, although plotted on the estimated DGR schedule for context, have been superseded. The relevant work scope has been independently estimated by NWMO; related costs are not included in this cost estimate.

- 56X.15 – Siting;
- 56X.20 – Repository System Development;
- 56X.25 – Safety Assessment;
- 56X.30 – Licensing and Approvals;
- 56X.35 – Public Affairs; and
- 56X.90 – Program Management.

## 2.5.2 56X.40 – Facility Design and Construction

“Facility Design and Construction” encompasses site selection, site improvements, engineering design and construction of surface and underground facilities, and procurement of facility equipment. This element spans years 1 to 25 for the Base and Alternate Cases. In the Alternate Case, additional service area construction also takes place in years 49 to 51. The following elements are included under 56X.40:

- 56X.40.10 – Preferred Site Confirmation;
- 56X.40.20 – Site Improvements;
- 56X.40.30 – Construction Phase Indirects (including Fire and Security);
- 56X.40.40 – Surface Process Facilities;
- 56X.40.50 – Surface Auxiliary Facilities;
- 56X.40.60 – Underground Facilities; and
- 56X.40.70 – Common Services.

Each of these elements is reviewed briefly below.

### 2.5.2.1 56X.40.10 - Preferred Site Confirmation

“Preferred Site Confirmation” runs from Year 1 to 25 of the project, and includes Geosphere Program Set-up (56X.40.10.10), Geosphere Evaluation (56X.40.10.20) and Underground Development Facility (UDF) design and construction (56X.40.10.30). Geosphere Evaluation and Geosphere Program Set-up have been independently estimated and are not included herein.

Note that the conceptual design anticipates Site Selection by the beginning of Year 9 and receipt of a Construction Licence at the beginning of Year 16. UDF design and construction, however, runs through the construction period, ending just before receipt of an Operations License.

UDF Design and Construction (56X.40.10.30) encompasses UDF Equipment (56X.40.10.30.10) and UDF Construction (56S.40.10.30.20). UDF Design and Construction activities run from Year 16 to 25. UDF Design and Construction does not include unique NWMO experimental and demonstration activities and equipment. These experimental and demonstration projects have been independently estimated by NWMO and are not included herein.

The current contracting strategy is to establish the UDF on an EPC basis: the contractor's price includes detailed design, procurement, supervision, etc. based on facility requirements. 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 56X.40.10.30.20.70, "Tunnel and Service Area Excavation".

Indirect labour and equipment costs incurred during the facility design and construction stage of the project that are not included in EPC price items are included under 56X.40.30, Construction Phase Indirects (including Fire and Security). Note that EPC procurement is used extensively: construction phase indirects are limited to visitor's centre operations and the maintenance of surface facilities after hand-over to owner.

Elements included under 56X.40.10.30 (UDF Design and Construction) include the following:

- 56X.40.10.30.20.20 – Concrete Plant;
- 56X.40.10.30.20.30 – Crushing Plant;
- 56X.40.10.30.20.40 – Campsite and Campsite Operations;
- 56X.40.10.30.20.50 – Service Shaft and Headframe; and
- 56X.40.10.30.20.70 – Tunnel and Service Area Excavation.

**Concrete Plant (56X.40.10.30.20.20)** includes construction and commissioning of the Concrete Batch Plant as per the design report.

**Crushing Plant (56X.40.10.30.20.30)** includes construction and commissioning of a crushing, screening and washing operation for the production of aggregate to be used as raw material for the concrete batch and sealing materials compaction plants as per the design report.

**Campsite and Campsite Operations (56X.40.10.30.20.40)** includes set up and operation of the temporary camp complex for mine/construction workers during the construction period. The camp complex includes accommodations, a medical centre, airstrip, infrastructure (e.g., roads, drains, lighting), kitchen, cafeteria, fuel storage area and recreation facilities. The camp provides related services such as potable and fire water, sewage collection and treatment, solid waste collection and disposal, and electrical power supply. The current project concept may include development of a townsite and/or a volunteer host community to support DGR operations; campsite operations, therefore, terminate at the beginning of the operations phase.

**Service Shaft and Headframe (56X.40.10.30.20.50)** includes construction of the shaft collar, headframe, hoisting system, ventilation fans, sinking of the service shaft and construction of rock handling systems. This element excludes installation of permanent ventilation fans at this location, both of which are installed on surface. Fan installation is covered by work element 56X.40.60.40 (Note: because of the skipping capacity, the Service Shaft is sometimes referred to as the 'production shaft').

**Tunnel and Service Area Excavation (56X.40.10.30.20.70)** includes excavation of the tunnels between the Main Shaft and Service Shaft, tunnels interconnecting the services facilities, excavations for the UDF, excavations for support services and outfitting of support facilities.

### 2.5.2.2 56X.40.20 - Site Improvements

“Site Improvements” includes the preparation of the site for surface facilities. This element spans the Years 16 to 24 for both the Base and Alternate Cases. Activities under this element include the following:

- Site civil preparation (clearing, blasting, grading, initial landscaping);
- Allotment for permit fees;
- Main access road (25 km incl. 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 (approx. 4.8 km);
- Road for Ventilation Shaft complex (approx. 5 km);
- Parking lots (paved, for up to 200 cars, 5 buses, 15 trucks: 6,000 m<sup>2</sup>);
- 2 large bus shelters (30 person shelters: 15 m<sup>2</sup> ea.);
- 6 standard small bus shelters (6 m<sup>2</sup>);
- Truck weigh scale, scale house, and traffic lights;
- Helipad - 30 m diameter, include drainage and lighting;
- Rail line – from sealing materials compaction plant to Service Shaft including switchgear;
- Off-site waste rock disposal area, with fencing, gate, access road and drainage pond;
- Outer perimeter fence, including 2 vehicle gates, 4 person gates, signage, lighting; and
- Protected area double fence (3 m high, 4 m offset, barbed wire), including signage, lighting and motion sensors.

It is assumed that the site is a relatively flat, previously undeveloped area in the Canadian Shield, within 25 km of an existing highway. Rail access is not required. Land acquisition costs have not been included as they are included in the NWMO estimate elements. Surface preparation is calculated for the facilities footprint (about 0.5 km<sup>2</sup>). Work will be conducted on a design-build basis, using corresponding labour rates that account for typical construction indirects.

### 2.5.2.3 56X.40.30 - Construction Phase Indirects (including Fire and Security)

“Construction Phase Indirects” includes those indirect labour and equipment costs incurred during the facility design and construction stage of the project that are not otherwise included in EPC price items. This element includes operation of the Visitor's Centre and incidental care/upkeep for structures after completion and hand-over by the EPC contractor. This element spans Years 16 to 25 for both the Base and Alternate Cases.

### 2.5.2.4 56X.40.40 - Surface Process Facilities

“Surface Process Facilities” includes the project management, design, construction and commissioning and the design, supply, installation and testing of equipment for the UFPP and the sealing materials plant. Activities will take place between Years 20 and 25 for both the Base and Alternate Cases.

This branch of the WBS includes provisions for resources required to supply fully fitted and operable UFPP and sealing materials facilities. UFPP costs include the following:

- Project management, design and engineering;
- The construction of the building together with permanent fixtures;
- The management of the building and its services commissioning;
- Detailed design, supply, installation and testing of process equipment, together local control and instrumentation for the receipt and transfer area, including the Irradiated Fuel Transport Cask (IFTC) receipt and un-packaging area;
- The detailed design, supply, installation and testing of building services;
- Mechanical services; and
- Electrical, controls and instrumentation.

Similarly, the sealing materials plant work comprises the supply and installation of building services and process equipment (specialty mixers, presses, vacuum lifting equipment, etc.). Detailed engineering, construction and other installation indirect costs (labour and equipment) incurred to execute the project have also been included.

#### **2.5.2.5 56X.40.50 - Surface Auxiliary Facilities**

“Surface Auxiliary Facilities” includes the engineering, detail design, construction and commissioning of surface facilities to service the daily operations of the DGR. Activities will take place during Years 16 to 25 for the Base and Alternate Cases. Such facilities include the following:

- Administration building (56X.40.50.20);
- Auxiliary building (56X.40.50.30);
- Quality control offices and laboratory (56X.40.50.40);
- Garage / warehouse (56X.40.50.50);
- Walkways and serviceways (56X.40.50.60);
- Fuel tank area (56X.40.50.70);
- Security checkpoints (56X.40.50.80);
- Emergency power generation (56X.40.50.90);
- Pumphouse and intake (56X.40.50.100);
- Water storage tank area (56X.40.50.110);
- Water treatment plant (56X.40.50.120);
- Process water settling pond (56X.40.50.130);
- Service Shaft water settling pond (56X.40.50.140);
- Storm run-off pond (56X.40.50.150);
- Sewage treatment plant (56X.40.50.160);
- Low level liquid waste storage building (56X.40.50.170);
- Active liquid waste treatment system (56X.40.50.180);
- Waste management area (56X.40.50.190);
- Low level solid waste storage building (56X.40.50.220);
- Electrical switchyard (56X.40.50.230);
- Transformer area (56X.40.50.240); and
- Visitors Centre (56X.40.50.250).

Elements include provisions for direct and indirect resources for design, construction, supply, installation, testing and commissioning to a fully operable status, including permanent fixtures.

In addition to the above, the DGR may, depending on the selected site, include the development of a townsite or an investment in an existing community, subject to discussions between the NWMO and the community. A "Townsite" work element has been included in the WBS (56X.40.50.10), however, costs associated with this work element have not been specifically assigned and would be drawn from contingency.

#### 2.5.2.6 56X.40.60 - Underground Facilities

"Underground Facilities" includes the engineering, detail design, construction and commissioning of shafts and underground infrastructure at the DGR. This element spans Years 16 to 25 for the Base and Alternate Cases with an additional expansion of perimeter and access drifts in Years 45 to 49 of the Alternate Case, as well as the construction and outfitting of a second vent shaft in Years 45 and 46 to accommodate a second set of placement panels.

Facilities under this element include the following:

- Main Shaft and Headframe (56X.40.60.20);
- Ventilation Shaft and Headframe (56X.40.60.30);
- Ventilation System (56X.40.60.40);
- Support Services and Facilities (56X.40.60.50);
- Perimeter and Access Drifts/Cross Cuts (56X.40.60.60); and
- Initial Placement Rooms / Boreholes (Panel A) (56X.40.60.70).

**Main Shaft and Headframe (56X.40.60.20)** encompasses construction and commissioning of the Main Shaft (sometimes referred to as the 'waste shaft') and associated infrastructure to convey UFCs from surface to underground.

**Ventilation Shaft and Headframe (56X.40.60.30)** covers construction and commissioning of the Ventilation Shaft to provide the DGR's main ventilation exhaust capacity. In the Alternate Case, a second shaft is constructed approximately mid-way through operations, in conjunction with perimeter drifts, to support a second set of placement panels.

**Ventilation System (56X.40.60.40)** covers the design, procurement, installation and commissioning of the main underground ventilation system, including fans, mine air heating and temporary auxiliary ventilation system(s) for the placement rooms. A second set of system equipment is purchased and installed approximately mid-way through the operations phase in the Alternate Case.

**Support Services and Facilities (56X.40.60.50)** encompass underground excavations to accommodate ancillary infrastructure items to support the construction of the DGR. This includes items not covered in the Tunnel and Service Area Excavation (56X.40.10.30.20.70).

**Perimeter and Access Drifts/Cross Cuts (56X.40.60.60)** covers excavation of the central, perimeter and panel access drifts comprising the DGR's 'skeleton' of ventilation and panel access ways.



**Initial Placement Rooms / Boreholes (Panel A) (56X.40.60.70)** encompasses excavating and preparing the first panel of placement rooms (Panel A - 16 placement rooms). Excavations will proceed from the far side of Panel A and retreat towards the central access drifts. Following excavations the contractor will install track in each of the placement rooms. As each room is developed, air, water and electrical power will also be installed.

### 2.5.2.7 56X.40.70 - Common Services

“Common Services” include the design, construction, installation and commissioning of utilities to support the DGR that is not specifically associated with other elements. This element spans Years 20 to 21 in both the Base and Alternate Cases.

**Service Air (56X.40.70.40.20)** includes the cost to design, procure, install and commission a building to house both service air and breathing air equipment. Other elements under this element include infrastructure/equipment/distribution network costs.

In total, facilities under 56X.40.70 - Common Services include the following:

- Facility Electrical Distribution (56X.40.70.10);
- Facility Communication System (56X.40.70.20);
- Facility Water System (56X.40.70.30), including:
  - Fire Water (56X.40.70.30.10);
  - Potable Water (56X.40.70.30.20);
  - Process Water (56X.40.70.30.30);
  - Sewerage (56X.40.70.30.40);
  - Stormwater and Drainage (56X.40.70.30.50);
- Facility Compressed Air (56X.40.70.40), including:
  - Breathing Air (56X.40.70.40.10); and
  - Service Air (56X.40.70.40.20).

### 2.5.3 56X.45 - Facility Operation

“Facility Operation” includes elements covering operation and management of the surface and underground facilities and underground construction activities concurrent with operations (fuel repackaging and placement). “Facility Operation” spans the period from Years 16 to 125 for the Base Case and from Years 16 to 155 for the Alternate Case. Elements covered under 56X.45 are described in more detail below.

#### 2.5.3.1 56X.45.10 - Operations Program Management

“Operations Program Management” encompasses an annual allocation for taxes or payments in lieu of taxes (\$6 million/year). For the Base Case this element spans Years 26 to 55, for the Alternate Case it spans Years 26 to 85.

Operations of the president’s office, engineering, finance, purchasing, safety and facility management are covered under element 56X.45.20 (Direct Operations Management).

### 2.5.3.2 56X.45.20 - Direct Operations Management

“Direct Operations Management” encompasses the management and administrative functions covering the day-to-day operation of the DGR facility during the operations phase. This element spans Years 26 to 55 for the Base Case and Years 26 to 85 for the Alternate Case. Core staff includes the following:

- 1 President;
- 5 Vice Presidents (Engineering, Human Resources, Society & Sustainability, Finance & Legal, Operations);
- 2 Directors of Engineering (aboveground and underground);
- 6 Engineering Managers;
- 6 Non-Engineering Managers; and
- 90 Staff.

Line staff for procurement, environmental management, security, fire and housekeeping is included under element 56X.45.30 (Operations Indirects). Line staff for maintenance is included under element 56X.45.40.40 (O&M of Auxiliary Surface Facilities).

Mine development, UFC placement, UFPP operations, sealing materials operations (including supervision and incidental engineering) are not included in this element. These costs are accounted for in element 56X.45.40.10 (UFPP Operation) and element 56X.45.50.60 (UFC Transport and Place).

### 2.5.3.3 56X.45.30 - Operations Indirects

“Operations Indirects” includes labour and equipment required to operate the DGR during the facility operations phase of the project. “Operations Indirects” spans Years 26 to 55 for the Base Case and Years 26 to 85 for the Alternate Case.

This element excludes the indirect labour and equipment provided for in underground excavation work elements, for O&M of auxiliary facilities (56X.45.40.40) and during the extended operations phase (56X.45.50.130).

“Operations Indirects” includes allocations for fire and security equipment with on-going refurbishment or replacement. Staff pay rates used throughout the estimate includes for sickness benefit, pension contributions, holidays and training; therefore these items are not accounted for here. Mine rescue will be covered by cross-trained line staff accounted for in other roles; a dedicated fire crew will also be supplemented by cross-training other staff.

Core staff includes the following (listed as full time equivalents, and taking into account shift coverage):

- 5 Visitor Centre Staff;
- 3 Finance Managers;
- 6 Financial Analysts;
- 6 Buyers;
- 10 Information Technology (IT) Support Personnel;
- 2 Procurement Managers;
- 2 Environmental Managers (Technicians are included in 56X.45.20);
- 12 Radiation Safety and Monitoring Personnel;

- 4 Payroll Officers;
- 2 Fire/Security Managers;
- 6 Security Officers/ Fire Supervisors;
- 80 Security Guards;
- 16 Fire Personnel;
- 8 Medical Staff (Paramedics/Doctors/Nurses);
- 2 HR Managers;
- 20 Conventional Safety (and Operations) Staff;
- 2 Administration Managers/Office Managers;
- 6 Administration Support Personnel;
- 40 General Upkeep Staff (housekeeping, janitorial) support; and
- 40 Operations Staff (Including cafeteria, laundry, etc.).

#### **2.5.3.4 56X.45.40 - Aboveground Operations**

“Aboveground Operations” includes direct labour and materials for the day-to-day operation of the UFPP and auxiliary surface facilities, management of baskets and UFCs for the UFPP and operation and maintenance of surface buildings and associated facilities. This element spans the operational period of the DGR, Years 26 to 55 for the Base Case and 26 to 85 for the Alternate Case.

##### **2.5.3.4.1 56X.45.40.10 – UFPP Operation**

“UFPP Operation” includes direct labour and materials for the day-to-day operation of the Used-Fuel Packaging Plant. This element spans the operational period from Years 26 to 55 for the Base Case and from Years 26 to 85 for the Alternate Case.

Costs are assumed to be distributed uniformly on an annualized basis for the duration of UFPP operations based on an annual throughput of approximately 333 UFCs/year. Low Level (Radioactive) Waste (LLW) operational arisings will be packaged and transported to a separate facility. LLW buffer storage is provided on site to accommodate these arisings. Operational Intermediate Level Waste (ILW) will be transferred to a separate facility from the DGR when it is generated. Costs are included to cover off-site transport, processing and disposal of both operational LLW and ILW arisings at other facilities (outside scope of this project).

##### **2.5.3.4.2 56X.45.40.20 – Supply of Baskets and UFCs**

“Supply of Baskets and UFCs” encompasses the supply, packaging and delivery of the required number of UFCs and UFC baskets during operations of the DGR. This element spans Years 26 to 55 for the Base Case and 26 to 85 for the Alternate Case.

Costs are assumed to be distributed uniformly on an annualized basis for the duration of operations. A total of \$250,000 per UFC (excluding final delivery) has been used in the current estimate. This value is the mid-point cost of a container (average of a modular cast iron insert and roll-formed inner vessel) and utilizes a 25 mm thick copper shell. UFCs and baskets will be manufactured and assembled off-site and shipped to the DGR as a completed item. Two UFC assemblies are expected to be shipped in one trip with empty packaging returned. UFC assembly transport frames are reusable and assumed to have a design life of 15 years. Licensing and approvals from relevant authorities are assumed to be obtained without significant delay to the schedule.

#### 2.5.3.4.3 56X.45.40.30 – SMCP Operation

Operational costs for the sealing materials plant (including power consumption) are embedded in the delivered/installed costs for sealing materials under 56X.45.50.60, UFC Transport and Place.

#### 2.5.3.4.4 56X.45.40.40 – Operation and Management of Auxiliary Surface Facilities

“Operation and Management of Auxiliary Surface Facilities” encompasses operation and maintenance of surface buildings and associated facilities. This element spans Years 26 to 55 for the Base Case and 26 to 85 for the Alternate Case. This element covers maintenance staff (including management) as well as building, civil and mechanical needs not otherwise covered elsewhere (for example as included elsewhere for mining, UFC placement, sealing materials and UFPP equipment).

The crew for this element accounts for general maintenance, water treatment, sewage treatment, switchyard/transformers, active liquid waste treatment, low level waste storage, etc. Staffing includes 8 maintenance supervisors, 4 administrative staff and 70 maintenance crew members. Electrical includes building HVAC, heat, power and light. An allocation of \$9 million/annum and the element allowance (10%) accounts for additional asset management charges, maintenance activities and materials.

Townsite operations are assumed to be funded through revenues raised by property taxes or a similar mechanism. Therefore, no costs are included for townsite operations.

#### 2.5.3.5 56X.45.50 - Underground Operations

“Underground Operations” include construction of the underground storage rooms, tunnels and boreholes, UFCs, preparation of UFCs for transport and placement, UFC placement and equipment acquisition and maintenance. This element spans Years 16 to 125 for the Base Case and 16 to 155 for the Alternate Case.

##### 2.5.3.5.1 56X.45.50.30 to 50 & 150 to 180/260 – Room/Tunnel/Borehole Excavation

These elements encompass excavation furnishings, the preparation of placement rooms and the load, haul, dump and spreading of waste rock from construction. The Base and Alternate Cases both include elements 56X.45.50.30 to 50 and 150 to 180 (Panels B through H). The Alternate Case includes the additional elements 561.45.50.190 to 260 (Panels I through P). The duration of these elements spans Years 26 to 49 for the Base Case and Years 26 to 80 for the Alternate Case.

Each panel except for panels B, I and J provide for the construction of a panel access cross-cut (panel B occurs in the Base and Alternate Cases; panels I and J only occur in the Alternate Case). The access cross-cuts for Panels B, I and J are covered under element 56X.40.60.60, Perimeter and Access Drifts/Cross Cuts. Alternating panels are constructed with either 15 or 16 placement rooms. Each placement room will contain 89 boreholes (allowing for a 10% rejection rate). Following borehole drilling, track will be installed on concrete plinths in each of the rooms to facilitate UFC placement. Following room development air, water and electrical power lines will also be installed.

### 2.5.3.5.2 56X.45.50.60 – UFC Transport and Place

“UFC Transport and Place” encompasses the emplacement of sealing materials and UFCs within the underground placement rooms, together with the construction of the room bulkhead seal. This element spans Years 26 to 55 for the Base Case and 26 to 85 for the Alternate Case.

Tasks directly related to the placement of UFCs include:

- Personnel and material transfers to/from placement rooms including shaft operations;
- Placement of 68 dense backfill (DBF) blocks for each UFC;
- Placement of two DBF rings for each UFC;
- Placement of 4 highly compacted bentonite (HCB) discs per UFC;
- Placement of 8 HCB rings per UFC;
- Placement of light backfill material;
- Removal of services and rails;
- Transfer placement equipment to new location; and
- Routine maintenance.

These activities are carried out approximately 81 times per placement room, with a total of 124 placement rooms filled over each 30-year block of operations, equating to 333 operating cycles per year. Additional deliverables included as part of UFC emplacement include:

- Construction of placement room bulkheads (124 in total);
- Major replacement capital equipment; and
- Supply of minor spares to service placement operations.

A total placement materials cost (including operations to produce sealing materials and the replacement of emplacement equipment over time) of \$123K per UFC has been estimated. In addition, a full set of UFC retrieval equipment will be purchased in the first year of operations and held on stand-by in the UDF.

### 2.5.3.5.3 56X.45.50.100 – Hoist Rope Replacement

“Hoist Rope Replacement” covers the replacement of ropes in the Service Shaft and Main Shaft every three years. Replacement intervals for the Ventilation Shaft are every nine years. This element spans Years 17 to 55 for the Base Case and 17 to 85 for the Alternate Case.

Stretch and deterioration of the ropes used in hoisting results in the requirement to replace a set of ropes. An allowance of 33% of the original purchase price of the hoisting ropes for the Main and Service Shafts is applied annually. The Ventilation Shaft hoist is not scheduled for regular use (emergency operations only) and will be maintained with a lesser expenditure. The allowance assigned to the work element covers incidental costs related to inspection and procurement.

#### 2.5.3.5.4 56X.45.50.110 – Indirects for Final Panel UFC Placement

“Indirects for Final Panel UFC Placement” includes indirect costs for placement of UFCs in the final panel. Underground indirect costs (the costs to keep the mine open) are built into the EPC-basis per-metre mine development prices; however mine development using this inclusive per-metre costing ceases prior to placement of UFCs in the final panel.

This work element therefore covers underground facility indirects for the brief period of UFC placement when development is not proceeding on a per-metre basis elsewhere in the repository. It spans Years 49 to 55 for the Base Case and Years 80 to 85 for the Alternate Case based on the end year for inclusive mine costing in each scenario. Costs related to items such as personnel carriers, sanitary vehicles, pumps, fans, lights, tools and support staff result in facility indirects of approximately \$20K/day.

#### 2.5.3.5.5 56X.45.50.120 – Mining Heat and Power

“Mining Heat and Power” encompasses costs incurred for mine heating and electricity. Other mining indirects are incorporated in the EPC-basis per-metre costs for underground development.

Costs are calculated for propane heating using Sudbury climate norms with an estimated consumption of 3.2 million litres/year of propane. Typical annual mine electrical demand is estimated as follows:

- Surface Ventilation Fans - 12,815,880 KWhr/yr;
- Hoisting (main, service and auxiliary hoists) - 11,300,400 KWhr/yr;
- Trammig (via one 16 tonne locomotive charger and four 4 tonne chargers) - 1,559,280 KWhr/yr;
- Underground Auxiliary Ventilation Fans (including shaft boosters as well as shop, excavation, placement and miscellaneous fans) - 15,655,255 KWhr/yr;
- Mine Dewatering (two 42 KW slurry pumps) - 343,085 KWhr/yr; and
- Miscellaneous Small Users (including surface compressors, diamond drills and other loads) - 3,628,217 KWhr/yr.

This element spans Years 16 to 55 for the Base Case and Years 16 to 85 for the Alternate Case.

#### 2.5.3.5.6 56X.45.50.130 – Extended Operations (Including Support Services)

“Extended Operations” includes operation and management of the DGR for 70 years following completion of UFC emplacement. Tasks include monitoring and preservation of key surface and underground facilities, monitoring the geotechnical integrity of the DGR, etc. This element spans Years 56 to 125 for the Base Case and Years 86 to 155 for the Alternate Case and covers:

- A DGR-site organization to maintain the structure, facilities and knowledge base in anticipation of decommissioning and closure;
- Asset management to maintain infrastructure and facility integrity against the prevailing environment;
- Power; and
- Annual taxes or payments in lieu of taxes.

Maintenance crew, hoist rope replacement and associated costs are addressed in element 56X.45.50.140 (Extended Operations Equipment Replacement/Refurbishment/Maintenance). Specifically, costs have been developed for:

- 1 President;
- 1 Engineering Manager;
- 1 Facility Manager;
- 1 Security Manager;
- 1 Finance Manager;
- 1 Human Resources Manager;
- 1 Procurement Manager;
- 5 Administrative Assistants;
- 2 Conventional Safety Staff;
- 2 Engineers;
- 1 Finance Analyst;
- 8 Housekeeping Personnel;
- 2 IT Support Personnel;
- 1 Payroll Officer;
- 1 Nurse;
- 2 Radiation Safety Officers;
- 20 Security Guards;
- 2 Security/Fire Supervisors;
- 2 Technical Support Staff;
- Surface facility maintenance (asset management expenditure of about \$3 million/year);
- Power, at an average annual consumption of 36 million KWhr; and
- Annual taxes or payments in lieu of taxes at \$250,000 per annum.

A relatively high degree of allowance (25%) has been assigned to account for items expected but not considered in detail, such as, engineering, surveying and maintenance supplies, fire protection, safety and first aid equipment, mine rescue supplies, training (rescue, fire, medical), operating pickups, loaders, forklifts, small tools, IT systems, vehicle purchase and leasing, special clothing, stores, spares and consumables.

#### **2.5.3.5.7 56X.45.50.140 – Extended Operations, Equipment Replace/Refurbish/Maintain**

“Extended Operations, Equipment Replace/Refurbish/Maintain” encompasses maintenance of the DGR facility for 70 years following completion of UFC emplacement in conjunction with the corporate functions as defined in element 56X.45.50.130. This element spans the period of Years 56 to 125 for the Base Case and 86 to 155 for the Alternate Case.

The ongoing maintenance and refurbishment of the DGR infrastructure and surface facilities is carried out to ensure their continued operability and integrity against the prevailing environment. Maintenance functions include for 2 full-time (2 shifts) maintenance managers and 12 staff.

Hoist rope inspection and maintenance is carried forward at 1/10 of the applicable rate for the operational period. Small equipment, incidentals and consumables are included in the assigned allowance (30%).

## 2.5.4 56X.55 - Environmental Management System

“Environmental Management System” encompasses the procurement, delivery, installation and commissioning of environmental response equipment, radiological monitoring equipment and non-radiological air monitoring equipment. Labour, maintenance and replacement costs are covered under on-going operational cost elements, including Operations Indirects (56X.45.30). Environmental Management System one-time purchases occur in Year 25 for both the Base Case and Alternate Case.

**Environmental Response Equipment (56X.55.40)** encompasses the procurement, delivery, installation and commissioning of environmental response equipment.

**Radiological Monitoring Equipment (56X.55.50)** covers the procurement, delivery, installation and commissioning of radiological monitoring equipment.

**Non Radiological Monitoring Equipment (56X.55.60)** encompasses the procurement, delivery; installation and commissioning of non-radiological air monitoring equipment.

Additional aspects of the Environmental Management System (such as Environmental Assessment Monitoring) have been estimated separately by NWMO and are not included herein.

## 2.5.5 56X.60 - Decommissioning and Closure

“Decommissioning and Closure” encompasses decommissioning management, construction and operation of related facilities and the decommissioning and closure of the surface and underground works. This element spans Years 126 to 150 for the Base Case and 156 to 180 for the Alternate Case.

### 2.5.5.1 56X.60.10 - Decommissioning Management

“Decommissioning Management” encompasses operation and management of the DGR for 10 years following completion of extended operations/monitoring. The major function here will be the management of contracts to backfill remaining mine openings and the demolition/salvage of surface facilities. This element spans Years 126 to 135 for the Base Case and Years 156 to 165 for the Alternate Case.

This element includes the corporate organization which applies for necessary instruments, lets contracts and manages contract delivery to carry out the decommissioning and support functions. It encompasses costs for in-house engineering; contractor engineering is accounted for in turn-key (design-build) pricing for individual decommissioning actions. Costs are based on the following:

- 1 President;
- 2 Directors of Engineering;
- 1 Building Manager;
- 1 Finance Manager;
- 1 HR Manager;
- 2 Maintenance Managers;



- 1 Security Manager;
- 6 Engineering Support Staff;
- 2 Finance Analysts;
- 2 IT Support Personnel;
- 1 Nurse;
- 6 Conventional Safety and Health Physics Staff;
- 20 Security Guards;
- 3 Technical Support Staff;
- 10 Administrative Staff;
- 8 Janitorial and Maintenance Staff;
- Power and utilities at approximately \$680K/annum;
- Vehicle fleet costs at \$120K/annum; and
- Assignment for taxes or payments in lieu of taxes at \$250K/annum.

This element does not include 'final closure', the anticipated period between the completion of major decommissioning work and obtaining the facility license to abandon. No specific allocation has been made for taxes or payments in lieu of taxes, insurance, engineering, surveying and maintenance supplies, fire protection, safety and first aid equipment, mine rescue supplies, training (rescue, fire, medical), IT systems, special clothing, stores, spares and consumables. These expected expenditures are included in a 25% allowance.

#### 2.5.5.2 56X.60.30 - Decommissioning Facilities (Construction and Operation)

"Decommissioning Facilities" encompasses the design, construction, installation, commissioning and operation of decommissioning works. These facilities include the backfill materials plant and the waste processing and handling operations. This element spans the Years 126 to 135 for the Base Case and 156 to 165 for the Alternate Case.

**Backfill Materials Plant (Supply and Operate) (56X.60.30.10)** accounts for supply and operation of a facility for the handling and preparation of backfill (sealing materials) required to decommission the DGR.

**Waste Processing and Handling Facility (56X.60.30.20)** accounts for the handling, volume reduction and packaging of various waste arisings produced during decommissioning.

Facility design, construction, installation and commissioning are assumed to be on a turn-key contract basis, with management and operation carried out with contract labour. Material costs and additional operating costs are not separately included, as they are built into the blended material costs used for backfill/decommissioning work elements. Transport, disposal and other operating costs are also not separately included (these costs are built into per tonne and per m<sup>3</sup> rates for waste disposal line items).

#### 2.5.5.3 56X.60.40 - Auxiliary Surface Facilities Decommissioning

This element encompasses the decommissioning (demolition and removal) of the auxiliary surface facilities. It spans Years 126 to 135 for the Base Case and 156 to 165 for the Alternate Case.

Decommissioning under this WBS does not include those items which are the subject of other facility-specific decommissioning work elements, such as the UFPP (56X.60.50), the Waste Processing and Handling Facility (56X.60.30.20), the Backfill Materials Plant (56X.60.30.10) and the Sealing Materials Compaction Plant (56X.60.60). The decommissioning of facilities put in place specifically for the decommissioning and closure period are also excluded. These excluded decommissioning-period-specific facilities include the Waste Storage Areas (56X.60.70), the Permanent Vent Fan (56X.60.90), and Decommissioning Facilities (56X.60.30).

Auxiliary Surface Facilities Decommissioning includes full decommissioning of the DGR site and the off-site waste rock storage/disposal area. The site will be made ready for the beginning of the final closure period, which runs for 15 years after the end of decommissioning. Costing is based on a lump-sum turn-key decommissioning contract assessed at approximately 2.5% of initial acquisition costs for items not incorporated in other work elements.

#### **2.5.5.4 56X.60.50 - Used Fuel Packaging Plant Decommissioning**

This element encompasses labour and equipment for the decontamination, decommissioning, dismantling and removal of the UFPP. It is assumed that post-operations clean-out is carried out after operations are complete. This element spans Years 128 to 130 for the Base Case and 158 to 160 for the Alternate Case.

It is assumed no ILW will arise due to decommissioning activities. Arisings not classified as LLW will be classified as conventional wastes. A facility for handling, volume reduction and packaging of the various waste arisings produced during DGR decommissioning is to be constructed on site (56X.60.30.20). The cost of waste containers, transport and disposal is covered under element 56X.60.160.

#### **2.5.5.5 56X.60.60 - Sealing Materials Compaction Plant Decommissioning**

This element covers labour and equipment for the decommissioning, dismantling and removal of the operations phase sealing materials compaction plant (the SMCP, see element 56X.40.40). It spans Years 131 to 132 for the Base Case and Years 161 to 162 for the Alternate Case.

It is assumed that there will be no need for radiological decontamination with equipment and materials disposed of as conventional waste. The cost of waste containers, transport and disposal are covered under WBS 56X.60.160.

#### **2.5.5.6 56X.60.70 - Ancillary Radiation Area Decommissioning**

“Ancillary Radiation Area Decommissioning” encompasses labour and equipment for the decontamination, decommissioning, dismantling and removal of the Active Liquid Waste Treatment Building (56X.60.70.10), the Low Level Liquid Waste Storage Building (56X.60.70.20) and the Low Level Solid Waste Storage Building (56X.60.70.30). This element spans Years 127 to 129 for the Base Case and 157 to 159 for the Alternate Case.

This element includes the cost to return the building sites to a 'green' state. It is assumed that post operation clean out is done after operations are complete. It is also assumed no ILW will arise due to decommissioning (arisings not classified as LLW will be classified as conventional wastes). A facility for sorting, volume reduction and packaging of the various waste arisings produced during the decommissioning is to be constructed on site under WBS number 56X.60.30.20. The cost of waste containers, transport and disposal is covered under element 56X.60.160.

### 2.5.5.7 56X.60.80 - UFC Handling Systems

“UFC Handling Systems” encompasses labour and equipment for the decontamination, decommissioning, dismantling and removal of UFC casks, buffer block casks, in-room emplacement equipment, locomotives, rail cars, parking areas and the surface rail link to the Main Shaft. This element spans Years 127 to 128 for the Base Case and 157 to 158 for the Alternate Case.

Components will be size reduced and packaged for transport from site to a final disposal location. Arisings from decommissioning are assumed to be conventional waste. The cost of waste containers, transport and disposal is covered under element 56X.60.160.

### 2.5.5.8 56X.60.90 - Permanent Vent Fan Removal (Decommissioning)

“Permanent Vent Fan Removal” encompasses temporary ventilation as required during shaft backfilling operations as well as the decommissioning of ventilation equipment, accessories, heating penthouses, HEPA units and associated electrical gear not encompassed in shaft decommissioning work elements (WBS 56X.60.100). It includes complete (greenfield) decommissioning of the ventilation systems. This element occurs in Year 126 for the Base Case and Year 156 in the Alternate Case.

### 2.5.5.9 56X.60.100 - Underground Decommission and Seal

“Underground Decommission and Seal” encompasses the decommissioning of access tunnels and drifts and stripping and dismantling of the three shafts. This element spans the Years 126 to 133 for the Base Case and 156 to 163 for the Alternate Case.

**Access Tunnels and Drifts (56X.60.100.10)** addresses the decommissioning of remaining access tunnels and drifts. This includes removal of road bed and track ballast, rock handling equipment, fuels and lubricants, transport equipment, infrastructure and backfilling and sealing the openings. Labour rates for this element include contractor indirects. This element spans Years 126 to 130 for the Base Case and 156 to 160 for the Alternate Case.

**Service Shaft (56X.60.100.20), Main Shaft (56X.60.100.30) and Ventilation Shaft (56X.60.100.50)** decommissioning will begin when there is no further requirement to access the underground facility.

Shaft stripping and dismantling involves the removal of concrete and damaged rock annulus and the removal of headframes, hoists, collar houses and hoist rooms. This element also includes the disposal of waste materials, removal and haulage of salvageable metals, credit for salvage, and the dismantling of ventilation, dewatering, electrical, compressed air, water, alarm and IT systems. Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material in a retreat fashion. A new slick line will be installed in the Service Shaft for backfill placement. Labour rates include contractor indirects.

Decommissioning of the Service Shaft spans the Years 130 to 132 for the Base Case and 160 to 162 for the Alternate Case. Decommissioning of the Main Shaft spans Years 131 to 133 for the Base Case and 161 to 163 for the Alternate Case. Decommissioning of the Ventilation Shaft(s) spans Years 126 to 128 for the Base Case (one shaft) and 166 to 168 for the Alternate Case (two shafts).

#### **2.5.5.10 56X.60.110 - In-Town Decommissioning**

Townsite decommissioning, if required, encompasses the dismantling and disposing of obsolete facility-related town buildings and related works. This element occurs in Year 135 for the Base Case and Year 165 for the Alternate Case.

The nature and extent of facilities subject to dismantling will depend, for example, on the selected host community and its economic base. No specific costs are included in the current estimate; however, NWMO assignment of contingency accommodates several options, including demolition of worker accommodations (motel).

#### **2.5.5.11 56X.60.120 - Crusher Plant Demolition (Decommissioning)**

This element addresses the demolition and disposal of the rock crushing plant and concrete batch plant. This includes dismantling of the plants, haulage of debris to a disposal facility, salvage of scrap metal and landscaping. Labour rates for this element include contractor indirects. This activity occurs in Year 134 for the Base Case and Year 164 for the Alternate Case.

#### **2.5.5.12 56X.60.130 - Site Cleanup (Decommissioning)**

“Site Cleanup” encompasses the dismantling and disposal of remaining non-building surface infrastructure as part of the preparation for final closure. This work would be performed during the last two years of the major decommissioning period. Only an access road would be left, and only to the extent required to support closure activities such as monitoring. The resulting site is assumed to be in a state suitable for public use (at surface). This element spans Years 134 to 135 for the Base Case and 164 to 165 for the Alternate Case.

#### **2.5.5.13 56X.60.150 - Decommissioning Indirects**

“Decommissioning Indirects” cover that not encompassed in turn-key (design-build) labour rates or host functions, for example 56X.60.10 Decommissioning Management. This element spans Years 126 to 135 for the Base Case and 156 to 165 for the Alternate Case. Its estimate is based on support costs modified from the operations phase for elements including:

- Mine heating – An average of \$1,403,000/year over ten years;
- Surface building heat - An average of \$924,000/year over ten years;
- Electricity - An average of \$1,289,000/year over ten years;
- Water and sewerage - An average of \$9,100/year over ten years;
- Miscellaneous waste - An average of \$50/tonne over ten years; and
- Office, engineering and safety expenses - An average of \$697,000/year over ten years.

As the decommissioning design update adapted annual indirect costs from operational/active phase estimates, annual power, heat, electricity and water/sewerage allotments are expected to be conservative (*i.e.*, biased high). This is reflected by the inclusion of relatively few additional line items and by a relatively low level of allowance (10%).

#### 2.5.5.14 56X.60.160 - Decommissioning Waste Disposal

This element addresses the packaging, transport and disposal of conventional waste, very low level waste and LLW resulting from decommissioning activities. It spans Years 126 to 135 for the Base Case and 156 to 165 for the Alternate Case. It includes the containerization of waste arisings, transport of arisings to suitable disposal facilities and disposal.

Disposal costs include about 1,100 m<sup>3</sup> of low level waste at \$1,400/m<sup>3</sup> over 10 years from the waste management area and UFPF. The costs also include 129,800 tonnes of conventional (free-release) waste at \$200/tonne (load/transport/dispose) over the same period.

#### 2.5.5.15 56X.60.170 - Final Closure

“Final Closure” encompasses labour, plant, equipment and services required to undertake the final closure phase of the DGR project using a combination of corporate and turn-key resources. This element spans Years 136 to 150 for the Base Case and 166 to 180 for the Alternate Case.

This element follows the decommissioning and backfilling of underground tunnels and shafts, as well as the removal of redundant surface facilities. During this 15 year phase, the DGR will remain under institutional management and control until a license to abandon is obtained. Site security will remain in place, albeit at reduced levels, with facilities also available for monitoring personnel and administration infrastructure to support their ongoing activities.

Once a license to abandon the site has been obtained, 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. The management and operation of the DGR during this time will be carried out using the following staff complement:

- President (part-time), duties to include closure and public affairs (0.5 FTE);
- Technical Director (President part-time) (0.5 FTE);
- 2 Regulatory Staff (for reporting and license applications);
- 1 Finance Manager;
- 2 Administrative Staff;
- 1 QA / Safety Manager;
- 2 Environmental Monitoring Staff; and
- 4 General Staff.

Other costs, including contract work packages, will encompass:

- Ecological restoration - \$3,750,000;
- Signage and land marking - \$500,000;
- Final dismantling, removal, and disposals - \$2,000,000;
- Security - \$3,000,000;
- Final sealing of deep boreholes - \$2,500,000;
- Maintenance - \$1,875,000;
- Other contracts - \$2,000,000;
- Equipment, spares, and consumables - \$780,000;

- Vehicle leases - \$525,000;
- Energy consumption - \$750,000;
- Conventional insurance - \$300,000;
- Vehicle insurance - \$63,000; and
- Taxes or payments in lieu - \$3,750,000 (\$250,000 per year).

## 2.6 Major Assumptions

Project estimates are based on the assumptions included above, in the companion design document and in the Work Element Definition Sheets attached to this report. Key assumptions that affect multiple parts of the estimate include the following:

- Experimental fuel storage or transfer is not included in the project scope;
- No costs are allowed for major accidents or loss of fuel bundle integrity;
- The DGR will be readily accessible by road (within 25 km of a major highway) and within close proximity to power and water sources (within 10 km of a regional power grid);
- The repository will be located within a high-quality (e.g., sparsely fractured) crystalline rock geosphere;
- The subsurface development will be constructed at a nominal depth of 500 m (shaft bottom allowances for sumps, etc. will be below this elevation);
- The repository layout and equipment (above ground and underground) will be as indicated in the design report;
- Construction will begin in Year 16 and progress as described to deliver a functional, licensed facility at the end of Year 25;
- Used fuel shipments will occur over 30 years under the Base Case and 60 years under the Alternate Case. All used fuel is to be 30 years out of the reactor prior to shipment;
- The used fuel will arrive in bundles within the storage modules of Irradiated Fuel Transportation Casks as described in design documents for the transportation system;
- Incoming fuel will be properly packaged and free from defect. The UFPP will not reject any incoming used fuel or modules;
- The transportation system and DGR will operate 365 days/year at 80% capacity to account for weather/traffic delays, maintenance downtime, crew rotations, etc.;
- The used fuel will be re-packaged at the UFPP into baskets which are in turn inserted into IV-25 type Used Fuel Containers (UFCs) for subsequent placement in the underground repository;
- The UFC consists of an outer copper vessel, an inner steel vessel and three UFC baskets (carrying a total of 360 used-fuel bundles);
- A rate of emplacement equivalent to 120,000 used-fuel bundles per year for both scenarios will be accommodated. This is equivalent to 333 UFCs placed per year;
- Interim storage capacity in the UFPP will be equivalent to six weeks' processing of UFCs and/or three months' processing of incoming modules;
- A maximum of two UFCs will be placed in the repository per day, being transported on railcars from the UFPP to the Main Shaft and then to the placement room;
- An in-floor borehole placement method will be utilized for the UFCs in the underground repository;

- An anticipated in-floor borehole rejection rate of 10% will increase the number of boreholes required to be drilled;
- After placement is complete there will be a 70 year period during which underground access will be maintained and the placement rooms will be monitored;
- During this extended monitoring period, the capability will be maintained to recover the placed UFCs and spent fuel bundles;
- Hoisting, ventilation, monitoring and protection measures will be as described in the design report;
- Raw material inventories will be adequate to compensate for any delivery delays due to adverse weather conditions; and
- Final closure characteristics will be as close to natural conditions as practical with no provision allowed for re-entry underground.

## 3. BASIS OF ESTIMATE

### 3.1 Estimating Methodology

The cost and lifecycle estimate was derived from the conceptual design update. The scope of the update and fundamental design assumptions were set out in “*Used Fuel Deep Geological Repository and Transportation System - System Requirements for APM Update*” (NWMO Document No.: APM-PR-01110-0001-R00, the ‘System Requirements’). Specific guidance for the DGR cost estimation was summarized in the ‘Estimate Requirements’ (NWMO Document No.: APM-PR-00400-0001-R000).

Based on consideration of the system components, guidance in the Estimate Requirements, and review of earlier estimate work (e.g., 2003 CTECH Report), a work breakdown structure was developed as discussed previously. The WBS was used to construct a Microsoft Access database for recording work element data, such as:

- Primary estimator (‘Prepared By’);
- WBS code and description;
- Deliverables;
- Assumptions;
- Basis for the assignment of allowance;
- Task start and end year;
- Type of cost (fixed, step-fixed or variable);
- Valid range (in millions of fuel bundles);
- Critical predecessors;
- Critical successors;
- Labour (labour ID, start year, finish year and hours per year);
- Material and Equipment (by item);
- Other costs (by item); and
- Allowance (as a percent of the value of Labour, Materials and Equipment and Other).

A consistent database has been constructed for the companion Used Fuel Transportation System lifecycle cost and schedule estimate. The databases allow the attachment of back-up calculations and quotes, including Microsoft Excel-format worksheets.

Based on the conceptual design, the database for the DGR was populated for each terminal node of the relevant WBS (costs were not assigned to branching points in the WBS). Costs were estimated for Labour, Materials and Equipment, Other and Allowance as discussed below:

- Labour – Labour has been input as hours and classifications. Each labour classification is associated with a specific rate (\$/hr) and available hours per year per Full Time Equivalent (FTE). Classifications are provided for a variety of labour types, including NWMO contract employees for DGR operations (categories DGR01 to DGR04) and design-build contractors (DB01 to DB08);



- Materials and Equipment – Materials and Equipment have been input on an item-by-item basis and refer to the cost of permanent materials and equipment, *i.e.*, those materials used to construct the project (consumables are not included) and incorporated equipment installations. This includes heavy equipment (trucks, forklifts, cranes) to be used during operations, UFC assembly equipment, and laboratory and office equipment;
- Other – Other has been input on an item-by-item basis. This includes items such as consumables (fuel, utilities and non-permanent materials), permits and fees, taxes, communication costs, furniture, temporary monitoring equipment, and travel and accommodation expenses; and
- Allowance – Allowance has been input as a percentage of the total of Labour, Materials & Equipment and Other. Allowance refers to an additional amount added to the cost for an individual work element to cover expected requirements that are not fully defined at the time of the estimate. Allowance is a budget element that is expected to be expended (allowance is not a 'reserve' that an owner seeks to retain).

Typically, element costs were developed as semi-detailed unit costs with assembly-level line items (with allowances).

NWMO developed and supplied data for the following work elements:

- 56X.40.40.10.10 - UFPP Project Management / Building Design & Construction;
- 56X.40.40.10.20 - UFPP Equipment Design, Supply & Install (Receive & Transfer);
- 56X.40.40.10.30 - UFPP Equipment Design, Supply & Install (Package);
- 56X.40.40.10.40 - UFPP Equipment Design, Supply & Install (Dispatch);
- 56X.40.40.10.50 - Building Services Design, Supply & Installation (UFPP);
- 56X.40.40.10.60 - Commissioning (UFPP);
- 56X.45.40.10 - UFPP Operation; and
- 56X.45.40.20 - Supply of Baskets and UFCs.

For the balance of the estimate, input costs other than labour were collected predominately by means of verbal and written quotes, searches of team member project records and searches of publicly available media over the November 2009 to November 2010 period. Costs were modified using the professional judgement of the design team and in reference to recent project experience related to operating experience at the Pickering and Bruce Nuclear Generating Stations.

Stand-alone shaft development costs were developed by a specialist sub-contractor (Nordmin Resource & Industrial Engineering) based on recent experience with large-diameter, blind shaft sinking and related headframe, collar and fit-out costs. These stand-alone costs were then deconstructed and redistributed during estimate compilation to account for parallel working crews and the existence of a support camp.

Underground development costs were estimated using an integrated mining cost model developed by Hwozdyk Inc. This model, which has been validated against costs for several commercial mining ventures, incorporates detailed consideration of crew composition, equipment replacement/repair, fuel consumption, consumables, advance rates, bonus structures, overheads and indirects to simulate all-inclusive per meter costs for an array of mine openings and structures.

To the extent possible, surface facilities were estimated on the basis of turn-key pricing derived from recent (2009) design and contracting activities in Ontario.

The database was used to generate Microsoft Word format 'Work Element Definition Sheets' (WEDS) as well as Microsoft Excel workbooks summarizing a variety of estimate data. Excel sheets were then manually manipulated, including use of Visual Basic for Applications (VBA) programming, to produce a scalable version of the estimate (as discussed later). The database and workbooks package accompany this report.

Costs were primarily developed from estimating team member project experience. As indicated in the supporting documents attached to specific work elements in the accompanying cost estimate database, the estimating team also solicited guidance from a range of specialists, vendors and contractors (see Section 8).

As noted in back-up attached to specific elements in the accompanying cost estimate database, additional cost and cost index information was obtained from the following sources:

- RS Means/Reed Construction Data (2009);
- CostMine Mining Intelligence & Technology Cost Guide (2010); and
- Statistics Canada Northern Ontario Cost Index Data (2010).

### 3.2 Guidance and Standards

Formulation of the estimate and this cost and schedule report was guided by the System Requirements and the Estimate Requirements discussed previously. In addition, the design and estimation team referred to common terminology and practice as conveyed, for example, in the following:

- Association for the Advancement of Cost Engineering International (AACE International). 2009. *Cost Engineering Terminology*. Recommended Practice No. 10S-90;
- AACE International. 2008. *Contingency Estimating – General Principles*. Recommended Practice No. 40R-08;
- AACE International. 2007. *Basis of Estimate*. Recommended Practice No. 34R-05;
- AACE International. 2005. *Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for the Process Industries*. Recommended Practice No. 18R-97; and
- AACE International. 2003. *Cost Estimate Classification System*. Recommended Practice No. 17R-97.

### 3.3 Scheduling

Based on the System Requirements, an overall schedule was determined, with identified phases. The design report describes the scheduling of construction and operations to meet these requirements. Associated activities were assigned dates. The derived schedule is thus neither resource-constrained nor resource-driven: it reflects project scheduling objectives (resources are assumed to be available when and as necessary).

Estimate compilation included an assessment of sequencing and the feasibility of executing tasks based on factors such as total feasible simultaneous site staff levels. It was concluded that the presented schedule is generally feasible.

Because costs are assigned on an annual basis and work element descriptions include items like start and finish years, an annual cost flow is directly exportable from the estimate database. This basic expenditure schedule was used in conjunction with activity logic, work element assumptions and project objectives to construct project timelines (Gantt charts).

### 3.4 Base Year, Currency and Escalation

The entire cost estimate has been developed in January 2010 Canadian dollars. While the use of a construction cost index to estimate 2010 values from historic data was allowed for, the current estimate reflects recent pricing, and index-based escalation of historic pricing was minimal.

In the case of several specific quotes related to early/mid 2009, an escalation factor of 1.03 was utilized at the discretion of the technical team (as indicated in the back-up spreadsheets attached to the relevant work elements in the cost estimate database).

### 3.5 Inflation, Escalation, Discount Rate and Cost of Capital

As discussed above, work is estimated on a constant dollar basis as if it were to take place in 2010. No inflation, escalation, discount rate assignment, cost of capital calculation or internal rate of return analysis is provided herein.

### 3.6 Planning Basis and Resource Strategy

The primary planning basis, including logistics and resource assumptions for the estimate is the conceptual design presented in the DGR design report. Within this context, a phase-based resourcing approach has been applied, as follows:

**Table 3: Resource Strategy**

Phase	Who Performs Work
Site Exploration & Approval	NWMO Staff
Construction (Design Build)	Engineer-Procure-Construct (EPC) delivery with NWMO managing contracts, licenses safety assessments, etc.
Construction Phase (Commissioning)	Primarily NWMO staff
Operation Phase	NWMO staff/ staff under contract
Decommissioning Phase	Primarily Contractor staff

Related labour categories, rates, annual availability and associated considerations are presented in later sections.

### 3.7 Labour Categories, Labour Rates, Included Costs and Productivity

The estimate database uses a central list of labour categories (resource codes). Individual estimates are input on the basis of hours required.

To calculate the cost of labour, the database calls on the current input rate for each labour code. Updates to codes are immediately and consistently propagated throughout the estimate. Labour codes for the current estimate were last updated on September 10, 2010, as identified on Table 4.

Labour rate derivation is as follows:

- DGR rates are derived from existing OPG, Association of Management, Administrative and Professional Crown Employees of Ontario (AMAPCEO) 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 (SAVH), as well as training;
- Architect/Engineer and purchased service costs are based on burdened labour with subcontractor overhead and profit, *i.e.*, they represent 'charge out rates'. Supervision, small tools, job-site overheads and indirects are not included; and
- Design Build costs represent inclusive labour costs and incorporate a range of typical project indirects, including training, tools, supervision, job-site housekeeping, etc.

Table 4: Labour Codes and Categories

Labour Code	Organization	Type	Hourly Rate	Yearly Available Hours	Notes
AE01	Architect Engineer	Executive/ Management/ Senior Engineer	\$220.00	1860	See Purchased Service 01 (PS01)
AE02	Architect Engineer	Administration	\$80.00	1860	Jan 2010\$ Golder estimate based on Ontario Consultant Charge-out Rates
AE03	Architect Engineer	Engineering/ Technical/ Specialist	\$110.00	1860	See Purchased Service 03 (PS03)
DB01	Design Build Contractor	Executive/ management/ Senior Engineer	\$220.00	1860	Jan2010\$, Golder Estimate based on Current Contracting Division (GAIA) Rates
DB02	Design Build Contractor	Administration	\$80.00	1860	Jan2010\$, Golder Estimate based on Current Contracting Division (GAIA) Rates
DB03	Design Build Contractor	Engineering/ Technical/ Specialist/ Design	\$110.00	1860	See Purchased Service 03 (PS03)
DB04	Design Build Contractor	Site Administration	\$80.00	1860	Jan2010\$, Golder Estimate based on Current Contracting Division (GAIA) Rates
DB05	Design Build Contractor	Site management/ Senior Engineers	\$160.00	1860	See Purchased Service 02 (PS02)
DB06	Design Build Contractor	Site Engineering/ Technical/ Specialist	\$110.00	1860	See Purchased Service 03 (PS03)
DB07	Design Build Contractor	Site Construction workers (Surface)	\$118.00	1860	NWMO supplied site worker rate including construction indirects
DB08	Design Build Contractor	Site Construction workers (Underground)	\$118.00	1860	NWMO supplied site worker rate including construction indirects
DGR01	DGR Contractor	Management/ Executive	\$130.00	1470	Jan 2010\$ - Based on current OPG Experience
DGR02	DGR Contractor	Administration	\$52.00	1470	Jan 2010\$ - Based on Association of Management, Administrative and Professional Crown Employees of Ontario (AMAPCEO) range midpoint for equivalent roles
DGR03	DGR Contractor	Engineering/ Technical/ Specialists	\$74.00	1470	Jan 2010\$ - Based on Association of Management, Administrative and Professional Crown Employees of Ontario (AMAPCEO) range midpoint for equivalent roles
DGR04	DGR Contractor	Civil	\$45.00	1680	Jan 2010\$ - Blended OPG Civil Maintainer & Ontario Industry Skilled Labour Rates
PS01	Purchased Service	Manager or Project Manager	\$220.00	1860	Jan 2010\$ Golder estimate based on Ontario Consultant Charge-out Rates
PS02	Purchased Service	Senior Technical Specialist	\$160.00	1860	Jan 2010\$ Golder estimate based on Ontario Consultant Charge-out Rates
PS03	Purchased Service	Intermediate Technical Specialist	\$110.00	1860	Jan 2010\$ Golder estimate based on Ontario Consultant Charge-out Rates
PS04	Purchased Service	Junior Technical Specialist or Senior Technician	\$100.00	1860	Jan 2010\$ Golder estimate based on Ontario Consultant Charge-out Rates

Design Build rates are based on an average 2010 Ontario Electrical Power Systems Construction Association (EPSCA) base hourly rate, supplemented with allowances for indirects as follows:

**Table 5: Design-Build Labour Rate Inclusions**

Base Labour Rate (\$/hr)		<b>\$43.94</b>
Canada Pension Plan	4.95%	\$2.18
Employment Insurance	2%	\$0.88
Workplace Safety and Insurance Board	6%	\$2.64
Travel Allowance	7.87%	\$3.46
Site Supervision	12%	\$5.27
Site Overhead and Profit	18%	\$7.91
Mark Up	15%	\$6.59
Construction Equipment	22%	\$9.67
On-going Safety	8%	\$3.52
Safety Orientation	4%	\$1.76
Small Tools	10%	\$4.39
Spot Premium Overtime	10%	\$4.39
Janitorial Clean Up	1.8%	\$0.79
Warehousing	1.1%	\$0.48
Surveying	2.8%	\$1.23
Pickup Trucks and Fuel	18%	\$7.91
Office Trailers	2.8%	\$1.23
Propane and Temporary Facilities	1.4%	\$0.62
Telephone	5.5%	\$2.42
Computer/Printer	5%	\$2.20
Sewage for Temporary Facilities	1%	\$0.44
Power for Temporary Facilities	2.8%	\$1.23
Sewage Pump Outs	1%	\$0.44
Special Rigging	5.5%	\$2.42
		<b>\$74.05</b>
		<b>\$117.99</b>

Input labour hours for each work element are as envisaged to complete the described deliverables, which includes assumptions as to productivity under the working conditions and schedules specified in the DGR design report.

Note that the differing labour classifications include different treatments of indirect costs. Consequently, activities utilizing inclusive (Design-Build, “DB”) labour rates carry few or no additional indirect cost line items; activities using relatively bare labour rates include separate line items and allowances to accommodate the same level of support. Please see Section 3.10 for additional information on accounting for indirects.

### 3.8 Assemblies, Unit Cost Data and Standard Crews

In consultation with NWMO, all-inclusive ('turn-key') prices based on recent projects, especially nuclear sector projects, were used to the degree feasible. These rolled-up costs have not been disaggregated or decomposed to develop crew compositions. The actual crew distribution for turn-key delivery is at the discretion of the contractor and represents a differentiator between contractors and source of competitive advantage.

### 3.9 Location and Location Factors

Cost data collected applies to Ontario purchases in 2010. As itemized in the back-up attached to work elements in the accompanying cost estimate database, unit rates particular to Southern Ontario (such as Darlington) were adjusted to Northern Ontario (Timmins as a proxy) using a location factor of 1.10 based on primary estimator experience, supported by discussions with team members, vendors and contractors familiar with the items in question.

### 3.10 Indirects

Indirect costs ('Indirects') have been defined by NWMO in the Estimate Requirements as:

- *In construction, all costs which do not become a final part of the installation, but which are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, start-up costs, contractor's fees, insurance, taxes, etc.*
- *In operations, costs not directly assignable to the end product or process, such as overhead and general purpose labour, or costs of outside operations. Indirect operating costs may include insurance, property taxes or grants in lieu of taxes, depreciation, warehousing and loading.*

These definitions are aligned with contemporary practice, for example, as expressed in AACE Recommended Practice RP10S-90 which further characterizes indirects as "costs not directly attributable to the completion of an activity" and notes that "indirect costs are typically allocated or spread across all activities on a predetermined basis."

Within the DGR estimate, indirects are implicitly or explicitly included in the estimate on the basis of the contracting strategy for individual work elements. As described previously, the current estimate assumes that construction and decommissioning activities are contracted to firms or consortia that will deliver a turn-key product, such as a building ready for occupancy, on the basis of technical requirements issued by the buyer. This turn-key delivery by an EPC entity results in a total price that accounts for risk, detailed design, indirects, incidentals, etc.

Where costing data allowed, all-inclusive ('turn-key') rates from recent project experience were applied to generate representative costs for well-understood structures, such as conventional buildings. As noted, because such rates thoroughly include components of cost, they represent complete and realistic costs for a given deliverable. After consultation with NWMO, costs on the basis of a full turn-key process are simply incorporated as 'Other' cost line items (and are not speculatively deconstructed into multiple cost categories). Within the total cost based on all-inclusive rates, the specific blend of labour, materials and other costs necessary for delivery would be entirely at the discretion of, and unique to, the selected contractor.

For underground development work, all-inclusive turn-key rates were developed using an existing mine development cost model (produced by Hwozdyk Inc.). The resulting rates, as expected, incorporate relevant indirects, with the exception of electrical power and propane for mine heating, which are entered as separate line items.

A number of items with anticipated turn-key delivery but where applicable all-inclusive costing was not available were estimated on the basis of permanent materials and equipment costs and installation or operational labour. In these cases, 'DB' (Design-Build) DB07 or DB08 labour rates were used to account for indirects as discussed previously. The use of DB labour rates accounted for items such as:

- Construction equipment;
- Safety orientation;
- Small tools;
- Janitorial clean-up;
- Warehousing;
- Surveying;
- Vehicles;
- Office trailers;
- Local heating and temporary facilities;
- IT support;
- Temporary utilities and sanitation; and
- Special rigging.

Additional indirect costs, for example as applicable to items without a significant turn-key delivery component, are accounted for in other components of the estimate as follows:

- Major activity-specific consumables and miscellaneous indirect costs (such as travel or building maintenance as a percentage of initial construction cost) have been explicitly included in 'Other' costs;
- 'Allowance' has been assigned to each work element to account for aspects of cost not explicitly included in estimate line items, including miscellaneous small indirects;
- Program Management, Repository System Development and Safety Assessment are incorporated as separate, major (second level) components of the WBS estimated separately by NWMO (not included herein);
- Additional indirect costs have been accumulated within dedicated elements of the WBS, such as the following:
  - 56X.40.10.30.20.40 - Campsite and Campsite Operations;
  - 56X.40.30 - Construction Phase Indirects (Incl. Fire & Security);
  - 56X.40.40.10.60 - Commissioning (UFPP);
  - 56X.45.10 - Operations Program Management (Incl. Tax);
  - 56X.45.20 - Indirect Operations Management (Incl. Quality Assurance);
  - 56X.45.30 - Operations Indirects (Incl. Fire & Security);
  - 56X.45.40.40 - Operations and Maintenance of Auxiliary Surface Facilities;
  - 56X.45.50.100 - Hoist Rope Replacement;
  - 56X.45.50.110 - Indirects for Final Panel UFC Placement;
  - 56X.45.50.120 - Mining Heat and Power;
  - 56X.45.50.130 - Extended Operations (Incl. Support Services);
  - 56X.45.50.140 - Extended Operations Equipment Replace/Refurb/Maintain;



- 56X.60.10 - Decommissioning Management;
- 56X.60.30 - Decommissioning Facilities (Construction & Operation);
- 56X.60.130 - Site Clean-up (Decommissioning);
- 56X.60.150 - Decomm(issioning) Indirects (Incl. Heat, Consumables); and
- 56X.60.160 - Decomm(issioning) Waste Disposal.

### 3.11 Insurance

Insurance costs are not currently incorporated in project costs (at NWMO's discretion, program level bonding or insurance may be added to 'Program Management'), with two exceptions as follows:

- (1) Insurance embedded in inclusive vehicle fleet costs and/or delivered materials and equipment costs; and
- (2) A lump sum assigned to account for conventional general and vehicle insurance over the entirety of 'Final Closure' (15 years).

### 3.12 Freight, Tax, Sales Tax, Duties and Community Payments

Materials and equipment and other costs are on an installed basis, inclusive of freight and duty unless otherwise noted. The cost of taxes on materials or services that would be purchased by a contractor to build real property (e.g., buildings) or to install fixtures (e.g., cranes) are also included in the materials and equipment and 'Other' costs for the relevant work elements.

Based on the Estimate Requirements, offsets, benefits, compensation, etc. to host communities may be included by NWMO as an aspect of 'Program Management' or a related element in newer NWMO WBSs. NWMO may also make a provision for the harmonized sales tax (HST) for the total cost of goods and services purchased by NWMO. Such assignments are the domain of NWMO and are not included herein.

At present, the estimate carries allocations for taxes or payments in lieu of taxes, as follows:

- An annual placeholder value for taxes or payments of \$6 million per year during major operations (used-fuel placement); and
- An annual placeholder value for taxes or payments of \$250K per year during Extended Operations (monitoring of repository, 70 years) and both stages of decommissioning, Major Decommissioning (10 years) and Final Closure (15 years).

### 3.13 Management Reserve, Allowance and Contingency

No management reserve is incorporated into the current estimate. Two different sums, 'Allowance' and 'Contingency' have been considered in order to account for incomplete design and project risk, respectively. The definition of 'Allowance' from the Estimate Requirements is as follows:

*"Additional resources included in estimates to cover the cost of known but undefined requirements for an individual activity or work item."*

NWMO reserved the assignment of 'Contingency', and the use of the term, to itself, noting:

*"The application of contingency is decided by the owner [i.e., NWMO] based on their assessment of risk within the estimate including allowance."*

'Allowance' is reported at the lowest level of the WBS, at the level of the terminal nodes on the WBS tree. 'Contingency' is calculated as a single value applied to the overall estimate and is independent of any specific work element or estimated annual expenditure. Contingency has been calculated as directed by the NWMO.

As applied herein, 'Allowance' accounts for the expected additional costs not captured in individual estimate line items. Given the conceptual state of the design, detail as to consumables, fittings, small parts, miscellaneous costs, etc. are not available. To create a realistic total price, judgement is used to assign a factor - the 'Allowance' - that accounts for these additional costs. These costs are expected expenditures, budgeted for completion of the work according to plan.

The amount of allowance is based on previous experience with similar work, similar projects and an assessment of both design completeness and the novelty of the undertaking. Overall, the general guidance as identified on Table 6 was provided for the estimate.

**Table 6: Allowance Guidelines**

Amount of Allowance	Characteristics of Work Element
≤15%	<ul style="list-style-type: none"> <li>• Commercial Off-the-Shelf (COTS) item with known price (no further work necessary);</li> <li>• Cost data from recent, similar identical or very similar work used;</li> <li>• High degree of confidence in design status and procurement specification;</li> <li>• Accurate measurement of quantities;</li> <li>• Firm contractor quotations on detailed specification(s); and</li> <li>• Risk areas identified and mitigated by assumptions.</li> </ul>
20%	<ul style="list-style-type: none"> <li>• Commercial Off-the-Shelf item with limited, identifiable modifications required;</li> <li>• Data used from previous similar contract or recent benchmarking;</li> <li>• Reasonable confidence in methods of measurement &amp; quantities;</li> <li>• High degree of confidence in design status and procurement specification;</li> <li>• Contractor firm or 'budget' quotations; and</li> <li>• Risk areas identified and mitigated by assumptions.</li> </ul>
25%	<ul style="list-style-type: none"> <li>• Design has been reviewed and assessed;</li> <li>• Suppliers provide budget quotations in response to a conceptual/provisional specification;</li> <li>• Previous similar contract or benchmarking data available;</li> <li>• Involves only conventional methods of construction / manufacture; and</li> <li>• Methods of measurement and quantities are reasonably reliable.</li> </ul>
30%	<ul style="list-style-type: none"> <li>• Design has been reviewed and assessed;</li> <li>• Estimating data from similar contracts have been used for reference;</li> <li>• Methods of measurement and/or quantities are unreliable or inexact;</li> <li>• Involves unconventional methods/materials of construction / manufacture; and</li> <li>• Labour-intensive (this includes many aspects of operations phases).</li> </ul>

Amount of Allowance	Characteristics of Work Element
40%	<ul style="list-style-type: none"> <li>• Design is an initial revision;</li> <li>• Labour intensive activity;</li> <li>• Activity or item likely to overrun (high cost variance in current practice);</li> <li>• Suppliers provide budget pricing based on design outline;</li> <li>• Little previous experience; and</li> <li>• Requires development for methods/materials of construction/manufacture.</li> </ul>
50%	<ul style="list-style-type: none"> <li>• State of the Art;</li> <li>• Requires significant development;</li> <li>• Never been done before commercially;</li> <li>• Innovative design;</li> <li>• Complex features; and</li> <li>• Labour intensive activity liable to overrun (this specifically includes commissioning phases).</li> </ul>
>50%	<ul style="list-style-type: none"> <li>• High cost risk, extremely speculative design or only a general concept.</li> </ul>

Allowances were assigned on a work-element basis by the relevant initial estimator. These allowances have been adjusted in collaboration with NWMO to be consistent across the estimate and to reflect the relatively low allowance warranted for realistic all-inclusive turn-key rates based on recent similar work.

### 3.14 Exclusions

A number of factors (and related costs) have been excluded from the current estimate. These include:

- Scope other than described or contract delivery other than that assumed;
- Major design or operational changes over the lifecycle of the project;
- Financing costs or lack of adequate and timely funding;
- Design, licensing, site acquisition, procurement, construction or operational delay;
- Site conditions or fuel conditions differing from those assumed in the design report;
- Impacts from floods, earthquakes or major climate change;
- Prolonged labour strikes and major work stoppages;
- Major protest or civil unrest, acts of crime, terrorism or war;
- Lawsuits or injunctions;
- Changes in regulatory requirements;
- Changes in science or technology or in health & safety requirements;
- Extreme economic conditions (such as deflation/depression with excess labour/equipment availability or runaway inflation and extremely low labour/equipment availability); and
- Foreign procurement, foreign currency costs and related risk.

Other than routine fees already embedded in the current cost data (for example, software fees allowed for in office costs), or as specifically mentioned in individual work element descriptions, no allowance for intellectual property fees (patents, royalties and licensing costs) related to future technology are included.

## 4. ESTIMATED COST

Based on the foregoing, detailed year-by-year costs were developed for each work element. These detailed costs are presented in associated Excel format workbooks which enable, for example, summaries of costs by year at each level of the WBS. The following sections present the overall cost estimate results in terms of the major elements of the WBS, project year, cost category, labour type, reactor site and waste owner. In total, and based on the methodology, scope and assumptions detailed in this report, the total 2010 constant Canadian dollar costs for the Base and Alternate Cases are as follows:

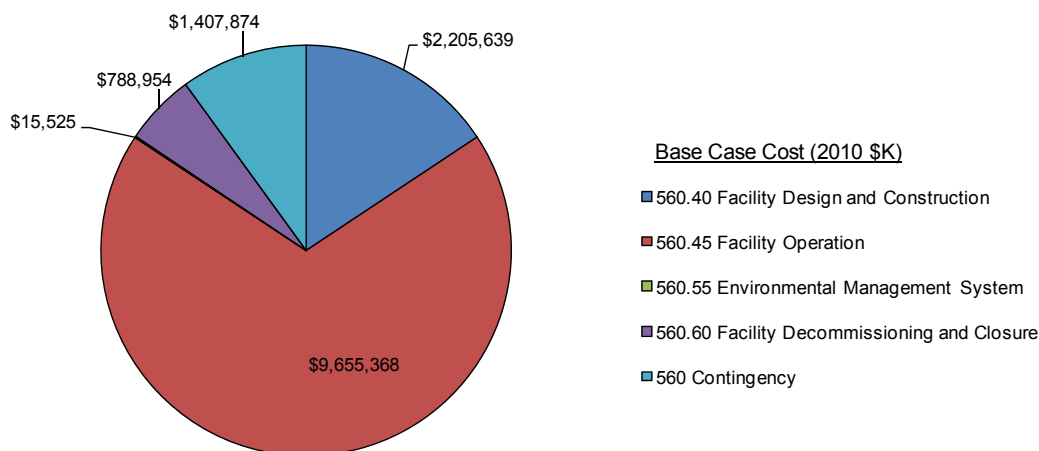
- Base Case (3.6 million used fuel bundles): \$12.7 billion; and
- Alternate Case (7.2 million used fuel bundles): \$21.7 billion.

### 4.1 Summary of Costs at Level 2 of the WBS

At the second level of the WBS, current Base and Alternate Case estimates are as presented below on Table 7 / Figures 1 and 2 and, Table 8 / Figures 3 and 4, respectively.

**Table 7: Base Case Estimate by Level 2 of the WBS**

WBS	Title (Base Case)	Estimate (2010 \$K)
560.40	Facility Design and Construction	\$2,205,639
560.45	Facility Operation	\$9,655,368
560.55	Environmental Management System	\$15,525
560.60	Facility Decommissioning and Closure	\$788,954
<b>560 Subtotal</b>		<b>\$12,665,487</b>
	Contingency	\$1,407,874
<b>560 Total</b>		<b>\$14,073,360</b>



**Figure 1: Base Case Estimate by Level 2 of the WBS (2010 \$K)**

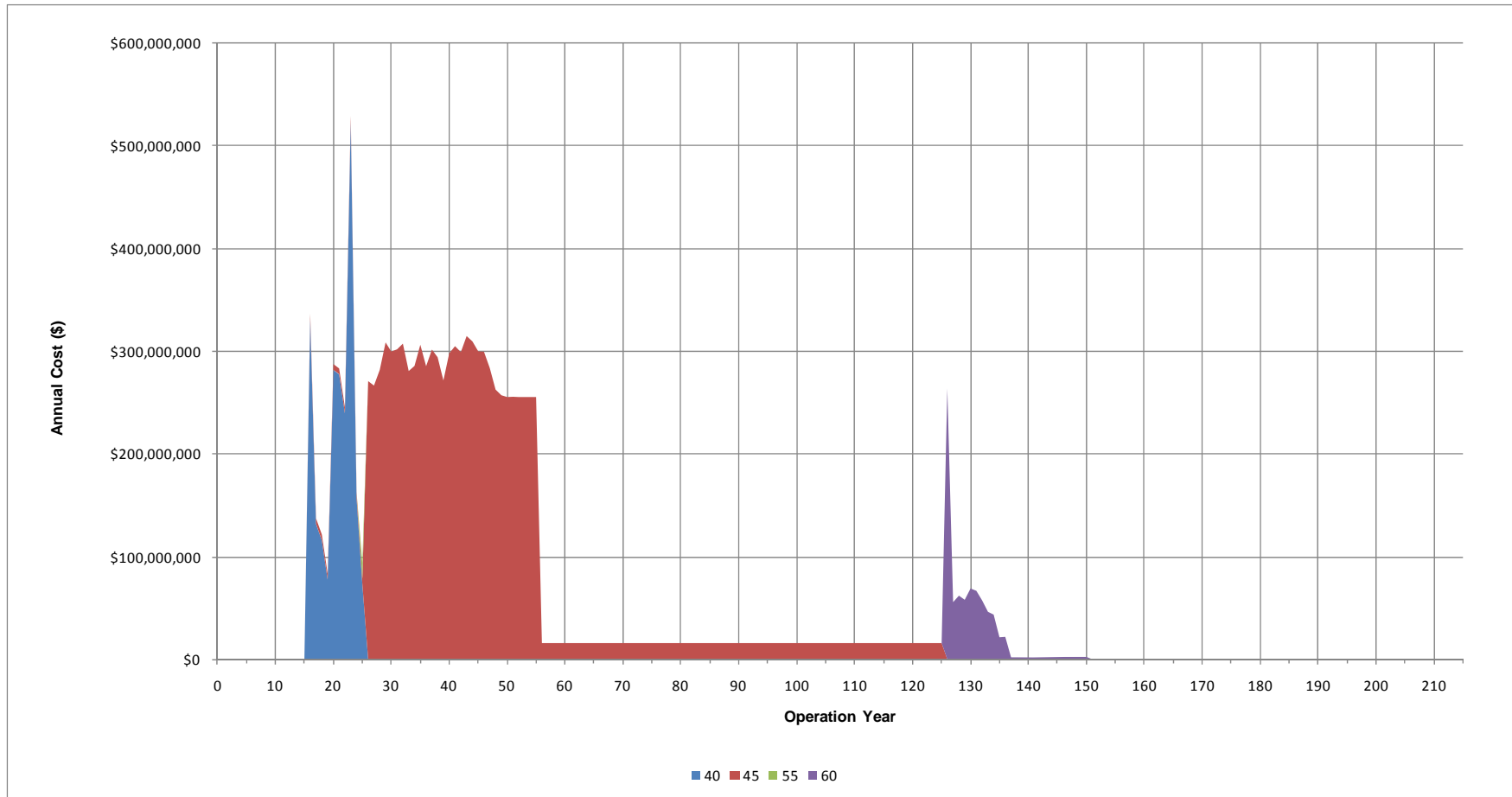
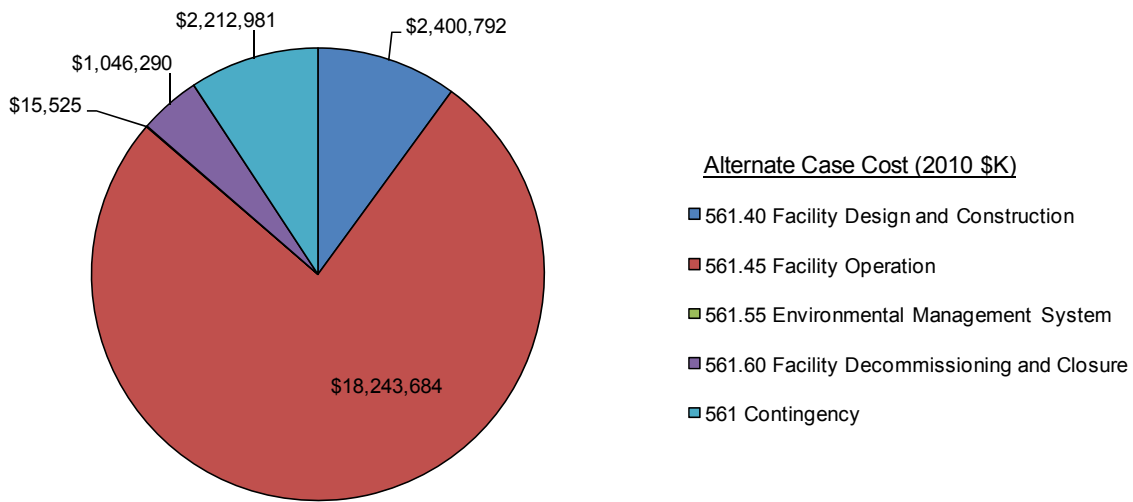


Figure 2: Annual Base Case Estimate by Level 2 of the WBS (2010 \$)

**Table 8: Alternate Case Estimate by Level 2 of the WBS (2010 \$K)**

WBS	Title (Alternate Case)	Estimate (2010 \$K)
561.40	Facility Design and Construction	\$2,400,792
561.45	Facility Operation	\$18,243,684
561.55	Environmental Management System	\$15,525
561.60	Facility Decommissioning and Closure	\$1,046,290
<b>561 Subtotal</b>		<b>\$21,706,291</b>
	Contingency	\$2,212,981
<b>561 Total</b>		<b>\$23,919,272</b>



**Figure 3: Alternate Case Estimate by Level 2 of the WBS (2010 \$K)**

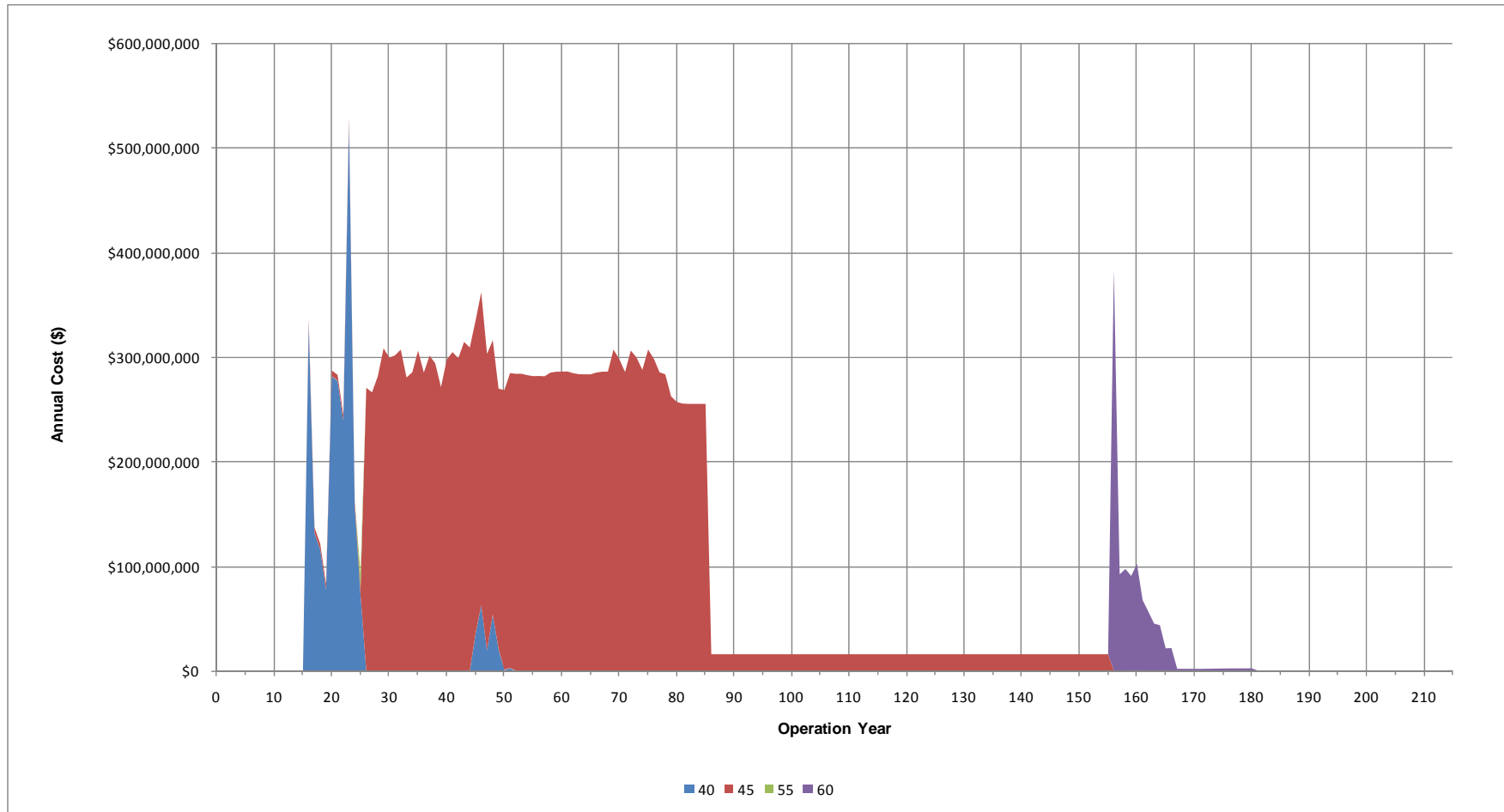


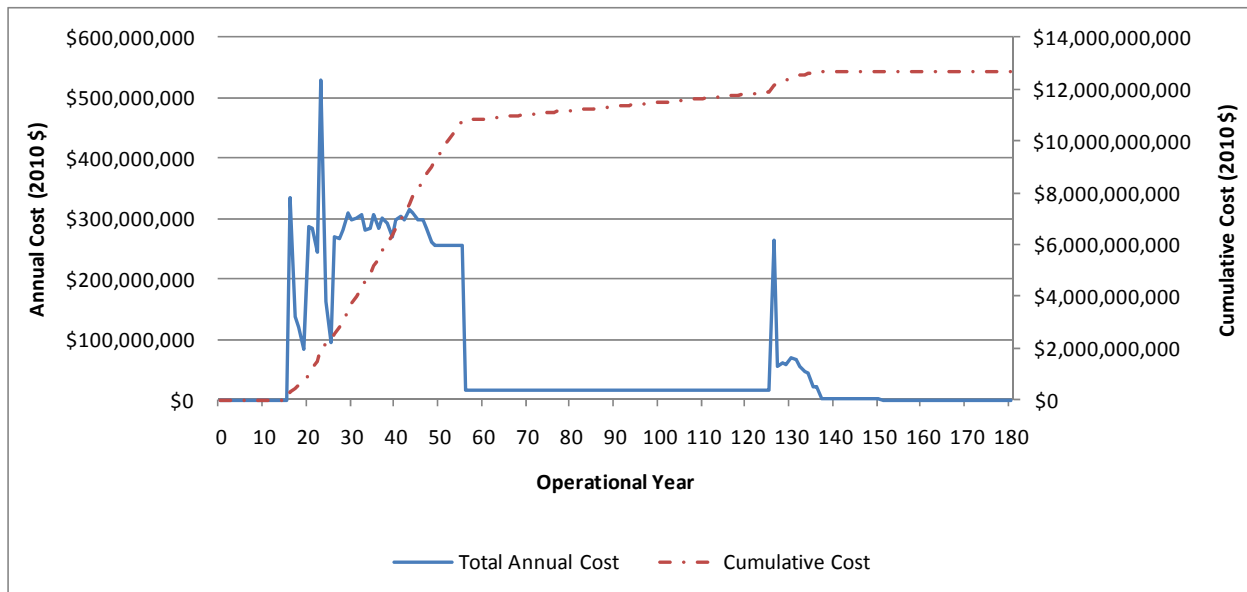
Figure 4: Annual Alternate Case Estimate by Level 2 of the WBS (2010 \$)

## 4.2 Detailed Cost Breakdown

Costs per work element are presented in Appendix A. Workbooks accompanying this report include annual costs per work element, per cost category, on an annual basis.

## 4.3 Annual and Cumulative Cost

Given the input years for each cost item, and the overall start and finish years for each work element, total annual costs in the Base and Alternate Case estimates are presented below in conjunction with the cumulative cost incurred over time (see Figures 5 and 6, respectively).



**Figure 5: Base Case Estimate – Annual and Cumulative Cost (2010 \$)**



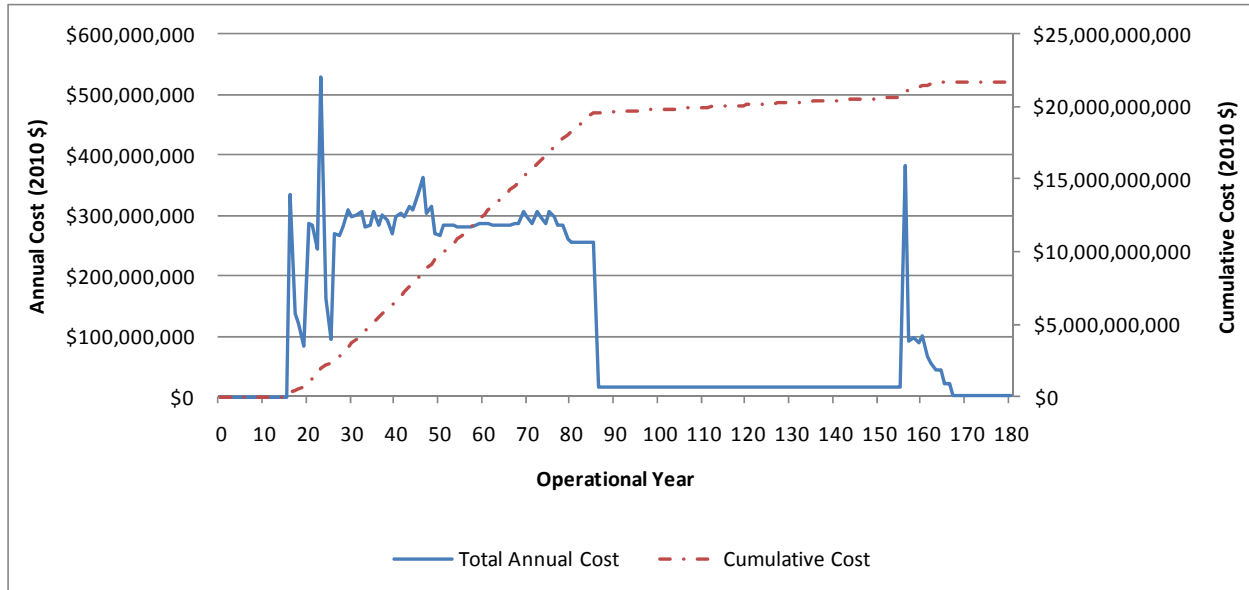


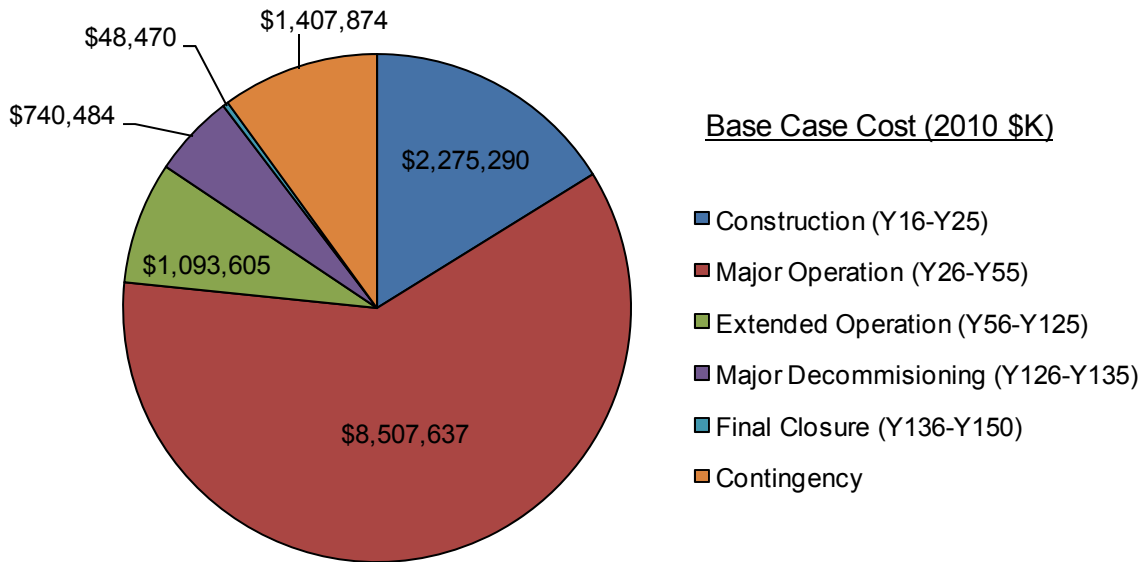
Figure 6: Alternate Case Estimate – Annual and Cumulative Cost (2010 \$)

#### 4.4 Summary of Cost by Phase

Assigning each work element to one of the project phases results in the estimated division of costs as provided in Table 9 and Table 10. Figures 7 and 8 illustrate the same information graphically for the Base and Alternate Cases, respectively.

**Table 9: Base Case Costs by Project Phase**

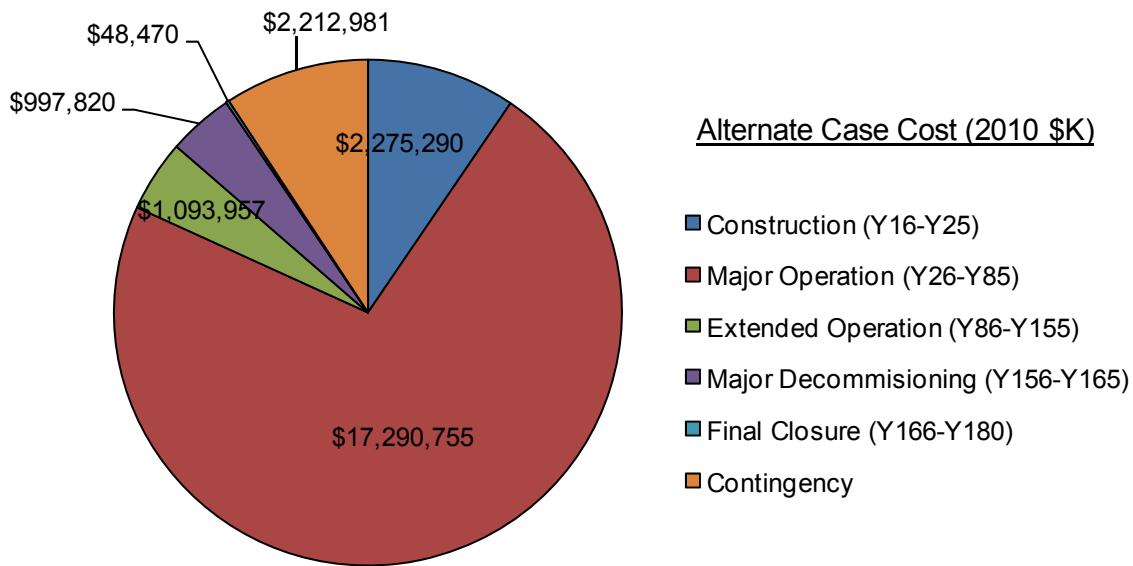
Project Phase		Base Case (2010 \$K)
Siting & Licensing (Y1-Y15)		\$0
Construction (Y16-Y25)		\$2,275,290
Operation	Major Operation (Y26-Y55)	\$8,507,637
	Extended Operation (Y56-Y125)	\$1,093,605
	<i>Operation Subtotal</i>	<i>\$9,601,243</i>
Closure & Decommissioning	Major Decommissioning (Y126-Y135)	\$740,484
	Final Closure (Y136-Y150)	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	<i>\$788,954</i>
<b>560 Subtotal</b>		<b>\$12,665,487</b>
Contingency		\$1,407,874
<b>560 Total</b>		<b>\$14,073,360</b>



**Figure 7: Base Case Estimate by Project Phase (2010 \$K)**

**Table 10: Alternate Case Costs by Project Phase**

Project Phase		Alternate Case (2010 \$K)
Siting & Licensing (Y1-Y15)		\$0
Construction (Y16-Y25)		\$2,275,290
Operation	Major Operation (Y26-Y85)	\$17,290,755
	Extended Operation (Y86-Y155)	\$1,093,957
	<i>Operation Subtotal</i>	<i>\$18,384,712</i>
Closure & Decommissioning	Major Decommissioning (Y156-Y165)	\$997,820
	Final Closure (Y166-Y180)	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	<i>\$1,046,290</i>
<b>561 Subtotal</b>		<b>\$21,706,291</b>
Contingency		\$2,212,981
<b>561 Total</b>		<b>\$23,919,272</b>



**Figure 8: Alternate Case Estimate by Project Phase (2010 \$K)**

#### 4.5 Summary of Cost by Cost Category

Estimated cost by specific category (Labour, Material & Equipment, Other and, Allowance) are presented below on Table 11 / Figure 9 and Table 12 / Figure 10, for the Base and Alternate Cases, respectively.

**Table 11: Base Case Cost Estimate by Cost Category**

Base Case (2010 \$K: 3.6M Bundles)						
Project Phase	Labour	Material & Equipment	Other	Allowance	Total	
Siting & Licensing (Y1-Y15)	\$0	\$0	\$0	\$0	\$0	
Construction (Y16-Y25)	\$126,069	\$800,936	\$976,190	\$372,095	\$2,275,290	
Operation	Major Operation (Y26-Y55)	\$1,310,476	\$2,686,850	\$3,398,084	\$1,112,227	\$8,507,637
	Extended Operation (Y56-Y125)	\$461,609	\$0	\$410,022	\$221,974	\$1,093,605
	<i>Operation Subtotal</i>	<i>\$1,772,085</i>	<i>\$2,686,850</i>	<i>\$3,808,106</i>	<i>\$1,334,202</i>	<i>\$9,601,243</i>
Closure & Decommissioning	Major Decommissioning (Y126-Y135)	\$302,510	\$204,428	\$124,491	\$109,055	\$740,484
	Final Closure (Y136-Y150)	\$22,271	\$0	\$21,793	\$4,406	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	<i>\$324,781</i>	<i>\$204,428</i>	<i>\$146,284</i>	<i>\$113,461</i>	<i>\$788,954</i>
<b>560 Subtotal</b>	<b>\$2,222,935</b>	<b>\$3,692,214</b>	<b>\$4,930,580</b>	<b>\$1,819,758</b>	<b>\$12,665,487</b>	
Contingency	-	-	-	-	\$1,407,874	
<b>560 Total</b>	<b>\$2,222,935</b>	<b>\$3,692,214</b>	<b>\$4,930,580</b>	<b>\$1,819,758</b>	<b>\$14,073,360</b>	

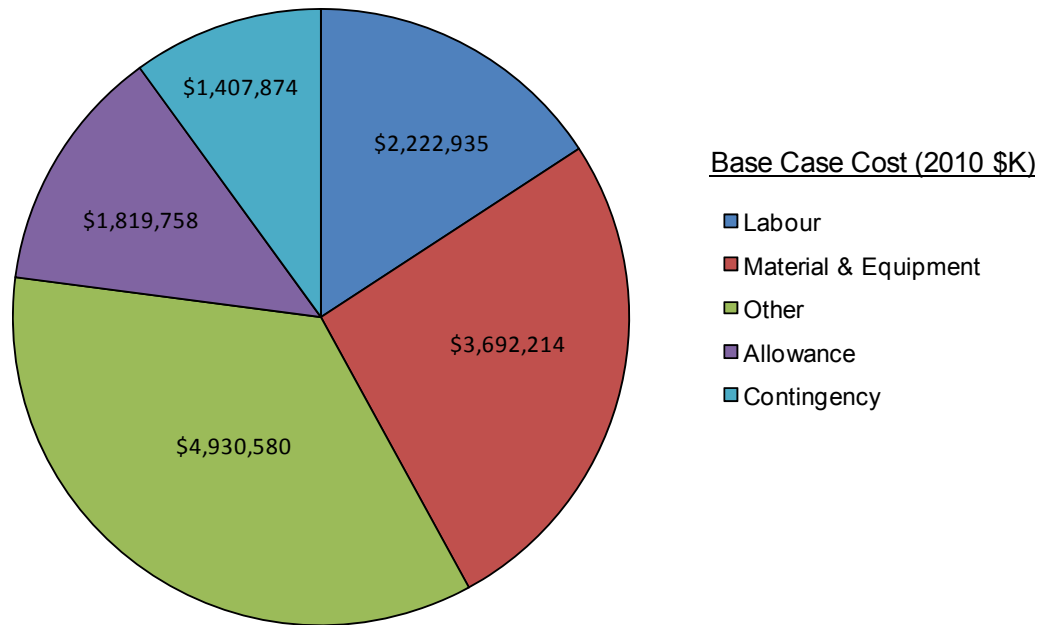


Figure 9: Base Case Estimate by Cost Category (2010 \$K)

Table 12: Alternate Case Cost Estimate by Cost Category

Alternate Case (2010 \$K: 7.2M Bundles)						
Project Phase	Labour	Material & Equipment	Other	Allowance	Total	
Siting & Licensing (Y1-Y15)	\$0	\$0	\$0	\$0	\$0	
Construction (Y16-Y25)	\$126,069	\$800,936	\$976,190	\$372,095	\$2,275,290	
Operation	Major Operation (Y26-Y85)	\$2,620,951	\$5,373,700	\$7,043,266	\$2,252,838	\$17,290,755
	Extended Operation (Y86-Y155)	\$461,609	\$0	\$410,292	\$222,055	\$1,093,957
	<i>Operation Subtotal</i>	<i>\$3,082,561</i>	<i>\$5,373,700</i>	<i>\$7,453,557</i>	<i>\$2,474,894</i>	<i>\$18,384,712</i>
Closure & Decommissioning	Major Decommissioning (Y156-Y165)	\$460,144	\$274,998	\$130,229	\$132,449	\$997,820
	Final Closure (Y166-Y180)	\$22,271	\$0	\$21,793	\$4,406	\$48,470
	<i>Closure &amp; Decommissioning Subtotal</i>	<i>\$482,414</i>	<i>\$274,998</i>	<i>\$152,022</i>	<i>\$136,855</i>	<i>\$1,046,290</i>
<b>561 Subtotal</b>	<b>\$3,691,044</b>	<b>\$6,449,633</b>	<b>\$8,581,769</b>	<b>\$2,983,844</b>	<b>\$21,706,291</b>	
Contingency	-	-	-	-	\$2,212,981	
<b>561 Total</b>	<b>\$3,691,044</b>	<b>\$6,449,633</b>	<b>\$8,581,769</b>	<b>\$2,983,844</b>	<b>\$23,919,272</b>	

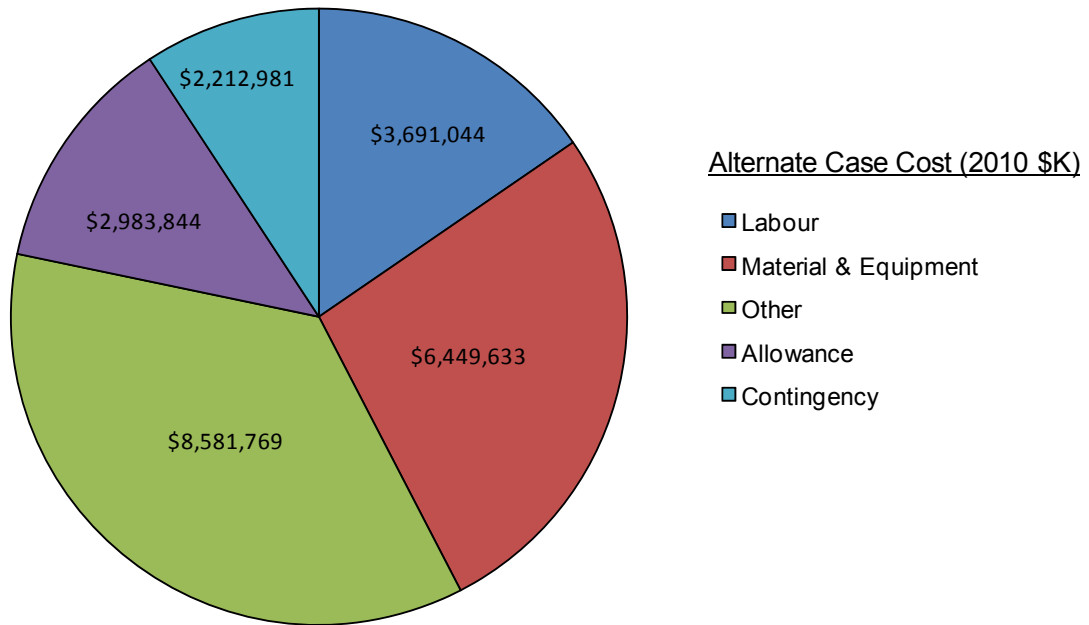


Figure 10: Alternate Case Estimate by Cost Category (2010 \$K)

#### 4.6 Labour Utilization

The estimated use of differing labour categories is summarized below on Tables 13 and 14, for the Base and Alternate Cases, respectively. Subsequent sub-sections present the use of labour categories on an annual basis and with respect to project phase.

**Table 13: Base Case Labour Category Use (Total)**

<b>Base Case (2010 \$K: 3.6 M Bundles)</b>				
<b>Labour Code</b>	<b>Labour Category</b>	<b>Hourly Rate</b>	<b>Total Hours</b>	<b>Labour Cost</b>
DB03	Engineering/Technical/Specialist/ Design	\$110.00	6,682	\$735
DB04	Site Administration	\$80.00	53,509	\$4,281
DB05	Site management/Senior Engineers	\$160.00	109,019	\$17,443
DB06	Site Engineering/Technical/Specialist	\$110.00	186,000	\$20,460
DB07	Site Construction workers (Surface)	\$118.00	2,259,771	\$266,653
DB08	Site Construction workers (Underground)	\$118.00	374,450	\$44,185
DGR01	Management/Executive	\$130.00	2,384,340	\$309,964
DGR02	Administration	\$52.00	15,332,100	\$797,269
DGR03	Engineering/Technical/Specialists	\$74.00	8,151,150	\$603,185
DGR04	Civil	\$45.00	3,528,000	\$158,760
<b>560 Total</b>			<b>32,385,020</b>	<b>\$2,222,935</b>
<b>Weighted Average Hourly Rate</b>		<b>\$68.64</b>		

**Table 14: Alternate Case Labour Category Use (Total)**

<b>Alternate Case (2010 \$K: 7.2 M Bundles)</b>				
<b>Labour Code</b>	<b>Labour Category</b>	<b>Hourly Rate</b>	<b>Total Hours</b>	<b>Labour Cost</b>
DB03	Engineering/Technical/Specialist/ Design	\$110.00	6,682	\$735
DB04	Site Administration	\$80.00	53,509	\$4,281
DB05	Site management/Senior Engineers	\$160.00	109,019	\$17,443
DB06	Site Engineering/Technical/Specialist	\$110.00	186,000	\$20,460
DB07	Site Construction workers (Surface)	\$118.00	2,259,771	\$266,653
DB08	Site Construction workers (Underground)	\$118.00	1,710,327	\$201,819
DGR01	Management/Executive	\$130.00	3,795,540	\$493,420
DGR02	Administration	\$52.00	25,166,400	\$1,308,653
DGR03	Engineering/Technical/Specialists	\$74.00	14,325,150	\$1,060,061
DGR04	Civil	\$45.00	7,056,000	\$317,520
<b>561 Total</b>			<b>54,668,397</b>	<b>\$3,691,044</b>
<b>Weighted Average Hourly Rate</b>		<b>\$67.52</b>		

#### 4.6.1 Utilization by Year

Labour hours by project year by labour category for the Base and Alternate Cases are illustrated on the following Figures 11 and 12, respectively.

#### 4.6.2 Utilization by Phase

Based on the classification of work elements, the estimated use of labour categories per phase is as presented below on Tables 15 and 16 for the Base and Alternate Cases, respectively.



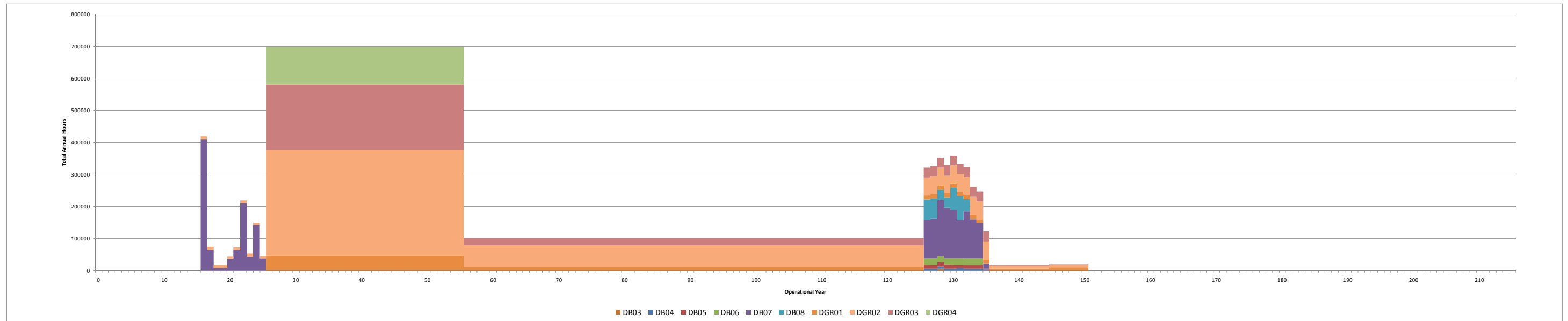


Figure 11: Base Case Labour Category Use by Year

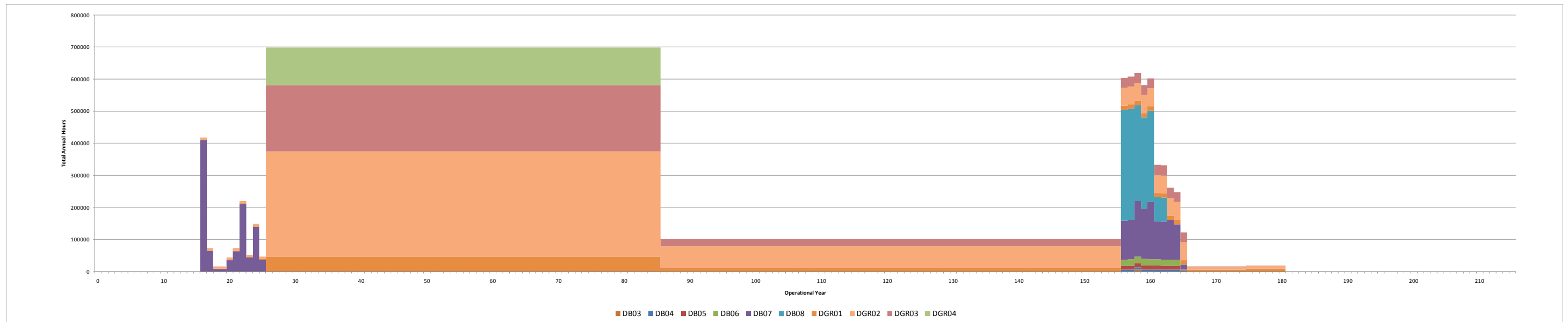


Figure 12: Alternate Case Labour Category Use by Year

**Table 15: Base Case Labour Use by Phase**

Base Case (2010 \$K: 3.6M Bundles)							
Project Phase	Labour Code	Labour Category	Hourly Rate	Total Hours	Labour Cost		
Siting & Licensing (Y1-Y15)		Not Included					
Construction (Y16-Y25)	DB07	Site Construction workers (Surface)	\$118	1,019,800	\$120,336		
	DGR01	Management/Executive	\$130	14,700	\$1,911		
	DGR02	Administration	\$52	73,500	\$3,822		
Operation	Major Operation (Y26-Y55)	DGR01	Management/Executive	\$130	1,411,200	\$183,456	
		DGR02	Administration	\$52	9,834,300	\$511,384	
		DGR03	Engineering/Technical/Specialists	\$74	6,174,000	\$456,876	
		DGR04	Civil	\$45	3,528,000	\$158,760	
	Extended Operation (Y56-Y125)	DGR01	Management/Executive	\$130	720,300	\$93,639	
		DGR02	Administration	\$52	4,733,400	\$246,137	
		DGR03	Engineering/Technical/Specialists	\$74	1,646,400	\$121,834	
	<i>Operation Subtotal</i>				<b>28,047,600</b>	<b>\$1,772,085</b>	
	Closure & Decommissioning	Major Decommissioning (Y126-Y135)	DB03	Engineering/Technical/Specialist/ Design	\$110	6,682	\$735
			DB04	Site Administration	\$80	53,509	\$4,281
DB05			Site management/Senior Engineers	\$160	109,019	\$17,443	
DB06			Site Engineering/Technical/Specialist	\$110	186,000	\$20,460	
DB07			Site Construction workers (Surface)	\$118	1,239,971	\$146,317	
DB08			Site Construction workers (Underground)	\$118	374,450	\$44,185	
DGR01			Management/Executive	\$130	132,300	\$17,199	
DGR02			Administration	\$52	558,600	\$29,047	
DGR03			Engineering/Technical/Specialists	\$74	308,700	\$22,844	
Final Closure (Y136-Y150)		DGR01	Management/Executive	\$130	105,840	\$13,759	
		DGR02	Administration	\$52	132,300	\$6,880	
		DGR03	Engineering/Technical/Specialists	\$74	22,050	\$1,632	
<i>Closure &amp; Decommissioning Subtotal</i>				<b>3,229,420</b>	<b>\$324,781</b>		
<b>560 Total</b>				<b>32,385,020</b>	<b>\$2,222,935</b>		

**Table 16: Alternate Case Labour Use by Phase**

Alternate Case (2010 \$K: 7.2M Bundles)						
Project Phase	Labour Code	Labour Category	Hourly Rate	Total Hours	Labour Cost	
Siting & Licensing (Y1-Y15)		Not Included				
Construction (Y16-Y25)	DB07	Site Construction workers (Surface)	\$118	1,019,800	\$120,336	
	DGR01	Management/Executive	\$130	14,700	\$1,911	
	DGR02	Administration	\$52	73,500	\$3,822	
Operation	Major Operation (Y26-Y85)	DGR01	Management/Executive	\$130	2,822,400	\$366,912
		DGR02	Administration	\$52	19,668,600	\$1,022,767
		DGR03	Engineering/Technical/Specialists	\$74	12,348,000	\$913,752
		DGR04	Civil	\$45	7,056,000	\$317,520
	Extended Operation (Y86-Y155)	DGR01	Management/Executive	\$130	720,300	\$93,639
		DGR02	Administration	\$52	4,733,400	\$246,137
		DGR03	Engineering/Technical/Specialists	\$74	1,646,400	\$121,834
	<i>Operation Subtotal</i>				48,995,100	\$3,082,561
	Closure & Decommissioning	Major Decommissioning (Y156-Y165)	DB03	Engineering/Technical/Specialist/ Design	\$110	6,682
DB04			Site Administration	\$80	53,509	\$4,281
DB05			Site management/Senior Engineers	\$160	109,019	\$17,443
DB06			Site Engineering/Technical/Specialist	\$110	186,000	\$20,460
DB07			Site Construction workers (Surface)	\$118	1,239,971	\$146,317
DB08			Site Construction workers (Underground)	\$118	1,710,327	\$201,819
DGR01			Management/Executive	\$130	132,300	\$17,199
DGR02			Administration	\$52	558,600	\$29,047
DGR03			Engineering/Technical/Specialists	\$74	308,700	\$22,844
Final Closure (Y166-Y180)		DGR01	Management/Executive	\$130	105,840	\$13,759
		DGR02	Administration	\$52	132,300	\$6,880
		DGR03	Engineering/Technical/Specialists	\$74	22,050	\$1,632
<i>Closure &amp; Decommissioning Subtotal</i>				4,565,297	\$482,414	
<b>561 Total</b>				<b>54,668,397</b>	<b>\$3,691,044</b>	

## 5. SCHEDULE

The overall schedule for the Base and Alternate Cases is as depicted below:

### Base Case

Phases		Item	(Y)ear	
Siting & Licensing		Complete Feasibility Studies (3)	Y3	(December)
		Complete Subsurface Investigations (2)	Y8	(December)
		Select Site	Y9	(January)
		End Siting & Licensing Process	Y15	(December)
Construction		Obtain Construction Licence/Begin Construction	Y16	(January)
		End Construction	Y25	(December)
Operation	Major Operations	Obtain Operations License/Begin Operations	Y26	(January)
		Complete Loading Fuel/End Operations	Y55	(December)
	Extended Operations	Begin Extended Operations (Monitoring)	Y56	(January)
		Complete Extended Operations (70 yrs)	Y125	(December)
Closure and Decommissioning	Major Decommissioning	Obtain Decommissioning Licence/Begin Decommissioning	Y126	(January)
		End Major Decommissioning (10 yrs)	Y135	(December)
	Final Closure	Begin Final Closure Period	Y136	(January)
		Abandonment Licence/End Final Closure (15 yrs)	Y150	(December)

### Alternate Case

Phases		Item	(Y)ear	
Siting & Licensing		Complete Feasibility Studies (3)	Y3	(December)
		Complete Subsurface Investigations (2)	Y8	(December)
		Select Site	Y9	(January)
		End Siting & Licensing Process	Y15	(December)
Construction		Obtain Construction Licence/Begin Construction	Y16	(January)
		End Construction	Y25	(December)
Operation	Major Operations	Obtain Operations License/Begin Operations	Y26	(January)
		Complete Loading Fuel/End Operations	Y85	(December)
	Extended Operations	Begin Extended Operations (Monitoring)	Y86	(January)
		Complete Extended Operations (70 yrs)	Y155	(December)
Closure and Decommissioning	Major Decommissioning	Obtain Decommissioning Licence/Begin Decommissioning	Y156	(January)
		End Major Decommissioning (10 yrs)	Y165	(December)
	Final Closure	Begin Final Closure Period	Y166	(January)
		Abandonment Licence/End Final Closure (15 yrs)	Y180	(December)

Each work element is also described in terms of its start and end years. Moreover, there is a necessary sequence to operations. Based on work element data, high-level project schedules for the Base and Alternate Cases are depicted below (see Figures 13 and 14, respectively), where Year 1 is assumed to be 2010.

Full schedules are attached in Appendix A as ANSI D-size sheets.

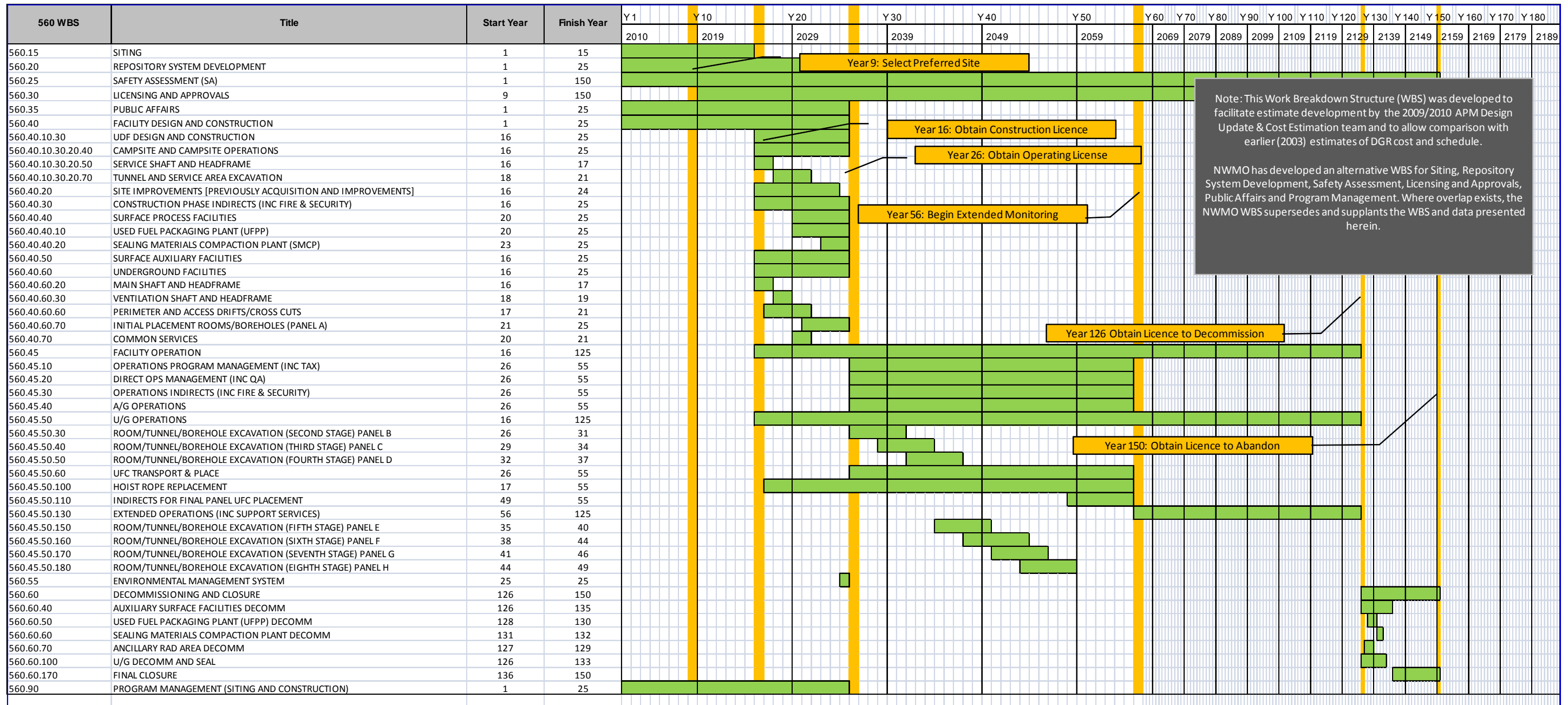


Figure 13: Summary (High-Level) Base Case Schedule

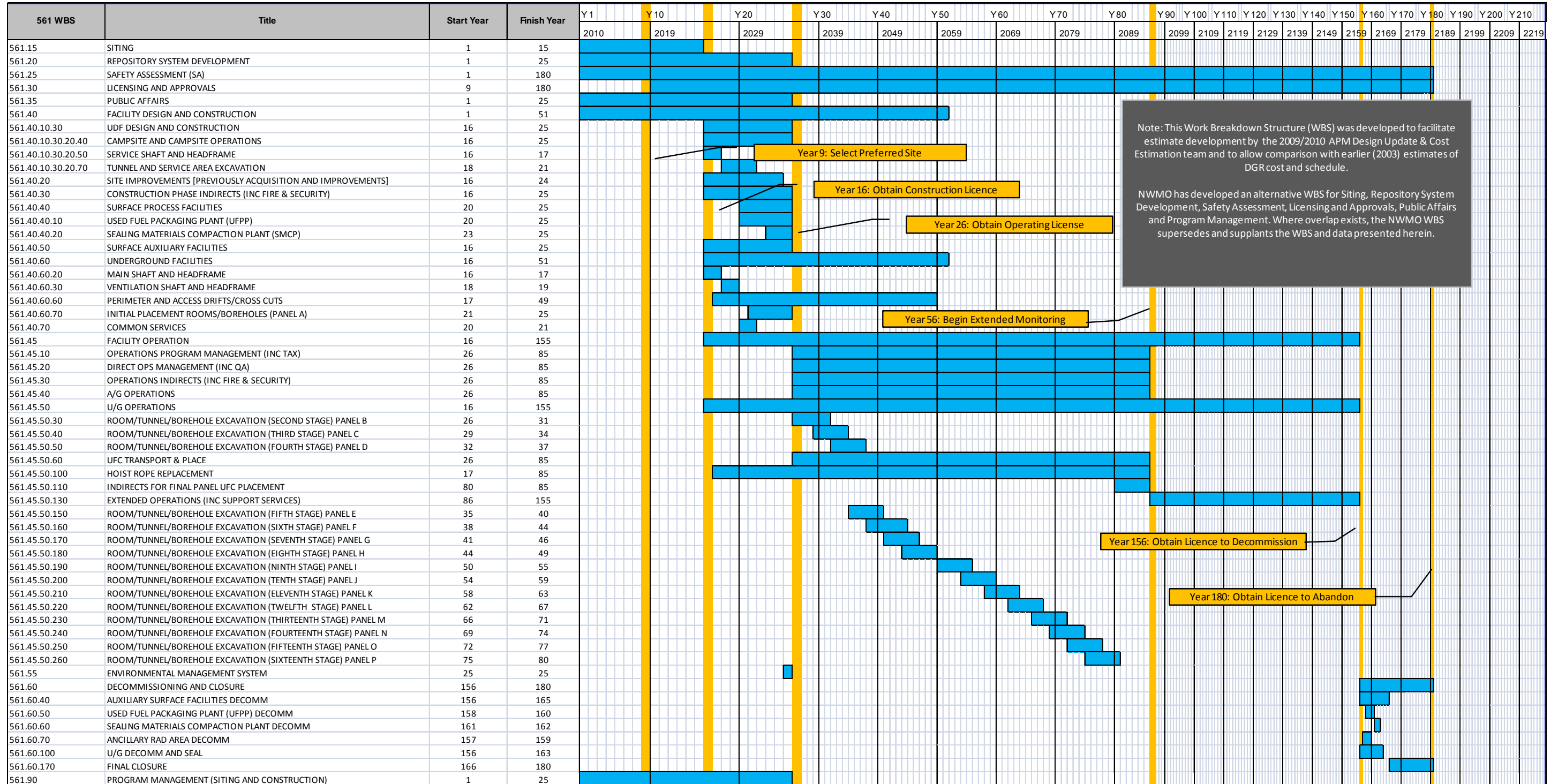


Figure 14: Summary (High-Level) Alternate Case Schedule

## 6. DISCUSSION

This report presents the current lifecycle cost estimate and schedule for the construction, operation and decommissioning of a DGR in a crystalline rock formation. Together with companion files, such as the attached Work Element Definition Sheets and Excel workbooks, the estimate constitutes a transparent, reproducible assessment of related costs and timelines.

Subject to the inclusions/exclusions, assumptions and limitations presented in this report, the estimated total cost of the DGR (in constant 2010 Canadian dollars) is as follows:

- Base Case (3.6 million used fuel bundles): \$12.6 billion; and
- Alternate Case (7.2 million used fuel bundles): \$21.5 billion.

The following sections review considerations with respect to estimate class and accuracy, the document trail for the estimate, estimate quality assurance, reconciliation with previous estimates, benchmarking and project risk analysis.

### 6.1 Estimate Classification and Accuracy

To avoid misapplication or misrepresentation, the following sections discuss the estimate classification, expected accuracy and related considerations. The estimate characteristics have been examined with regard to contemporary practice in cost engineering, including:

- Association for the Advancement of Cost Engineering International (AACE International). 2003. *Cost Estimate Classification System*. Recommended Practice No. 17R-97. ("AACE RP 17R-97"); and
- AACE International. 2005. *Cost Estimate Classification System – As Applied in Engineering, Procurement and Construction for the Process Industries*. Recommended Practice No. 18R-97 ("AACE RP 18R-97").

All else being equal, estimate accuracy is generally correlated with estimate class. It is noted, however, that the accuracy range is affected by many factors, and should be evaluated on an estimate-by-estimate basis.

As the project progresses, its definition will advance and progressively more detailed and accurate cost estimates will be possible. Resolving items such as the following will help improve the accuracy of future estimates:

- The confirmation or modification of estimate assumptions (the design basis);
- Identification of the actual DGR location and geosphere characteristics; and
- Final shipping inventories and fuel condition (such as age).

#### 6.1.1 Estimate Class and Level of Project Definition

'Project Definition' is a primary determinant of estimate class and is commonly taken to correspond to the percent completion of engineering. As engineering is advanced, quantities, characteristics and schedules are finalized, allowing progressively more complete/accurate estimate entries.

While industry-wide guidance for assessing project definition for nuclear waste management is not available, it is informative to look to the process engineering community for indications of design state. For example, AACE RP 18R-97 maps the extent and maturity of estimate input information (deliverables) against five classification levels as shown below where 'S' denotes 'Started', 'P' denotes 'Preliminary' and 'C' denotes 'Complete':

**Table 17: Available Design Data vs. Estimate Class**

General Project Data	Estimate Class				
	Class 5	Class 4	Class 3	Class 2	Class 1
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils & Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
<b>Engineering Deliverables</b>					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans		S	P/C	C	C
Process Flow Diagrams (PFDs)		S/P	P/C	C	C
Utility Flow Diagrams (UFDs)		S/P	P/C	C	C
Piping & Instrument Diagrams (P&IDs)		S	P/C	C	C
Heat & Material Balances		S	P/C	C	C
Process Equipment List		S/P	P/C	C	C
Utility Equipment List		S/P	P/C	C	C
Electrical One-Line Drawings		S/P	P/C	C	C
Specifications & Datasheets		S	P/C	C	C
General Equipment Arrangement Dwgs		S	P/C	C	C
Spare Parts Listings			S/P	P	C
Mechanical Discipline Drawings			S	P	P/C
Electrical Discipline Drawings			S	P	P/C
Instrumentation/Control Discipline Dwgs			S	P	P/C
Civil/Structural/Site Discipline Drawings			S	P	P/C

Notes:

- S – 'Started'. Work on deliverable begun. Development typically limited to sketches, rough outlines, or similar.
- P – 'Preliminary'. Work on deliverable advanced. Interim, cross-functional reviews have usually been conducted.
- C – 'Complete'. The deliverable has been reviewed and approved as appropriate.



Overall, the current state of the DGR corresponds to a low Class 4 estimate, *i.e.*, to one defined in the order of 1% to 15% of full project definition. As presented in the companion DGR design report:

- Material flow and cycle times have been plotted out;
- Reasonably detailed equipment and labour requirements have been produced; and
- The general characteristics of major equipment have been determined.

Schematics of major processes have also been developed, and crew size and support requirements have been assessed in light of both operational requirements and applicable regulations.

Accepting the design basis (including the hypothetical location of the DGR, the characteristics of the geosphere and the postulated used-fuel inventories), this estimate can therefore be considered a 'Study' or 'Conceptual' cost estimate. Semi-detailed unit costs with assembly-level line items dominate the estimate, as do item costs based on existing, available applications. Overall, while the estimate can be considered as AACE Class 4, the accuracy with respect to actual costs is likely to be lower than typically assumed for such estimates (as is discussed in following sections).

### 6.1.2 Classification of Estimates for Individual Work Elements

Individual cost estimates in the overall lifecycle cost estimate are predominantly build-ups based on specific deliverables using gross unit costs/ratios, installation factors, and (in the case of mining) parametric modelling, as is typical for AACE Class 4 estimates. Quoting AACE Recommended Practice No. 18R-97:

*"...Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques..."*

*"...Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typically, engineering is from 1% to 15% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams (PFDs) for main process systems, and preliminary engineered process and utility equipment lists..."*

Several work elements have been estimated using a relatively large number of detailed unit prices integrated with factors to account for minor components (for example, Auxiliary Surface Facilities, especially Active Liquid Waste Treatment). These work elements are supported by preliminary layout drawings, preliminary process flow diagrams and itemized equipment lists. They could be considered to be estimated at a Class 3 level, except that they depend on, and are sized to reflect, multiple elements of lesser definition. It is suggested that these detailed sub-estimates are best considered as relatively well-developed Class 4 estimates, given the inherited uncertainty.

Conversely, a relatively small number of work elements involve expert judgement applied to technical or operational concepts without precedent, such as extended monitoring over a 70 year period. These elements may be considered Class 5 estimates, as they are based primarily on expert judgement and limited information, and cannot be checked against 'typical' costs for the same scope of work.

### 6.1.3 State of Technology

As discussed in AACE RP 17R-97, estimate accuracy is partially a function of the state of technology, as follows:

*"For a 'first-of-a-kind' project there is a lower level of confidence that the execution of the project will be successful (all else being equal). There is generally a higher confidence for projects that repeat past practices. Projects for which research and development are still under way at the time that the estimate is prepared are particularly subject to low accuracy expectations. The state of technology may have an order of magnitude (10 to 1) effect on the accuracy range."*

In some sense, the DGR will be a 'first-of-a-kind' project for Canada. However, it is not the first of its kind internationally. Organizations in Belgium, Finland, France, Germany, Great Britain, Japan, Sweden, Switzerland and the United States have made progress towards the common goal of the safe containment of radioactive waste in a deep geologic repository. The Canadian DGR design has been informed, in part, by the work of these other agencies.

In particular, Svensk Kambranslehantering AB (SKB-IC) has provided input on UFPP design and lessons learned at the Äspö Hard Rock Laboratory in Sweden, which is currently operating in deep crystalline rock. In addition, it must be recalled that Canada has extensively researched and tested aspects of a deep repository, including activities at the AECL Underground Research Laboratory in Pinawa, Manitoba (1990 to 1998; nominal depth of 400 m in crystalline rock). Furthermore, as demonstrated by the conceptual design, the vast majority of project activities simply apply existing mining, construction and nuclear material handling technologies.

With regard to the state of technology, therefore, the DGR is not a novel undertaking. Although aspects of the design are subject to additional research, development, value-engineering, trade-off analysis and safety case development, the fundamental operating principals and structures are well-understood and eminently feasible.

It is true, however, that the DGR design extends presently existing equipment and techniques to a new scale, timeframe and level of coordination. UFPP operations in particular, represent a significant extension of current experience. As a result, cost estimate accuracy is expected to be slightly decreased by technological risk.

#### 6.1.4 Quality of Reference Data

As it is a unique project, full-scale costs for a comparable DGR in crystalline rock are not available. As later discussed, the estimate has been compared with a previous independent estimate of a similar concept, with reasonable agreement when NWMO assignment of contingency is allowed for.

The pricing of individual components was primarily ascertained by the design and estimating team through past experience with similar activities and by market queries. However, pricing for large volume production, and/or long-term contracts could conceivably be lower than estimated as economies of scale, market forces and institutional learning come to bear. Furthermore, the UFC (IV-25 container) is not a commercially available item. The estimated price of the container and its handling cannot be directly compared to an available market rate.

Overall, the quality of reference data is moderate – in the absence of a similar procurement exercise, limited reference data is available. The relatively modest quality of reference data is a factor undermining projected estimate accuracy.

#### 6.1.5 Uncertainty and Risk

Formal design optimization, value engineering and/or risk analysis have not been performed on the conceptual design. However, on the basis of the work conducted to date, three relatively significant sources of cost and schedule risk (defined here as actual results varying more than expected from predictions, either negatively or positively) have been identified, as follows:

1. Assumptions: The estimate is based on a number of design basis assumptions, identified in the description of scope and the cost estimating process. Violations of these assumptions will likely cause unforeseen changes to cost and schedule. For example, real-world rock characteristics may necessitate different physical layouts, development sequences and cycle times;
2. Complexity: Estimated costs and schedules are for activities conducted according to plan. The project, however, involves many activities taking place over more than a century. Events that are relatively improbable in a conventional project timeframe may occur over the course of many decades. Because of complexity, it is unreasonable to expect that every part of the program will take place exactly as planned. While the facility will be built to rigorous standards to safeguard human health and the environment, improbable combinations of events may still have cost and schedule impacts. Furthermore, a wide range of unexpected events with no practical impact on health or the environment (e.g., procurement difficulties) may nevertheless affect cost and schedule; and
3. Exclusions: A potentially very significant source of risk stems from items specifically excluded from the estimate (itemized earlier in this report). As a specific example, changes in the regulatory environment cannot be reliably predicted, yet could have a dramatic affect on cost and schedule.

Both positive and negative risks are possible and unpredicted events may increase or decrease costs. Overall, however, the aggregate impact of multiple risks typically results in costs greater than initially predicted. Studies which have demonstrated that under-estimation is epidemic at the conceptual design or project approvals stage for large capital projects include:

- Merrow (1988) studied 52 civilian megaprojects ranging from \$500 M to over \$10 B in 1984 US dollars. The average cost growth from the beginning of detailed engineering to completion was 88%;
- Pohl and Mihalek (1991) examined 1,015 World Bank Projects and concluded that actual costs were, on average, 22% higher than projected despite ample contingencies built into the cost estimates;
- The British Consultancy Mott McDonald (2002) examined 50 major (over 40 M GBP in 2001) public projects in the UK and concluded that results clearly showed that historically there has been a tendency for project estimates to be highly optimistic;
- Based on 258 public sector transportation infrastructure projects worth \$90 B US, Bent Flyvbjerg (2002) found that on average, project costs were 28% higher than early-stage estimates (standard deviation of 38.7%); and
- As reported in Bertisen and Davis, previous studies by Bennett (1997), Thomas (2001) and Gypton (2002) found that as-built costs for 16 large capital projects exceeded the feasibility study estimate by an average of 27%.

Accurate contingency assignment is an important tool in preventing underestimation. For example, studies by the University of Bath in 1998 and 1999 (cited in Mott McDonald, 2002) that included a number of projects having risk contingency allotments found a median capital cost underestimate of 6% at the approvals stage and 1% at the pre-tender stage. This should be compared to the 38% average underestimation for a similar Mott McDonald study which excluded risk contingencies.

Current AACE guidance (*i.e.*, RP 40R-08) does not provide a definite amount of contingency for a given level of design definition. However, AACE does state that research has consistently shown that the level of project scope definition is a predominant risk driver and a good starting point for most risk analyses.

The British Department of Transport for Transport Planning (Flyvbjerg, 2004) has advocated taking nominally “most likely” estimates for transportation projects and adding pre-determined percentage-based “optimism bias uplifts” based on project type and available data for similar, reference projects. Unfortunately, accurate reference class uplifts rely on valid statistics from a large group of similar projects, and assumes estimates are consistent in their optimism bias.

NATO (2007) produced the “Optimism Bias Uplift Percentages” for major weapons system procurement for use where the relevant items/issues have not been fully accounted for in the basic estimate. The objectives of the uplifts are to increase the total estimate value to one that roughly represents the 50th percentile (*i.e.*, roughly a 50/50 chance that the actual price will be either higher or lower than the total estimate). While the comparison of a DGR to a weapons system is tenuous, it is useful to consider NATO’s interpretation of the relative importance of risk factors (see Table 18).

**Table 18: NATO Risk Factors and Uplift**

Item (Issue)	% Uplift to Add to Estimate
Complexity of contract	7%
Late contractor involvement in design	7%
Poor contractor capabilities	4%
Information Management	5%
Design complexity	10%
Degree of innovation	17%
Inadequacy of business case	18%
Poor management team	5%
Poor project intelligence	4%
Legislation/regulations	5%
Technology	18%

Rothwell (2004) examined both traditional contingency rules-of-thumb and the expected standard deviation of a cost estimate implied by the accuracy range for the relevant estimate class. Essentially, Rothwell demonstrated that rule-of-thumb percentage-based guidance for contingency was approximately equal to the standard deviation of the distribution of a cost estimate assuming the rule-of-thumb accuracy range for the estimate class. Rothwell also presented a summary of recommended contingencies vs. estimate class and expected accuracy that specifically includes energy sector projects (Table 19).

**Table 19: Historic Relationships between Estimated Accuracy and Contingency (Rothwell, 2004)**

Project Stage (AACE 1997, superseded)	Expected Accuracy Range (Low & High)	AACE Suggested Contingency (1997, superseded)	EPRI Project Stage (1993)	EPRI Suggested Contingency (1993)
Concept Screening	L: -20% to -50% H: +30% to +100%	50%	Not Applicable	Not Applicable
Feasibility Study	L: -15% to -30% H: +20% to +50%	30%	Simplified Estimate	30% to 50%
Authorisation or Control	L: -10% to -20% H: +10% to +30%	20%	Preliminary Estimate	15% to 30%
Control or Bid/Tender	L: -5% to -15% H: +5% to +20%	15%	Detailed Estimate	10% to 20%
Check Estimate or Bid/Tender	L: -3% to -10% H: +3% to +15%	5%	Finalised Estimate	5 to 10%

AACE – Association for the Advancement of Cost Engineering  
EPRI – Electric Power Research Institute

NWMO has determined an amount of contingency to include in the DGR estimate to reflect risk and uncertainty in the cost model. However, even with the inclusion of appropriate contingency, the scale and complexity and duration of the project should temper overly optimistic assessments of estimate accuracy.

#### **6.1.6 Estimated Accuracy**

In deference to a lack of benchmark cost data for an overall facility, technological risk, project complexity and the relatively long period before commissioning, the anticipated accuracy of the Base and Alternate Case estimates is on the low side of Class 4 norms, potentially on the order of -30% to +50% per AACE RP18R-97, after the inclusion of an appropriate contingency.

#### **6.1.7 End Use**

This estimate has been prepared for NWMO's use in planning and consultation. Given the class of estimate and the supporting information, this work can be considered a "conceptual" or "screening" study, and may be appropriate for strategic planning, business development, alternative analysis, confirmation of feasibility and preliminary approvals to proceed.

Users must understand that the estimate is for a specific scope of work, subject to a number of important assumptions and exclusions. This estimate is not suitable for full funding requests or project controls. It should not be considered a "definitive", "detailed" or "control" estimate.

### **6.2 Document Trail**

Excel workbook deliverables, including Work Element Definition Sheets, have been exported from the estimate database. These deliverables have been submitted in conjunction with this report.

The estimate database, which includes the root data for the exports, is itself included in this submission. Effectively, information flows from the database (which includes back-up files attached to specific work elements) to the estimate deliverables. Revision to the estimate is made by updating the database and then regenerating exports.

### **6.3 Estimate Quality Assurance**

Overall project management and project quality assurance has been implemented by SNC-Lavalin Nuclear. This quality assurance program has included coordination with NWMO's internal quality assurance resources.

Estimate guidance, including associated requirements, was provided to individual estimators and embedded in the database, along with a "Frequently Asked Questions" function. The database was designed to prevent common estimation errors by constraining inputs, such as available labour categories. Database functionality and design were validated through design-test-improve cycles which included the NWMO.

Data for individual work elements has been cross-checked against design documentation, estimate calculation sheets, quotes and associated backup. The compiled estimate was then considered as an integrated whole, with scope and assumption data cross-checked between

elements. Each component of the estimate has been double-checked by a person other than the author.

During compilation of the integrated estimate from individual packages, work elements were edited as required to reflect NWMO assumptions as to execution and to be internally consistent within the overall estimate.

#### 6.4 Benchmarking

Due to the uniqueness of the project, benchmarking has not been conducted against analogous undertakings.

#### 6.5 Project Risk Analysis

As previously described, actual and predicted costs will vary from one another because of project aspects such as:

- Project complexity and duration;
- Violation of design assumptions; and
- Other risk factors specifically excluded from the estimate (see, for example, Section 3.14, Exclusions).

NWMO may, as design proceeds, choose to undertake structured assessment(s) of project risk (for example, validating and perhaps reducing the assignment of contingency).

Several well-documented risk analysis processes exist for the refinements of cost estimates, such as 'TRUE' (Transportation Risk and Uncertainty Evaluation), the Lichtenberg Successive Principle and variants of Delphi analysis. One potentially appropriate process, modified from the Army Corp of Engineers procedure promulgated in 2008 (USACE, 2008) is as follows:

- An estimating team assembles and develops a cost estimate with Monte Carlo simulation using low, most likely and high values for individual components;
- Monte Carlo (probabilistic) modelling software is used to identify the specific line items and/or risks that are primarily responsible for overall estimate variance;
- The model outcomes, both in terms of overall estimate variance and the identified critical risk items are subject to structured expert panel review. Reviewers examine results, which should be in line with the level of design maturity, estimate quality, previous experience, etc.; and
- The model and check cycle is repeated until multiple lines of evidence (model results, experience on other projects, expert judgement, available guidance) converge.

Typically, initial runs result in large estimate variances and in unacceptably large suggested contingencies to achieve, for example, 80% confidence that the final cost will not exceed the estimate. The check step then results in the modification of assumptions and in the collection of additional data.

As noted by USACE (2008), the model and check cycle should include careful consideration of how risks embedded in the costs relate to one another. For example, in the case that UFPP design costs are higher than expected, is it likely that UDF or placement equipment design costs will be high as well? It is imperative that reviewers worry out the implicit and explicit correlations in critical risks.

Once the modelled estimate distribution makes sense, both in comparison with other lines of evidence and when variance is traced back to individual inputs, the team generates a table that depicts the project cost with corresponding confidence levels. The total estimate to achieve a target level of confidence less the mean value (the mean of the estimate representing 50% confidence – half of the time too high, half of the time too low) constitutes the total contingency for the desired confidence level.



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## 7. ESTIMATING TEAM

SNC-Lavalin Nuclear led the conceptual design for the DGR. The design team included the following (in alphabetical order):

- AirFinders Inc.;
- Candesco;
- Golder Associates Ltd.;
- Golder Paste Technology Ltd. (PasteTec);
- Hwozdyk, Inc.;
- Nordmin Resource and Industrial Engineering;
- NWMO (UFPP Components);
- P & E Mining Consultants; and
- Palladium Product Development and Design.

This cost and schedule estimate was undertaken by Golder Associates under the management of SNC-Lavalin Nuclear. Initial work element data was contributed by technical leads for each design component as indicated on the individual Work Element Definition Sheets.

The estimating team gratefully acknowledges the assistance of a number of specialists, contractors and equipment vendors, including, but not limited to (in alphabetical order):

- ACI-CANEFSCO (Advanced Combustion, Inc.);
- Alphair Ventilating Systems Inc.;
- American Colloid Company;
- American Wire Group;
- ATCO Structures and Logistics;
- Atlas Copco Canada;
- BASF Canada;
- BMH Systems;
- Bradley Lifting Corp.;
- Canadian Clay Products;
- Canadian Scale Company Limited;
- Ecologix Environmental Systems;
- Eirich Machines Inc.;
- EllisDon Corporation;
- Feeco International Inc.;
- Fenton Fire Equipment;
- Hawkridge Industrial Inc.;
- MEC (Magna Electric Corporation);
- NRB Inc.;
- Patrick Sprack Ltd.;
- Premier Recycling;
- SMS Meer GmbH;
- Svensk Kambranslehantering AB (SKB-IC);
- Terrafix Geosynthetics Inc.;
- The Miller Group;
- Tigg Corporation;
- Toromont Power Systems; and
- ZCL Composites Inc.

## 8. STUDY LIMITATIONS, RISKS AND OPPORTUNITIES

As described in preceding sections, this estimate is conceptual in nature and subject to a number of limitations.

The project is relatively complex and the target facility in-service date lies years in the future. Consequently, there are a number of project risks that could result in costs exceeding the scoping level estimate documented herein. However, it must also be recognised that the conceptual design is relatively conservative, and that a number of opportunities exist to reduce project lifecycle costs while satisfying performance objectives.

The following sections briefly summarize major limitations, risks and opportunities.

### 8.1 Limitations

As presented in Section 2.6 (Major Assumptions), Section 3.14 (Exclusions), 7.1.6 (Uncertainty and Risk) and 7.1.8 (End Use), the estimate presented herein is a conceptual estimate and depends on the conceptual design and design assumptions used as a basis for estimate.

This estimate reflects a specific conceptual design, which is subject to further development. Cost and schedule estimates reported in this document are therefore subject to change; readers are cautioned to confer with NWMO to verify that this version of the estimate is current.

This report was specifically developed for submission to NWMO. It should not be referenced in published reports or papers without the express consent of NWMO.

Any reference to a specific firm, commercial entity, consultant, commercial product, material, process or service by trade name, trademark, manufacturer or otherwise, does not constitute or imply its endorsement, recommendation, or preference.

### 8.2 Risks

As discussed in Section 7.1.6 (Uncertainty and Risk), the estimate presented herein represents an estimate for the project if it were to unfold according to plan (an “Everything According to Plan” or EAP estimate). Because of the scale, complexity and extended duration of the project, it is relatively unlikely that events will unfold exactly as expected. As presented in Section 7.1.6, actual cost of the project is therefore likely to be higher than an EAP estimate. Section 7.6 (Project Risk Analysis) presents additional information on risk analysis tools.

To address this issue, NWMO has instructed on the inclusion of contingency sums (determined by NWMO on the basis of project risk) to the estimate presented herein.

The total project estimate, with the inclusion of NWMO’s contingency assignment, therefore accommodates project risk and represents a realistic cost for project delivery.

### 8.3 Opportunities

The estimate herein is for a specific conceptual design. It should be noted that this conceptual design is relatively conservative – a well-characterized and well-developed set of technologies and approaches was used to develop the conceptual project plan. This approach was intended to result in defensible, transparent, reproducible and realistic costing.

A number of opportunities exist to reduce the estimated cost of delivering equivalent safe, long-term management of used nuclear fuel. For example, estimated project costs could be reduced by changes in the conceptual design and/or the design assumptions such as the following:

- Alternate UFC (Used Fuel Container) Design - recent studies suggest that a carbon steel canister (without a copper sheath) could be a viable alternative to the relatively high-cost copper canisters assumed herein. Furthermore, cast (as opposed to roll-formed plate) vessel internals and/or different methods of construction (such as piece-and-draw copper vessel fabrication with an integral mandrel-formed vessel bottom) have the potential to significantly reduce canister pricing;
- Detailed Utilities Evaluation – Given the long duration of activities such as mine heating, significant cost savings may be achievable through detailed evaluation of utility uses, the substitution of lower-cost energy sources and the use of “green” processes (such as geexchange/geothermal heating/cooling);
- Improved Standby Capacity – Extended Operations costs are extensive, and are driven by a project requirement to maintain, for 70 years, the ability to retrieve and re-package fuel. Structures or processes that minimize the cost of keeping resources on standby could significantly reduce the economic burden of the extended operations period;
- Storage/Shipment Optimization – Scenario analysis has not yet been carried out to minimize total project costs by varying shipping schedules and/or facility throughput. For example, workflow optimization could result in economies of scale and/or economies of learning (knowledge) that lower projected costs with respect to transportation fleet equipment, fuel containers, sealing materials, etc.;
- Supply Chain Management and Strategic Procurement – Pro-active procurement planning and the use of buyer power (large-scale purchases), financial instruments (such as options) and contracting mechanisms (including long-term supply contracts) to obtain favourable utilities, material, equipment, service and salvage rates and/or hedge against risk could decrease estimated project costs and/or reduce the amount of contingency assigned by NWMO;
- Waste Reduction – Depending on variables such as final project location and host rock characteristics, waste reduction/reuse studies may indicate opportunities to reduce the volume and/or cost of rock waste, conventional waste, construction waste and/or demolition waste; and

- Adoption of New Technologies and Materials – As technology continues to advance, project components can be re-evaluated with the objective of finding cheaper alternatives (for example, better materials or assembly techniques) or increasing productivity (for example, by reducing the number of personnel required to complete a given task). Specifically, staffing plans used in the current estimate are based on existing operational experience, and call for relatively large contingents of security and maintenance personnel. Improvements in information technology, tools, remote sensing and remotely-operated or monitored equipment have the capacity to increase labour productivity over time or allow the substitution of low-rate for high-rate labour. In addition, improvements in sensing, process control and monitoring may reduce assumed rejection and/or rework rates, for example with respect to boreholes or canisters.

These areas of opportunity, and others, fall under the aegis of “Value Engineering” or “Value Analysis”, in which aspects of the conceptual design are critically and creatively examined in an attempt to fulfill the functional requirements of the project at a lower cost or with higher quality than originally anticipated.

NWMO’s design development team continues to examine design alternatives. It is intended that future design updates and the corresponding lifecycle cost estimates will reflect the results of such study.

## 9. CONTENTS OF THE ACCOMPANYING DVD

This report is accompanied by electronic files on DVD. These files have been organized as follows:

**Table 20: DVD Contents**

Folder Title	Sub-folder	Contents
Report		This report and Appendices.
Database		Single Microsoft Access database containing both 560 and 561 data, as well as attached back-up calculations and quotes.
Base Case	L2 Workbooks	Individual Microsoft Excel 2007 workbooks for costs associated with each 2nd level component of the Base Case (560) WBS.
Base Case	Master Workbook	One Microsoft Excel 2007 workbook containing the Base Case (560) WBS and related costs, as well as a pivot table enabling roll-up within the WBS.
Alternate Case	L2 Workbooks	Individual Microsoft Excel 2007 workbooks for costs associated with each 2nd level component of the Alternate Case (561) WBS.
Alternate Case	Master Workbook	One Microsoft Excel 2007 workbook containing the Alternate Case (561) WBS and related costs, as well as a pivot table enabling roll-up within the WBS.

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## 10. TECHNICAL REFERENCES

Canadian federal acts, regulations and codes apply to the DGR. Key system references are documented in the design report, “*Deep Geological Repository Design Report – Crystalline Rock Environment*”, submitted to NWMO by SNC Lavalin Nuclear (SLN 020606-6100-REPT-0001), which describes the crystalline rock DGR conceptual design for the Base and Alternate Cases.

In addition, the lifecycle cost and schedule estimate was informed by the following:

- Association for the Advancement of Cost Engineering International (AACE International). 2003. *Cost Estimate Classification System*. AACE International Recommended Practice No. 17R-97;
- AACE International. 2005. *Cost Estimate Classification System – As Applied in Engineering Procurement, and Construction for the Process Industries*. AACE International Recommended Practice No. 18R-97;
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  - Rothwell, Geoffrey. 2004. *Cost Contingency as the Standard Deviation of the Cost Estimate for Cost Engineering.* Stanford Institute for Economic Policy Research Discussion Paper No. 04-05. February 2004; and
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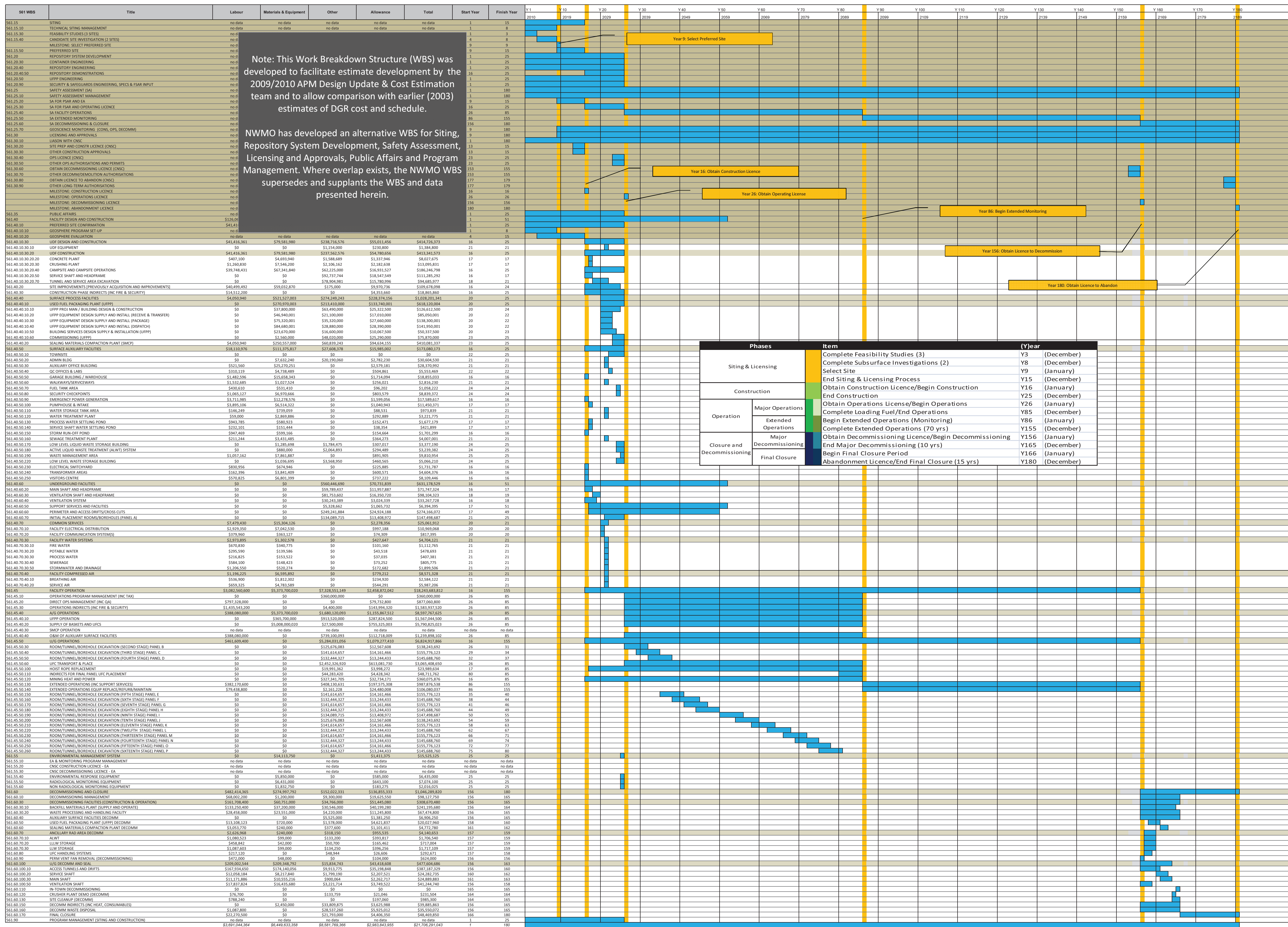
**DOCUMENT END**

## APPENDIX A

### WORK BREAKDOWN STRUCTURE TO THE LOWEST LEVEL







Phases		Item	(Y)ear
Siting & Licensing	Major Operations	Complete Feasibility Studies (3)	Y3 (December)
		Complete Subsurface Investigations (2)	Y8 (December)
		Select Site	Y9 (January)
Construction	Major Operations	End Siting & Licensing Process	Y15 (December)
		Obtain Construction Licence/Begin Construction	Y16 (January)
		End Construction	Y25 (December)
		Obtain Operations License/Begin Operations	Y26 (January)
		Complete Loading Fuel/End Operations	Y85 (December)
Operation	Major Operations	Begin Extended Operations (Monitoring)	Y86 (January)
		Complete Extended Operations (70 yrs)	Y155 (December)
		Obtain Decommissioning Licence/Begin Decommissioning	Y165 (January)
		End Major Decommissioning (10 yrs)	Y165 (December)
Closure and Decommissioning	Major Operations	Begin Final Closure Period	Y166 (January)
		Abandonment Licence/End Final Closure (15 yrs)	Y180 (December)

Note: This Work Breakdown Structure (WBS) was developed to facilitate estimate development by the 2009/2010 APM Design Update & Cost Estimation team and to allow comparison with earlier (2003) estimates of DGR cost and schedule. NWMO has developed an alternative WBS for Siting, Repository System Development, Safety Assessment, Licensing and Approvals, Public Affairs and Program Management. Where overlap exists, the NWMO WBS supersedes and supplants the WBS and data presented herein.

Note: This Work Breakdown Structure (WBS) was developed to facilitate estimate development by the 2009/2010 APM Design Update & Cost Estimation team and to allow comparison with earlier (2003) estimates of DGR cost and schedule. NWMO has developed an alternative WBS for Siting, Repository System Development, Safety Assessment, Licensing and Approvals, Public Affairs and Program Management. Where overlap exists, the NWMO WBS supersedes and supplants the WBS and data presented herein.

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86,493,044.304 17% 86,493,044.304 30% 86,493,044.304 14% 86,493,044.304 14%

## APPENDIX B

### WORK ELEMENT DEFINITION SHEETS

## Work Element Definition Sheet

28-Jul-2010

4:37:21 AM

WEDS ID #

7012

Organization Name:

Hwozdyk Inc.

Prepared by:

Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.10.30.10

UDF EQUIPMENT

### **WBS 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.

(This element was formerly named "UCF Design" - Underground Characterisation Facility Design. 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 .40.10.30.20.70, "Tunnel and Service Area Excavation")

### **WBS Deliverable:**

Initial set of specialized UDF equipment as required for UDF research activities (support installations, such as maintenance shops, located in the main and service shaft complex, are included in work element .40.10.30.20.70, "Tunnel and Service Area Excavation")

### **WBS Assumptions:**

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

Exclusive of contingency.

### **WBS Allowance Basis:**

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

Start Year: 21

Finish Year: 21

Duration: 1 year(s)

WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$1,154,000	\$1,154,000	20%	\$1,384,800

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

22-Apr-2010

9:35:05 PM

WEDS ID # 5001

---

Organization Name: Golder Associates Ltd.  
Prepared by: Isaac Ahmed                      Reviewed by: Chuck Steed  
Modified by:    Last Modification Date: 4-Dec-2010

---

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.10.30.20.20                      CONCRETE PLANT

---

## WBS Description:

---

Construction and commissioning of a concrete batch plant.  
The batch plant would include 3 binder storage silos to produce a low heat, high performance (LHHP) concrete.  
The binders include: cement T50, silica fume and silica flour.  
The plant would be outfitted with admixture addition capacity to allow reduced water content LHHP concrete mix design.  
Five storage domes are included.

## WBS Deliverable:

---

Concrete batch plant includes:

- 75 tonne Cement T50 & Silica Fume Silos
- 150 tonne Silica Flour Silo
- Binder Hopper
- Cement Batcher
- PD Blowers
- Hoppers (Coarse and Fine)
- Belt Feeder
- Short Hop Conveyor
- Internal Transfer Conveyors
- Aggregate Hopper
- Aggregate Batcher
- Hot Water Tank
- Admixture Tanks
- Long Field Conveyor to SMC Plant
- Ready-Mix Truck
- Trailers for Binder Storage
- Dust Collection System
- Heated Floor Slabs In Storage Domes
- Storage Domes (5)

## WBS Assumptions:

---

Batch plant to be 25 m<sup>3</sup> per hour capacity; sized on a basis of pouring concrete bulkheads at the placement room entrances. Pricing derived from commercially-available (quoted) BMH dry batch plant (9 m<sup>3</sup> scales; fills standard truck with single batch).

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.

Exclusive of contingency.

## WBS Allowance Basis:

---

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

Start Year: 17                      Finish Year: 17                      Duration: 1 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$407,100	\$4,693,940	\$1,588,689	\$6,689,729	20%	\$8,027,675

WBS Specific Supporting Documentation:

BMH quote S-4453 - GOLDER (ONTARIO).pdf  
RE Quotation S-4453 - Dry Batch Plant (Labour).msg  
Re Ready Mix Truck Cost.msg

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx  
09-1117-0032 NWMO Equipment List R6.xlsx

# Work Element Definition Sheet

16-May-2010

9:54:48 PM

WEDS ID #

5003

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Organization Name: Golder Associates Ltd.  
Prepared by: Isaac Ahmed      Reviewed by: Chuck Steed  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.10.30.20.30      CRUSHING PLANT

## WBS Description:

Construction and commissioning of a crushing, screening and washing operation for the production of crystalline rock aggregate. This material will be used as raw material for the concrete batch and sealing materials compaction plants. The aggregate plant is expected to produce an estimated 69,000 tonne of material per year and may be operated at a nominal capacity of 220 tonne/h. It would consist of a primary, secondary and tertiary crushing and screening circuit as well as a wash plant for producing manufactured concrete sand. The respective raw materials will be conveyed to the concrete batch plant and sealing materials compaction. At the concrete batch plant the material will be stored in domes, while the material at the sealing materials compaction plant will be housed in silos.

## WBS Deliverable:

This includes equipment necessary to process aggregate:

- Vibratory Pan Feeder
- Vibratory Grizzly Feeder
- 50 tonne Dump Hopper
- Two Deck Screens
- Three Deck Wash Screen
- Primary Crusher
- Secondary Crusher
- Tertiary Crusher
- Short Hop Conveyor
- Internal Transfer Conveyor
- Field Conveyor
- Stacking Conveyor
- Crusher Feed Hopper
- 200 tonne Surge Hopper
- Classifying Tank
- Dewatering Screws
- Freshwater and Wastewater Pump
- Belt Magnets

## WBS Assumptions:

Sized to suit concrete batch plant and Sealing Materials Compaction 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.

Exclusive of contingency.

## WBS Allowance Basis:

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

---

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,260,830	\$7,546,200	\$2,106,162	\$10,913,192	20%	\$13,095,831

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx09-1117-0032 NWMO Equipment List R6.xlsx



# Work Element Definition Sheet

1-Jun-2010

3:42:57 PM

WEDS ID # 6041

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Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen Reviewed by: Peter Keohane  
 Modified by: Last Modification Date: 4-Dec-2010

---

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.10.30.20.40 CAMPSITE AND CAMPSITE OPERATIONS

**WBS Description:**


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

**WBS Deliverable:**


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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.

**WBS Assumptions:**


---

Current project concept includes potential development of a Townsite to support DGR operations, subject to discussions between the NWMO and the community.

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 \$50 per person/per day (includes food, all camp indirects).

Exclusive of contingency.

**WBS Allowance Basis:**


---

10% allowance, due to unknown topography , soils information and source of water and power supply.

Start Year: 16 Finish Year: 25 Duration: 10 year(s) WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$39,748,431	\$67,341,840	\$62,225,000	\$169,315,271	10%	\$186,246,798

WBS Specific Supporting Documentation:

ATCO CONSTRUCTION CAMP.pdf  
 ZCL ULC Petroleum storage tanks.msg  
 CAT TOROMONT GEN SETS.pdf  
 MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

27-Jul-2010

11:24:24 AM

WEDS ID #

7008

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk      Reviewed by:  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.10.30.20.50      SERVICE SHAFT AND HEADFRAME

**WBS Description:**

The construction of the shaft collar, erection of permanent headframe, installation of hoisting system, installation of ventilation fans, the sinking of the Service/Production Shaft and the excavation and construction of rock handling systems.

The shaft will serve as an exploration shaft during underground characterization in the UDF and be 6.5 m diameter. Upon completion of sinking the shaft, construct, install and commission a permanent headframe and hoist house for the shaft.

The work excludes installation of permanent ventilation fans at this facility, both of which is installed on surface.

Fan installation is covered by work element .40.60.40.

**WBS Deliverable:**

A 6.5 m finished internal diameter, concrete-lined exploration shaft, complete with associated infrastructure.

**WBS Assumptions:**

The collar is 30 m in depth.

Shaft sinking will utilize the permanent headframe, and the permanent double-drum hoist to be used for later skipping. There will be a tower-mounted Koepe hoist for the 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 550 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.

**WBS Allowance Basis:**

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 16      Finish Year: 17      Duration: 2 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$92,737,744	\$92,737,744	20%	\$111,285,292

WBS Specific Supporting Documentation:

9036-01-ES01rA\_LRH.xls

All Shafts 9036-01 Hoisting Summary Rev 2.pdf

Service Shaft 9036-01-10-1000-SK1 10-1000 SK1 (1).pdf

Service Shaft 9036-01-ES01rA\_LRH.xls

Service Shaft Surface Fan Assemblage Design.pdf

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

30-Jul-2010

4:14:43 AM

WEDS ID #

7013

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.10.30.20.70                      TUNNEL AND SERVICE AREA EXCAVATION

**WBS Description:**

Excavation of the tunnels between the main and service shaft, tunnels interconnecting the services facilities, excavations for the UDF, excavations for support services and outfitting of support facilities.

**WBS Deliverable:**

Provision of tunnels and service areas, including:

- Trackless Maintenance Shop
- Locomotive and Rail Car Shop and Charging Station
- UDF Permanent Refuge Station
- UDF Office
- Main Detonator and Explosives Magazines
- Fuel Station
- UDF Latrine
- Main Dewatering Sump
- Main Storage Area
- Rockbreaker & Grizzly
- Bridge Cranes (5 & 15 tonne)
- Battery Chargers
- 7t Battery Racks
- 4t Battery Racks
- 3 Tonne Jib Crane
- Clear Water Pumps

Initial underground geosphere characterization assessment work. UFC placement equipment test area for design data gathering and design verification.

**WBS 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.

Exclusive of contingency.

**WBS Allowance Basis:**

20% allowance encompasses non-itemized equipment, including as-yet-to-be specified laboratory components of UDF.

Start Year: 18                      Finish Year: 21                      Duration: 4 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$78,904,981	\$78,904,981	20%	\$94,685,977

WBS Specific Supporting Documentation:

Infrastructure cost details.xls

TrackSwitchInstall.xls

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

31-May-2010

2:45:27 PM

WEDS ID #

6016

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.20      SITE IMPROVEMENTS

**WBS Description:**

Site preparation for surface facilities.

**WBS Deliverable:**

Preparation of the site, including:

- Site civil preparation (clearing, blasting, grading, initial landscaping)
- Allotment for permits
- Main (25 km) 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 (approx. 4.8 km)
- Road for vent shaft complex (approx. 5 km)
- Parking Lots (Paved, for up to 200 cars, 5 buses, 15 trucks: 120 m x 50 m/6000 m2)
- Two large bus shelters (30 person shelters: 15 m2 ea.)
- Six standard small bus shelters (6 m2)
- Truck weigh scale, scale house, and traffic lights.
- Helipad - 30 m dia., include drainage and lighting
- Rail line – up to 1.2 km from sealing materials compaction plant to the service shaft, including switchgear
- Off-site waste rock disposal area, including fencing, gate, access road and relief pond
- Outer perimeter fence, including 2 vehicle gates, 4 person gates, signage and lighting
- Protected area double fence (3 m high, 4 m offset, barbed wire), including signage, lighting and motion sensors.

**WBS Assumptions:**

Site is a flat green area situated in the Canadian Shield, within 25 km of an existing highway. Access road will be 10 m wide and 25 km in length. Rail access to the site is not required.

Land acquisition is accounted for in other work elements as part of the siting process.

Surface preparation is calculated for surface facilities footprint only (0.5 km<sup>2</sup>). \$175,000 allotted for provincial/federal permits.

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

Exclusive of contingency.

**WBS Allowance Basis:**

Layout of site facilities, preparation and provision of infrastructure are standard Civil Engineering works were benchmarking against similar works is possible. On this basis an allowance of 10% has been applied.

Start Year: 16      Finish Year: 24      Duration: 9 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$40,499,492	\$59,032,870	\$175,000	\$99,707,362	10%	\$109,678,098

WBS Specific Supporting Documentation:

Canadian Scale.msg

MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

RE TERRAFIX GEO HDPE.msg

SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

9:56:13 AM

WEDS ID #

6022

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.30      CONSTRUCTION PHASE INDIRECTS (INC FIRE & SECURITY)

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

Construction is on an EPC Basis - All conventional construction phase indirects are included in pricing for individual work elements. 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.

**WBS Allowance Basis:**

30 % allowance accounts for probable incidentals and miscellaneous charges given the conceptual state of design.

Start Year: 16      Finish Year: 25      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$14,512,200			\$14,512,200	30%	\$18,865,860

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:



# Work Element Definition Sheet

20-Sep-2010

10:27:03 AM

WEDS ID #

9010

---

Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

---

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.40.10.10 UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION

## WBS Description:

Project management, design, construction and commissioning management of the Used Fuel Processing Plant (UFPP), a multi-level structural steel framed building mounted on a reinforced concrete slab. The building will be a nuclear-grade, seismically qualified impact-resistant structure, containing radiation shielding cells (hot cells). All facilities within the building that are used to process nuclear materials will be clad with stainless steel, while other areas that may potentially become contaminated will be provided with high-quality surface finishes (for ease of decontamination and housekeeping). The building exterior will be constructed using blockwork and aluminum clad walls.

## WBS Deliverable:

The provision of all resources required to supply a fully fitted and operable UFPP facility. These will include:

- Project management, design and engineering for all areas (i.e., building & civil, mechanical, construction engineering/inspection and process)
- The construction of the building together with all permanent fixtures
- The construction of the ventilation discharge stack
- The management of the building and its services commissioning

## WBS Assumptions:

The CTECH (2003) scope and cost model was reviewed and updated by SKB International and forms the basis for updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

The building design / contract / commissioning model and delivery scope were not changed from the CTECH assumed cost basis.

The building project management, design, construction and commissioning management will be let on a turnkey contract basis. The building design will comply with functional specifications provided by Architect Engineers included within the Program Management work element.

Although the building dimensions have changed from CTECH (2003), the volume reduction of the building (<4%) is assumed to be negligible and has no impact on the previous cost estimate.

Activity duration is 5 years (Y20-Y24), including a 4 year design and construction phase with an eighteen month year inactive / active commissioning period. This schedule will allow one year to accommodate a possible overrun.

Exclusive of contingency.

## WBS Allowance Basis:

Generally, the UFPP building is a conventional nuclear materials handling facility, albeit housing certain processes that require significant development. However, as these areas are small compared to the overall facility, any uncertainties in these areas should not have a significant effect on the total cost of the building. In addition, although the building layout is only at the conceptual stage all major process areas have been established. Therefore, should the building dimensions alter as a result of further design input these changes should be small and consequently have an equally small effect on the projected cost of the facility. On this basis an allowance of 25% has been placed on the design and construction of the UFPP.

Start Year: 20                      Finish Year: 24                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$37,800,000	\$63,490,000	\$101,290,000	25%	\$126,612,500

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 560.40.40.10.160.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

20-Sep-2010

4:40:29 PM

WEDS ID #

9011

---

Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.40.10.20 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (RECEIVE & TRANSFER)

---

## WBS Description:

Detailed design, supply, installation and testing of all process equipment together with its local control and instrumentation (C&I) for the receipt and transfer area of the Used Fuel Processing Plant (UFPP), including the Irradiated Fuel Transport Cask (IFTC) receipt and unpackaging area.

## WBS Deliverable:

Equipment will comprise all the process equipment, together with its local C&I, in the following areas of the UFPP:

- Irradiated Fuel Transport Cask (IFTC) receiving and shipping area.
- Module handling cell.
- Module storage pool.
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International to form the basis of updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010. Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis (i.e., un-escalated), updated plant costs have increased by ~\$20 M compared to the 2003 CTECH cost model .

Contracts for major items of process equipment, together with their local C&I, will be let on a turnkey basis. Contractors, provided with functional specifications, will provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included. Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied, accommodating the aggregate distribution of off-the-shelf vs. new technology items.

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Start Year: 20 Finish Year: 22 Duration: 3 year(s) WBS Type: Step Fixed

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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$46,940,001	\$21,100,000	\$68,040,001	25%	\$85,050,001

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 560.40.40.10.20.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

21-Sep-2010

2:09:42 PM

WEDS ID #

9013

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

---

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.40.10.30 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (PACKAGE)

## WBS Description:

Detail design, supply, installation and testing of all process equipment, together with local control and instrumentation (C&I), for packaging used fuel in the Used Fuel Packaging Plant (UFPP).

## WBS Deliverable:

The process equipment together with local C&I for packaging used fuel in the following work areas in the UFPP:

- Empty UFC receiving area
- Empty UFC storage area (external non-zoned area)
- Used fuel handling cell
- UFC inerting cell.
- UFC welding cell
- UFC non-destructive testing (NDT) cell
- UFC machining and lid cutting cell.
- UFC transfer area (i.e., empty and filled UFC transfer)
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International to form the basis of updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010. Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis (i.e., un-escalated), updated plant costs have increased by ~\$20 M compared to the 2003 CTECH cost model .

Contracts for major items of process equipment, together with their local C&I, will be let on a turnkey basis. Contractors, provided with functional specifications, will provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included. Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied, accommodating the aggregate distribution of off-the-shelf vs. new technology items.

Start Year: 20                      Finish Year: 22                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$75,320,001	\$35,320,000	\$110,640,001	25%	\$138,300,001

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 40.40.10.30.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

21-Sep-2010

2:19:24 PM

WEDS ID #

9014

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.40.10.40 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (DISPATCH)

## WBS Description:

Detailed design, supply, installation and testing of all process equipment, together with local control and instrumentation (C&I), for dispatching used-fuel containers in the Used Fuel Processing Plant (UFPP).

## WBS Deliverable:

The process equipment together with local C&I for dispatching used fuel containers in the UFPP, including:

- UFC monitoring and storage cell.
- UFC dispatch area.
- Mechanical workshop
- Waste management
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) scope and cost model was reviewed and updated by SKB International and forms the basis of the updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis, plant costs have decreased by ~\$20 M un-escalated against the CTECH (2003) cost model

Contracts for major items of process equipment together with their local C&I will be let on a turnkey basis. Contractors, provided with functional specifications, to provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included. Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development.

Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied.

Start Year: 20                      Finish Year: 22                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$84,680,001	\$28,880,000	\$113,560,001	25%	\$141,950,001

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 40.40.10.40.xlsx

Multi Element Supporting Documentation:



# Work Element Definition Sheet

21-Sep-2010

2:33:43 PM

WEDS ID #

9015

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.40.10.50 BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)

## WBS Description:

The detailed design, supply, installation and testing of all Used Fuel Processing Plant (UFPP) building services.

## WBS Deliverable:

All building services plant, equipment and systems, together with their local control and instrumentation, required to operate the UFPP. Services covered by this activity include:

- Mechanical Services, that comprise: heating and ventilation system; compressed air supply; steam supplies; vacuum system; domestic water supply; cold water; environmental monitoring system (EMS) pipework; inert gas delivery system; breathing air supply; drains (Low and High Active, and Plant Washings).
- Electrical, Control and Instrumentation, that comprise: three-phase power supply networks (normal, guaranteed interruptible, local guaranteed non-interruptible); lighting and small power supply; emergency lighting; security systems; criticality incident detection system (CIDAS); fire detection and alarm system; area monitoring systems (EMS, gamma, oxygen depletion); drain leak detection; lightening protection system; personnel monitoring; personnel announcement system.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International forms the basis of the updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).  
On a 2002 cost basis, plant costs have increased by ~\$11 M (un-escalated) vs. CTECH (2003).

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

Detail design of equipment and / or systems will be based on functional specifications provided by Architect Engineers included within Program Management.

Costs will include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

The integration of individual items of equipment and / or systems with the main control system, and their testing, is also included.

Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment

is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied.

Start Year: 20                      Finish Year: 23                      Duration: 4 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$23,670,000	\$16,600,000	\$40,270,000	25%	\$50,337,500

WBS Specific Supporting Documentation:  
APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 40.40.10.50.xlsx

Multi Element Supporting Documentation:

## Work Element Definition Sheet

21-Sep-2010

2:48:13 PM

WEDS ID #

9016

Organization Name: NWMO - Nuclear Waste Management Organization

Prepared by: A. Murchison

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.40.10.60 COMMISSIONING (UFPP)

### WBS Description:

Commissioning of Used Fuel Packaging Plant (UFPP) building systems and services, in addition to the non-active and active functionality of all plant and equipment contained within the facility.

### WBS Deliverable:

- Completed commissioning schedules signed and approved, covering all systems and services and items of plant and equipment, necessary to demonstrate their operability and safety function both under non-active and active operations.
- Commissioned systems
- Final UFPP Commissioning Report

### WBS Assumptions:

Costs are distributed uniformly on an annualized basis for duration of the work (Y23 to Y25).

Cost update is based on scope adjustments to the 2003 CTECH cost estimate, with escalation to \$2010.

All work carried out under this activity will be carried out by an Engineering Commissioning contractor. The activity will include all direct labour and resources required to complete the deliverables.

The UFPP commissioning estimate has been based on historical reference ratios identified by benchmarking costs from similar plants and functions. These ratios are based on commissioning costs taken as a percentage of the project design, build and installation costs. On this basis the ratios used for this activity are between 5 and 15% of the total UFPP design, build and installation costs.

The commissioning schedule is based on 18 months to commission the complete UFPP facility and assumes completed build scope can be commissioned during the UFPP construction either at site or at OEM's site, with minimal commissioning required for those items commissioned at OEM.

Commissioning management costs are excluded from this activity and are covered elsewhere in the conceptual cost estimate.

Exclusive of contingency.

### WBS Allowance Basis:

Commissioning plant and equipment, and in particular remotely operated plant and equipment for nuclear materials, is a labour intensive activity liable to overrun. Traditionally the main causes are unforeseen issues revealed during commissioning, as well as complications that may have been previously identified but were not addressed at the time. For this reason an allowance of 50% has been applied to this activity.

Start Year: 23                      Finish Year: 25                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$2,560,000	\$48,020,000	\$50,580,000	50%	\$75,870,000

### WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 40.40.10.60.xlsx

### Multi Element Supporting Documentation:

# Work Element Definition Sheet

16-May-2010

10:10:35 PM

WEDS ID #

5004

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Organization Name: Golder Associates Ltd.  
Prepared by: Isaac Ahmed                      Reviewed by: Chuck Steed  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS  
Number: 560.40.40.20                      SEALING MATERIALS COMPACTION PLANT (SMCP)

## **WBS 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.

## **WBS Deliverable:**

The design and construction of a multi-story structural steel-framed 80m x 60m x 20m 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
- Conveyors
- 150 tonne clay materials silo
- 150 tonne modified granular A silo
- 50 tonne fine sand silo
- Weigh hoppers
- Dust collector
- Mixers
- Vacuum pump
- Bentonite press
- Hydraulic power pack for bentonite press
- Dense Backfill (DBF) Press
- Hydraulic Power Pack for DBF Press
- Vacuum Lifting Device
- Locomotive
- Rail Cars

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.

## **WBS 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 costs developed with press vendor (SMS MEER); vacuum lift costs developed with vacuum lifter vendor (Bradley Lifting); mixer costs developed with mixing vendor (Eirich).

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

Exclusive of contingency.

**WBS Allowance Basis:**

Conceptual cost estimate, major item such as DBF presses are not off-the-shelf items and can not be fully specified at this time. A 30% allowance has been assigned to compensate for incomplete design.

Start Year: 23      Finish Year: 25      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$4,050,940	\$250,557,000	\$60,839,243	\$315,447,183	30%	\$410,081,337

WBS Specific Supporting Documentation:

041022080\_DEV22\_DW29-4 Clay and Aggregate mixes.doc1371-7\_D-Type.pdfEM-002-2M\_D-Type.pdfAW Closed Die Forging Presses Power Packs 4.msgVacuum Ring And Disc Lifter Our Quote BQ-026910.msg

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx  
09-1117-0032 NWMO Equipment List R6.xlsx

## Work Element Definition Sheet

31-May-2010

3:03:57 PM

WEDS ID #

6018

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.50.10

TOWNSITE

**WBS Description:**

Development of a townsite to service the DGR.

**WBS Deliverable:**

Construction and commissioning of a townsite may be the subject of discussions between the NWMO and the community. Any future requirements would be drawn from contingency.

**WBS Assumptions:**

N/A

**WBS Allowance Basis:**

N/A

Start Year: 22

Finish Year: 25

Duration: 4 year(s)

WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
			\$0		\$0

WBS Specific Supporting Documentation:

MILLER PAVING EARTHWORKS.pdf

TRANSFORMERS.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

RE TERRAFIX GEO HDPE.msg

SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

9:51:58 AM

WEDS ID # 6003

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen                      Reviewed by: Peter Keohane  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.50.20                      ADMIN BLDG

### WBS Description:

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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.

### WBS Deliverable:

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Fully equipped, 2-storey administration building (2,200 m<sup>2</sup> foot print providing a total gross floor area of 4,400 m<sup>2</sup>).

### WBS Assumptions:

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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.

### WBS Allowance Basis:

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Use 10% allowance for minor items not itemized in estimate.

Start Year: 21                      Finish Year: 21                      Duration: 1 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$7,632,240	\$20,190,060	\$27,822,300	10%	\$30,604,530

### WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

10:19:31 AM

WEDS ID #

6004

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.50.30

AUXILIARY OFFICE BUILDING

### **WBS 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.

### **WBS Deliverable:**

Two-storey Auxiliary Building without basement with 1,040 m<sup>2</sup> foot print & total floor area of 2,080 m<sup>2</sup>. 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.

### **WBS Assumptions:**

Building size based on assumed occupancy of 80 permanent DGR personnel, and 25 campaign mining personnel on an intermittent basis.

Exclusive of contingency.

### **WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21

Finish Year: 21

Duration: 1 year(s)

WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$521,560	\$25,270,251		\$25,791,811	10%	\$28,370,992

### WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls



# Work Element Definition Sheet

31-May-2010

12:03:36 PM

WEDS ID #

6009

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.40      QC OFFICES & LABS

**WBS Description:**

Construction and commissioning of Quality Control Offices and Laboratory building.

**WBS Deliverable:**

Single-storey building with no basement, 825 m<sup>2</sup> 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.

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 22      Finish Year: 22      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$310,119	\$4,738,489		\$5,048,608	10%	\$5,553,469

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

12:10:27 PM

WEDS ID #

6010

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.50      GARAGE BUILDING / WAREHOUSE

**WBS 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.

**WBS Deliverable:**

Equipped single storey building, no basement, 1,920 m<sup>2</sup> total gross floor area.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,482,596	\$15,658,343		\$17,140,940	10%	\$18,855,033

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

1:07:37 PM

WEDS ID #

6011

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.60      WALKWAYS/SERVICeways

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

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

- 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,532,685	\$1,027,524		\$2,560,209	10%	\$2,816,230

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

2:01:43 PM

WEDS ID #

6014

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.70      FUEL TANK AREA

**WBS 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.

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 24      Finish Year: 24      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$430,610	\$531,410		\$962,020	10%	\$1,058,222

WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

2:19:06 PM

WEDS ID #

6015

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.80      SECURITY CHECKPOINTS

**WBS Description:**

Construction and commissioning of security buildings and access control points.

[This work element was previously 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]

**WBS Deliverable:**

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 5 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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 24      Finish Year: 24      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,065,127	\$6,970,666		\$8,035,793	10%	\$8,839,372

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

12-Aug-2010

1:56:26 PM

WEDS ID # 6055

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.50.90      EMERGENCY POWER GENERATION

**WBS Description:**

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

**WBS Deliverable:**

---

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 1.5 MW diesel generators.  
Electrical tie-ins to main camp facilities.

**WBS Assumptions:**

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

**WBS Allowance Basis:**

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Use 10% allowance for items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,711,985	\$12,278,576		\$15,990,561	10%	\$17,589,617

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

10:32:29 AM

WEDS ID #

6006

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.100      PUMPHOUSE & INTAKE

**WBS Description:**

Construction and commissioning of a water intake of 200 m<sup>3</sup>/day capacity, pump house and pipeline Including an intake structure with screen

**WBS Deliverable:**

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:

- Pumphouse 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).

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,895,106	\$6,514,322		\$10,409,428	10%	\$11,450,371

WBS Specific Supporting Documentation:

MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

10:49:41 AM

WEDS ID #

6007

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.50.110

WATER STORAGE TANK AREA

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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 350 m3/hour plus 24 hours of raw water demand.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21

Finish Year: 21

Duration: 1 year(s)

WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$146,249	\$739,059		\$885,308	10%	\$973,839

WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls



## Work Element Definition Sheet

31-May-2010

11:55:14 AM

WEDS ID #

6008

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.120      WATER TREATMENT PLANT

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$59,000	\$2,869,886		\$2,928,886	10%	\$3,221,775

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

3:37:37 PM

WEDS ID #

6020

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.130      PROCESS WATER SETTLING POND

**WBS Description:**

Construct and commission a Process Water Settling Pond to hold 24 000 m3 of water. Pond is located at Rock Crushing Plant with water recycled for use in cleaning raw stone and in production of sand.  
 Pond size = 60m x 130 m x 3 m depth with a freeboard of 0.4 m.

**WBS Deliverable:**

Pond for settling of process water.

**WBS Assumptions:**

Pond to be excavated in soil; no blasting required. Pond to be 24 000 m<sup>3</sup>. Includes geomembrane.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$943,785	\$580,923		\$1,524,708	10%	\$1,677,179

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

9:32:27 AM

WEDS ID #

6021

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.50.140

SERVICE SHAFT WATER SETTLING POND

**WBS 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 0.4 m

Pond volume = 5 500 m<sup>3</sup>

Pumps and piping included

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

**WBS Deliverable:**

Water settling pond for water discharged from Service Shaft.

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17                      Finish Year: 17                      Duration: 1 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$232,101	\$151,444		\$383,545	10%	\$421,899

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

RE TERRAFIX GEO HDPE.msg

SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

1:43:48 PM

WEDS ID #

6013

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.150      STORM RUN-OFF POND

**WBS Description:**

Construction and commissioning of three equal size stormwater run-off detention ponds to collect surface water runoff from across the DGR site. Ponds nominally designed for a 100-year storm event. For conceptual design, total volume of approximately 23,000 m3 assumed.

**WBS Deliverable:**

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

**WBS Assumptions:**

Ponds to be designed for 23 000 m<sup>3</sup> total stormwater flow over the site. Three ponds to be constructed in soils with no rock excavation. Pricing includes bedding and geomembrane.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$947,469	\$599,166		\$1,546,635	10%	\$1,701,299

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

1:19:32 PM

WEDS ID #

6012

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.160      SEWAGE TREATMENT PLANT

**WBS Description:**

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

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$211,244	\$3,431,485		\$3,642,728	10%	\$4,007,001

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

5:43:45 PM

WEDS ID #

3003

Organization Name: SNC-Lavalin  
 Prepared by: Derek Elion                      Reviewed by: Peter Keohane  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.170                      LOW LEVEL LIQUID WASTE STORAGE BUILDING

**WBS Description:**

Detail design, construction, equipping and commissioning of a single storey low level liquid waste storage building with a total floor area of 500 m<sup>2</sup>.

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.

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

Because of the conventional nature of the design and construction activities involved in this work element, and the relatively clear specification of deliverables, a 10% level of allowance has been applied.

Start Year: 24                      Finish Year: 25                      Duration: 2 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,285,698	\$1,784,475	\$3,070,173	10%	\$3,377,190

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

# Work Element Definition Sheet

1-Jun-2010

6:05:16 PM

WEDS ID #

3008

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Organization Name: SNC-Lavalin  
Prepared by: Derek Elion  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.50.180 ACTIVE LIQUID WASTE TREATMENT (ALWT) SYSTEM

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## WBS 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 m<sup>2</sup>. It will not have a basement. The process within the building include evaporation system and associated tanks.

## WBS Deliverable:

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.

## WBS 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 m<sup>3</sup> of liquid effluent per annum. It is based on using 1 m<sup>3</sup> 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.

## WBS Allowance Basis:

The building and equipment that comprise the Active Liquid Waste Treatment Building will be a conventional nuclear/chemical plant. Although the plant requirements are well defined, its capacity is only indicative at this stage of the DGR design. Therefore, the major portion of the 10% allowance attached to this activity, results from the uncertainty in capital expenditure relating to the extent of equipment required.

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Start Year: 24      Finish Year: 25      Duration: 2 year(s)      WBS Type: Step Fixed

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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$880,000	\$2,064,893	\$2,944,893	10%	\$3,239,382

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

Bag Filter RF-080205-01.pdf

ENCON-SNC-041810R-MVC600.pdf

ENCON Drum Evaporator-Dryer 2010.pdf

ENCON-SNC-111810R-DE.pdf

ENCON-SNC-121810R-Thermal.pdf

NPxxVx-48 Specifications 2009 Rev 2.pdf

# Work Element Definition Sheet

1-Jun-2010

10:03:01 AM

WEDS ID #

6023

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.50.190      WASTE MANAGEMENT AREA

## **WBS Description:**

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Detail design, construct and commissioning of a Waste Management Area.

This area conceptualized as an approximate 10,000m<sup>2</sup> graveled yard with 2,500m<sup>2</sup> 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.

## **WBS Deliverable:**

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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.

## **WBS Assumptions:**

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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 constructed using conventional methods.

Costs include:

- 10,000 m<sup>2</sup> graveled yard with 2500 m<sup>2</sup> concrete pads
- A 1200 m<sup>2</sup>, 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 .40.50.220.

Exclusive of contingency.

## **WBS Allowance Basis:**

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Because of the conventional nature of the design and construction activities involved in this work element, and the relatively clear specification of deliverables, a 10% level of allowance has been applied.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,057,162	\$7,861,887		\$8,919,049	10%	\$9,810,954

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

# Work Element Definition Sheet

18-Jun-2010

5:13:31 PM

WEDS ID #

3021

Organization Name: SNC-Lavalin  
 Prepared by: Derek Elion                      Reviewed by: Peter Keohane  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.220                      LOW LEVEL WASTE STORAGE BUILDING

**WBS Description:**

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

Covering an area 1,000 m<sup>2</sup>, 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.

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

As the LLW storage facility will be constructed using conventional building methods, a 10% allowance level is appropriate for this cost estimate.

Start Year: 24                      Finish Year: 25                      Duration: 2 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,036,695	\$3,568,950	\$4,605,645	10%	\$5,066,210

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

## Work Element Definition Sheet

1-Jun-2010

10:46:09 AM

WEDS ID #

6027

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.230      ELECTRICAL SWITCHYARD

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

2000 m<sup>2</sup> switchyard including 800 m<sup>2</sup> of concrete pads . Estimated cost includes site preparation, fencing and yard foundations.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 15% as electrical requirement is reasonably well-defined.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$830,956	\$674,946		\$1,505,902	15%	\$1,731,787

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

10:53:24 AM

WEDS ID #

6028

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.240      TRANSFORMER AREAS

**WBS Description:**

Construct and commission transformer area.

**WBS Deliverable:**

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

**WBS Assumptions:**

Estimated on the basis of 120 m<sup>2</sup> (10 m by 12 m) area with two 20 MW transformers.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 15% as electrical requirement is reasonably well-defined.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$162,396	\$3,841,409		\$4,003,805	15%	\$4,604,376

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

3:11:21 PM

WEDS ID #

6038

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.50.250      VISITORS CENTRE

**WBS 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.

**WBS Deliverable:**

Fully equipped single storey visitors' centre (1,100 m<sup>2</sup> foot print).

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$570,825	\$6,801,399		\$7,372,224	10%	\$8,109,446

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

3-Nov-2010

11:33:20 AM

WEDS ID #

7141

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.60.20                      MAIN SHAFT AND HEADFRAME

**WBS Description:**

Construction and commissioning of a shaft and associated infrastructure to convey used nuclear fuel 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 7.5 m (finished internal) diameter, concrete lined shaft, change-over from sinking to handling of used fuel in UFCs Waste Shaft hoist installation

[This element previously referred to as WASTE SHAFT(S) AND UFC HEADFRAME/HOIST]

**WBS Deliverable:**

A functional 500 m deep shaft of 7.5 m finished internal diameter complete with required services and accessories for transfer of used fuel in UFCs.

**WBS 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 525 m to allow for the overwind/underwind required for safety concerns.

Exclusive of contingency.

**WBS Allowance Basis:**

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 16                      Finish Year: 17                      Duration: 2 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$59,789,437	\$59,789,437	20%	\$71,747,324

WBS Specific Supporting Documentation:

- All Shafts 9036-01 Hoisting Summary Rev 2.pdf
- Main Shaft 9036-01-ES02rA\_LRH.xls
- Main UFC Shaft Surface Fan Assemblage Design.pdf
- Waste Shaft 9036-01-10-1100-SK1 9035-01-10-1100 (1).pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf



## Work Element Definition Sheet

26-Jul-2010

7:03:35 PM

WEDS ID #

7007

Organization Name:

Hwozdyk Inc.

Prepared by:

Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.60.30

VENTILATION SHAFT AND HEADFRAME

### **WBS Description:**

Construction and commissioning of the ventilation shaft (exhaust 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 6.5 m internal diameter, concrete lined shaft

Install associated equipment.

### **WBS Deliverable:**

A functional 500 m deep x 6.5 m finished internal diameter shaft complete with required services and accessories.

### **WBS Assumptions:**

The temporary headframe is 30 m in height.

The collar is 35 m in depth.

The shaft is nominally 500 m in length.

Exclusive of contingency.

### **WBS Allowance Basis:**

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 18

Finish Year: 19

Duration: 2 year(s)

WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$46,971,101	\$46,971,101	20%	\$56,365,321

### WBS Specific Supporting Documentation:

9036-01-ES03rA\_LRH.xls

All Shafts 9036-01 Hoisting Summary Rev 2.pdf

Vent Shaft 9036-01-10-1200-SK1 9036-01-10-1200\_SK1 (1).pdf

Vent Shaft 9036-01-ES03rA\_LRH.xls

Vent Shaft - Exhaust Ventilation Raise Surface Fan Assemblage Design.pdf

### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

21-Jul-2010

6:27:07 AM

WEDS ID #

7006

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.60.40 VENTILATION SYSTEM

---

## **WBS Description:**

Design, procure, install and commission :

- (1) main underground ventilation system, including fans for the main, service and vent shaft, as well as mine air heating
- (2) temporary auxiliary ventilation system(s) for the emplacement rooms

## **WBS Deliverable:**

Main Fans:

Service Shaft: 60 m<sup>3</sup>/sec throughput, one 60 HP fan on surface, with 60 m<sup>3</sup>/sec throughput, 60 HP fan underground. In addition; one spare surface fan one spare underground booster fan.

Ventilation Shaft: 340 m<sup>3</sup>/sec throughput, two 450 HP fans on surface, with 340 m<sup>3</sup>/sec throughput, two 400 Hp booster fans underground. In addition: one spare surface fan, one spare underground booster fan. HEPA filtration capacity for facility exhaust on an as-as needed basis.

Main Shaft: 402 m<sup>3</sup>/sec throughput fan, two 500 HP exhausting on surface with 402 m<sup>3</sup>/sec throughput, two 400 HP booster fans underground.

In addition: one spare surface fan, one spare underground booster fan. Mine air heating (natural gas fired) of 32 MW (110Mbtu) capacity.

Auxiliary ventilation and development ventilation systems w/ fans and ducts. HEPA filtration for in-room placement auxiliary ventilation.

## **WBS Assumptions:**

Cost estimate assumes the following:

- Main Shaft fan package based on 10150 AMF 5000 Arr. #4 Mine Fan
- Service Shaft fan package based on 8400 AMF 3150 Arr. #4 Mine Fan
- Vent shaft fan package based on 10150 AMF 5000 Arr. #4 Mine Fan
- Burner (airflow 851,500 cfm @ 1" w.c; Burner Capacity 110 MMBTUH)
- Inlet bells, screens, discharge cones, ducting
- Manually operated fan brakes with limit switches.
- Spare running sections and fans
- Flow, pressure and vibration monitoring
- Control house, controls
- Allocation for in-room and exhaust complex HEPA filtration
- Prime, paint, install, commission

Repository-level ducting is included in per metre mine development costs and is not assessed in this cost element.

Exclusive of contingency.

**WBS Allowance Basis:**

The components of the emplacement room auxiliary ventilation system are “off the shelf items” utilizing known technologies, as are the main fans and associated system. A 10% allowance is required.

Start Year: 16                      Finish Year: 18                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$18,303,379	\$18,303,379	10%	\$20,133,717

WBS Specific Supporting Documentation:

- Fan System Quotes.pdf
- Quote PCL.pdf
- Surface Vent Sys Price Schedule (3).xls
- UFC Shaft Surface Fan Assemblage Heater RFP.pdf
- Overall DGR Ventilation Planning.pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

2-Aug-2010

4:06:33 AM

WEDS ID #

7015

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.60.50 SUPPORT SERVICES AND FACILITIES

## **WBS Description:**

---

Underground excavation to accommodate ancillary infrastructure items to support the construction of the DGR. These ancillary items comprise the following:

- Sumps
- Electrical Substation
- Storage Area
- Magazines Access Drift
- Explosives Magazine
- Detonators Magazine

These items are not covered in the Tunnel and Service Area Excavation (.40.10.30.20.70).

## **WBS Deliverable:**

---

Excavations to accommodate ancillary infrastructure to support underground construction.

## **WBS Assumptions:**

---

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model.

- Sumps (5 m W X 5 m H) : 60 metres
- Electrical Substation (6 m W X 4 m H) : 20 metres
- Storage Area (20 m W x 5 m H) : 30 metres
- Magazines Access Drift (5 m W X 5 m H) : 110 metres
- Explosives Magazine (7 m W X 7 m H) : 20 metres
- Detonators Magazine (5 m W X 4 m H) : 10 metres

Exclusive of contingency.

## **WBS Allowance Basis:**

---

Assigned allowance of 20%, as the requirements for these facilities are not fully defined. Allowance captures details of finish and equipment not captured in estimate line items.

Start Year: 17                      Finish Year: 19                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$2,664,331	\$2,664,331	20%	\$3,197,197

## WBS Specific Supporting Documentation:

waste rock reference table.xlsx

## Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

2-Aug-2010

4:46:15 AM

WEDS ID #

7016

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.60.60                      PERIMETER AND ACCESS DRIFTS/CROSS CUTS

**WBS Description:**

Excavation of the central, perimeter and panel access drifts comprising the DGR's "skeleton" of ventilation and panel access ways. The mining of these drifts will be by full face drill and blast technique employing control perimeter blasting to minimize creation of an excavation damage zone (EDZ). Central access drifts will be of 7.0 m width by 5.0 m height. Panel access drifts and perimeter drifts will be of 5.0 m width by 5.0 m height.

**WBS Deliverable:**

12,773 m of new tunnels comprising the "skeleton" of the DGR and access to the main exhaust shaft.

**WBS Assumptions:**

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model.

- Perimeter Drift 1 (5 m W X 5 m H) : 2304.5 metres
- Perimeter Drift 2 (5 m W X 5 m H) : 2183.5 metres
- Perimeter X-Cut A (5 m W X 5 m H) : 845 metres
- Perimeter X-Cut B (7 m W X 5 m H) : 1690 metres
- Exhaust Ventilation Shaft Station (7 m W X 5 m H) : 350 metres
- Access Drift 1 (7 m W X 5 m H) : 2600 metres
- Access Drift 2 (7 m W X 5 m H) : 2600 metres
- Access 1 & 2 Crosscuts (7 m W X 5 m H) : 200 metres

Also includes 5400 linear metres of tracks and switches (installed), based on 110 lb (50 kg) rails with ties, concrete, fish plates, tie plates, spikes and frog switches. Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.  
 Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 17                      Finish Year: 21                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$124,620,942	\$124,620,942	10%	\$137,083,036

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls  
 Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

2-Aug-2010

5:47:43 AM

WEDS ID #

7017

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.60.70 INITIAL PLACEMENT ROOMS/BOREHOLES (PANEL A)

**WBS Description:**

Excavate, furnish and prepare the first panel of placement rooms (Panel A – 16 placement rooms). Excavation will proceed from the “east” side of Panel A and retreat westwards towards the central access drifts.

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed. As each room is developed it will be equipped with a ventilation system comprising ventilation duct, exhaust fan and portable HEPA filtration system.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install (includes concrete, track, switches): 6336 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 21                      Finish Year: 25                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$134,089,715	\$134,089,715	10%	\$147,498,687

WBS Specific Supporting Documentation:

Borer.xls

Crystalline PanelA3\_6.xls

TrackSwitchInstall.xls

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

1-Jun-2010

10:57:49 AM

WEDS ID #

6029

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.10      FACILITY ELECTRICAL DISTRIBUTION

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

10% allowance - conventional (off-the-shelf) equipment.

Start Year: 20      Finish Year: 20      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$2,929,350	\$7,042,530		\$9,971,880	10%	\$10,969,068

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls



# Work Element Definition Sheet

1-Jun-2010

11:05:45 AM

WEDS ID #

6030

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.70.20      FACILITY COMMUNICATION SYSTEM(S)

## WBS Description:

Design, installation and commissioning of DGR communication system on surface.

## WBS Deliverable:

Communication system to include: Telephone and radio communication systems. Public address system, Clock system, Security system, Fire alarm system.

## WBS Assumptions:

All process instrumentation and control systems are included:

- Data communication links and inter connections (5,000 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.

## WBS Allowance Basis:

10% allowance - conventional (off-the-shelf) equipment.

Start Year: 20      Finish Year: 20      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$379,960	\$363,127		\$743,087	10%	\$817,395

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

11:36:25 AM

WEDS ID #

6034

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.40.70.30.10

FIRE WATER

### WBS 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.

### WBS Deliverable:

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

### WBS 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.

### WBS Allowance Basis:

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21

Finish Year: 21

Duration: 1 year(s)

WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$670,830	\$340,775		\$1,011,605	10%	\$1,112,765

### WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:43:39 AM

WEDS ID #

6035

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.30.20      POTABLE WATER

**WBS 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.

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$295,590	\$139,586		\$435,176	10%	\$478,693

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

11:48:55 AM

WEDS ID #

6036

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.30.30      PROCESS WATER

**WBS 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.

**WBS Deliverable:**

Water system to distribute fresh water to surface buildings.

**WBS Assumptions:**

Water taken form 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$216,825	\$153,522		\$370,347	10%	\$407,381

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:09:05 AM

WEDS ID #

6031

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.30.40      SEWERAGE

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$584,100	\$148,423		\$732,523	10%	\$805,775

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:53:43 AM

WEDS ID #

6037

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.30.50      STORMWATER AND DRAINAGE

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS Assumptions:**

No abnormal construction issues/problems. Designed based on nominal 100-year storm event.

Includes:

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

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 10% is used (conventional equipment and techniques)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,206,550	\$520,274		\$1,726,824	10%	\$1,899,506

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

11:16:40 AM

WEDS ID #

6032

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.40.70.40.10      BREATHING AIR

**WBS Description:**

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

**WBS Deliverable:**

Breathing compressed air supply and distribution systems to UFPP and other surface facilities. Breathing Air at 0.15 m<sup>3</sup> /s (~300 cfm) surface and underground supplied by 2 compressors each supplying 0.15 m<sup>3</sup> /s (~300 cfm)@ 700 kPa .

**WBS Assumptions:**

Breathing Air requirements to be at 0.15 m<sup>3</sup> /s . Verbal quote received from Atlas Copco Mississauga Ontario. Includes:

- Breathing air supply units (0.15m<sup>3</sup>/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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$536,900	\$1,812,302		\$2,349,202	10%	\$2,584,122

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:26:52 AM

WEDS ID #

6033

Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.40.70.40.20      SERVICE AIR

## WBS 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.

## WBS Deliverable:

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 m<sup>3</sup> /s (~2,100 cfm) surface and underground supplied by 3 rotary screw type compressors each supplying 0.5 m<sup>3</sup> /s (~1,050 cfm) @ 900 kPa . Concrete block construction with insulation and cladding. Steel frame roof with sprayed insulation.

## WBS Assumptions:

Service air requirements to be at 1.0 m<sup>3</sup> /s . Verbal quotation for equipment received from Atlas Copco of Mississauga Ontario.

Includes:

- One storey 20 m by 15 m building (300 m<sup>2</sup>, furnished and equipped)
- Service air supply units (0.5m<sup>3</sup>/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.

## WBS Allowance Basis:

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$659,325	\$4,783,589		\$5,442,914	10%	\$5,987,206

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls



# Work Element Definition Sheet

15-Sep-2010

2:26:35 PM

WEDS ID #

6195

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.10 OPERATIONS PROGRAM MANAGEMENT (INC TAX)

### WBS Description:

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The management and administration of the DGR facility during the Operation Phase is encompassed by other work elements. This element has been reduced to an annual allocation for taxes or payments in lieu of taxes.

For the operations of the President`s Office, engineering, finance, purchasing, safety and facility management, see element .45.20 (Direct Operations Management).

### WBS Deliverable:

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Annual tax, payment in lieu of tax or associated payment.

### WBS Assumptions:

---

Annual allocation of \$6M per year for the duration of operations (Y26 to Y55, inclusive)

Exclusive of contingency.

### WBS Allowance Basis:

---

No additional allowance assigned.

Start Year: 26      Finish Year: 55      Duration: 30 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$180,000,000	\$180,000,000		\$180,000,000

### WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

3:07:25 PM

WEDS ID #

6019

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.20      DIRECT OPS MANAGEMENT (INC QA)

**WBS Description:**

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

**WBS Deliverable:**

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.

**WBS Assumptions:**

Management numbers determined on the basis of the staffing plan for site (Y26 to Y55, inclusive).

Includes management and engineering as follows:

- One President
- Five Vice Presidents (Engineering, HR/HD, Society & Sustainability, Finance & Legal, Operations)
- Two Directors of Engineering (Aboveground and Underground)
- Six Engineering Managers
- Six Non-Engineering Managers
- 90 Staff

Line staff for procurement, environmental management, security, fire, housekeeping, etc. are included under .45.30 (Operations Indirects). Line staff for maintenance are included under .45.40.40 (O&M of Auxiliary Surface Facilities).

Mine development, UFC placement, UFPP operations, SMCP, crushing plant 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 (UFC Transport and Place).

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.

**WBS Allowance Basis:**

A 10% allowance has been attributed to this activity to account for consumables and incidentals.

Start Year: 26      Finish Year: 55      Duration: 30 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$398,664,000			\$398,664,000	10%	\$438,530,400

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

3:46:57 PM

WEDS ID #

6042

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.30      OPERATIONS INDIRECTS (INC FIRE & SECURITY)

## WBS Description:

Indirect labour and equipment required to operate the DGR facility during the Facility Operations phase of the project (Y26 to Y55), excluding 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).

## WBS Deliverable:

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

## WBS Assumptions:

Based on staffing as follows:

- Visitor Centre Staff (5 FTE)
- Visitor Centre Manager (1 FTE)
- Finance Manager (3 FTE)
- Financial Analyst (6 FTE)
- Buyer (6 FTE)
- I/T Support (10 FTE)
- Procurement Manager (2 FTE)
- Environmental Manager (Technicians in .45.20) (2 FTE)
- Rad. Safety and Monitoring (12 FTE)
- Payroll Officer (4 FTE)
- Fire/Security Manager (2 FTE)
- Security Officer/ Fire Supervisor (6 FTE)
- Security Guard (80 FTE)
- Firemen (16 FTE)
- Paramedic/Doctor/Nurse (8 FTE)
- HR Manager (2 FTE)
- Conventional Safety (and Operations) (20 FTE)
- Administration Manager/Office Manager (2 FTE)
- Administration Support (6 FTE)
- Housekeeping, Janitor support (40 FTE)
- Mess hall staff, cook, cleaners, drivers (40 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.

**WBS Allowance Basis:**

A 10% allowance has been attributed to this activity to account for consumables and incidentals.

Start Year: 26                      Finish Year: 55                      Duration: 30 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$717,771,600		\$3,200,000	\$720,971,600	10%	\$793,068,760

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

23-Sep-2010

9:25:37 AM

WEDS ID # 9020

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.40.10 UFPP OPERATION

## WBS Description:

Direct labour and materials for the day-to-day operation of the Used-Fuel Packaging Plant.

## WBS Deliverable:

UFPP direct operational manpower for the following areas:

- Receipt and unloading of transport casks
- Transport cask unloading and transfer of bundles
- Surge storage of shipping modules
- Shielded cart transfer tunnel operations
- UFC loading cells
- UFC sealing cell
- UFC welding cell
- UFC weld inspection cell
- UFC Machining cell
- UFC receipt cells
- UFC dispatch cells
- UFC and basket storage
- UFC transfer to waste shaft
- ILW/LLW handling, packaging and transport
- Health physics
- Control room operations
- Maintenance activities

Direct plant and materials i.e. LLW and ILW containers, major and minor spares, consumables. ILW/LLW disposal costs.

## WBS Assumptions:

All costs 2010 dollars

Assume costs distributed uniformly on an annualized basis for duration

UFPP to operate 2 shifts/day; 230 days /year; 30 year operation (normally) Y26-Y55.

Estimate assumes 46 weeks of operation per year, 6 weeks shut down for Operators leave and maintenance periods.

Throughput:

522 bundles per day producing ~ 2 UFCs/day;

333 UFCs/year, 10,000 UFCs total.

Fuel modules are to be decontaminated to LLW standards and packaged within full height ISO containers prior to being returned to the fuel owner.

LLW operational arisings to be packages in 200 litre drums. Arising assumed to be 500 drums per year, including

those containing encapsulated liquid waste arisings. Drums to be loaded into full height ISO containers and transported from the DGR to a separate facility. LLW buffer storage is provided on site to accommodate LLW operations arisings

Operational ILW will be packed in to 500 liter drums and transferred to a separate facility from the DGR when it is generated. Arisings assumed to be 12 drums per year.

LLW arisings will be transported from site in re-usable ISO containers. It is assumed to two containers per year are required (@10K per container) together with one trailer per year at \$150k per trailer).

A unit cost has been applied to cover the off-site transport, processing and disposal of both operational LLW and ILW arisings. The unit costs applied are \$1,400 per m3 of LLW and \$24,000 per m3 of ILW. See CTECH (2003) ED039, Annex 1.

Note: Waste arisings costs were not escalated from CTECH (2003) as the 2002 cost included a nominal 30 % contingency. See CTECH (2003) ED039, Annex 1.

Assumed job category for Operator Staff was OPG Cat 5 @ \$79.01 per hour

Operational trades support based on EPSCA rates assumed to be \$118 per hour fully burdened, DB07

Exclusive of contingency.

**WBS Allowance Basis:**

Allowance adjusted to 22.5 % to bring UFPP costs in-line with SKB estimate. Slight discrepancy arises due to escalation factors in the SKB I cost update versus updating the labour rates in the CTECH table, which is the basis of the inputs for the cost estimate in the WED.

Start Year: 26	Finish Year: 55	Duration: 30 year(s)	WBS Type: Step Fixed		
Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$182,850,000	\$456,760,020	\$639,610,020	23%	\$783,522,275

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 45.40.10.xlsx

Multi Element Supporting Documentation:

## Work Element Definition Sheet

22-Sep-2010

4:16:07 PM

WEDS ID #

9019

Organization Name: NWMO - Nuclear Waste Management Organization  
 Prepared by: A. Murchison Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.40.20 SUPPLY OF BASKETS AND UFCs

**WBS Description:**

Supply, packaging and delivery of the required number of UFCs and UFC baskets during the operational period.

**WBS Deliverable:**

- Supply of 333 UFCs per year over the 30 year operational period (total 10,000 UFCs).
- Supply of about 1,000 UFC baskets per year over the 30 year operational period (total 30,000 baskets).
- Reusable packaging for UFCs and baskets.
- Transport of UFCs and baskets from assembly plant to DGR facility.

**WBS Assumptions:**

All costs 2010 \$  
 Assume costs distributed uniformly on an annualized basis for duration  
 Duration of work: Y26 to Y55.

- A total cost per UFC of C\$250,000 excluding final delivery has been assumed. This value is the mid-point cost of a container (average of a nodular cast iron insert and roll formed inner vessel) and utilizes a 25 mm copper shell.

UFCs and baskets will be manufactured and assembled off-site and shipped 1000km to the DGR as a completed item.

Two UFC assemblies to be shipped in one trip with empty packaging returning on return journey. Round trip to cost \$2,743.

UFC assembly transport frames are reusable and assumed to have a design life of 15 years and an average frame cost of \$20 K. It is assumed 200 frames will be required over the life of operation.

Licensing and approvals sought from relevant authorities will be obtained without significant delay to the agreed schedule.

Exclusive of contingency.

**WBS Allowance Basis:**

Defective container costs assumed to come out allowance (15%)

Start Year: 26 Finish Year: 55 Duration: 30 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$2,504,000,010	\$13,750,000	\$2,517,750,010	15%	\$2,895,412,511

WBS Specific Supporting Documentation:

APM Master Estimate 560 D1 Rev. 13 for SKB Input to Golder 45.40.20.xlsx

Multi Element Supporting Documentation:





# Work Element Definition Sheet

2-Aug-2010

9:08:15 AM

WEDS ID # 7019

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.50.30 ROOM/TUNNEL/BOREHOLE EXCAVATION (SECOND STAGE) PANEL B

---

**WBS Description:**

Excavate, furnish and prepare the second stage placement rooms (Panel B – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 5940 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 26      Finish Year: 31      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$125,676,083	\$125,676,083	10%	\$138,243,692

WBS Specific Supporting Documentation:

Crystalline PanelB3\_6.xls  
waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

2-Aug-2010

10:53:47 AM

WEDS ID #

7020

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.50.40                      ROOM/TUNNEL/BOREHOLE EXCAVATION (THIRD STAGE) PANEL C

**WBS Description:**

Excavate, furnish and prepare the third stage placement rooms (Panel C – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 29                      Finish Year: 34                      Duration: 6 year(s)                      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:

Crystalline PanelC3\_6.xls  
waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

5-Aug-2010

7:12:06 AM

WEDS ID #

7029

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.50.50 ROOM/TUNNEL/BOREHOLE EXCAVATION (FOURTH STAGE) PANEL D

## WBS Description:

Excavate, furnish and prepare the fourth stage placement rooms (Panel D – 15 placement rooms).

## WBS Deliverable:

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

## WBS Assumptions:

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

Pricing includes waste rock delivered and spread at waste rock pile.

Per linear metre costs include conduit, etc.

Exclusive of contingency.

## WBS Allowance Basis:

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 32 Finish Year: 37 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

## WBS Specific Supporting Documentation:

Crystalline PanelD3\_6.xls  
waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

4-Aug-2010

2:04:40 PM

WEDS ID #

7023

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS  
Number: 560.45.50.60                      UFC TRANSPORT & PLACE

## WBS Description:

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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.

## WBS Deliverable:

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Tasks directly relating to the emplacement of UFCs include:

Personnel and material transfers to / from emplacement rooms including main and service shaft operation;  
Placement of 68 DBF blocks for each UFC;  
Placement of two DBF rings for each UFC;  
Placement of 4 HCB discs per UFC;  
Placement of 8 HCB rings per UFC;  
Placement of light backfill material;  
Removal of services and rails;  
Transfer placement equipment to new location;  
Routine maintenance.

These activities are carried out approximately 81 times per placement room, with a total of 124 placement rooms being filled over the 30-year operations period, equating to 333 operating cycles per year. As the UFCs are placed, removal of the rail and concrete plinth will be undertaken and the placement room filled with DBF blocks and light backfill.

Further deliverables included during UFC emplacement include:

Construction of approximately 4.1 placement room bulk heads per year (124 in total);  
The supply and installation of major replacement capital equipment;  
Supply of minor spares to service emplacement operations;  
Indirect NWMO staff i.e. Superintendents, Supervisors, Surveyors, Ventilation Technicians.  
Indirect plant and materials i.e. safety and first aid equipment, engineering and surveying supplies, fire protection, mine rescue supplies, training, small tools and shop supplies.

## WBS Assumptions:

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An assumption has been made that 10% of the drilled boreholes will not be useable, therefore a total of 89 boreholes are to be drilled per placement room.

An average of 80.5 UFCs will be placed in each placement room.

Pricing based on full set of UFC retrieval equipment (on stand-by) and an all-inclusive per UFC emplacement rate.

All-inclusive per UFC cost includes Aggregate Plant, Concrete Plant and SMCP costs such as:

- Average Power Plant Consumption
- Supervisors
- Foremen
- Operators
- Parts & Supplies for Maintenance
- Maintenance Labour

- Loader Operating/Maintenance Cost
- Raw Material Cost (Cement T50, Silica Fume, Silica Flour, Superplasticizer, Concrete Stone, Concrete Sand, MX 80 Bentonite, Modified Granular A, Glacial Lake Clay, Granite Sand)

Per UFC cost also includes:

- Crews for UFC placement and room backfill
- Locomotives
- UFC Transport trollies - flatbed
- UFC Transfer Units
- Trollies for Transfer Unit
- Placement Machines
- Trollies for Placement Machine
- Borehole Shielding Barriers
- Bentonite Recovery Equipment Trollies
- Temporary Borehole Covers
- Specialized Backfill Placement Equipment
- Bulkhead Key & Placement Equipment

Exclusive of contingency.

**WBS Allowance Basis:**

Operating activities within the emplacement rooms have been identified and numbers of personnel assigned to each activity. Uncertainties relate to the possible omission of activities as well as incorrect personnel allocation. However, because of the detailed breakdown carried out, an Allowance level of 25% is considered to be appropriate.

Start Year: 26      Finish Year: 55      Duration: 30 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$1,226,913,460	\$1,226,913,460	25%	\$1,533,641,825

WBS Specific Supporting Documentation:

- Crystalline UFC Placement - Assumption List - Vertical.xls
- Crystalline Vertical Placementl Equipment List.xls
- Sequencing for Vertical Placement Process.xls
- Vertical 9.dwg
- Vertical Placement Story Board.pdf
- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04.xls
- 09-1117-0032 NWMO Equipment List R6.xlsx
- Revised Vert Placement Costs 28NOV2010.xlsx

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf



## Work Element Definition Sheet

27-Jul-2010

9:00:25 PM

WEDS ID #

7009

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.50.100 HOIST ROPE REPLACEMENT

**WBS Description:**

Replacement of the ropes in the Service Shaft and Main Shaft as often as every three years; set-aside for replacement of vent shaft rope (not scheduled for use) as often as every nine years.

**WBS Deliverable:**

Replacement hoist ropes: hoists ready for use.

**WBS 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 vent shaft hoist is not scheduled for use; emergency hoist capacity in the vent shaft will be maintained.

Exclusive of contingency.

**WBS Allowance Basis:**

Rope costs and frequency of replacement is well established from industry experience - allowance of 20% covers incidental costs related to inspection and procurement.

Start Year: 17                      Finish Year: 55                      Duration: 39 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$10,343,021	\$10,343,021	20%	\$12,411,625

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls  
 Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

4-Aug-2010

2:08:24 PM

WEDS ID #

7027

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.45.50.110 INDIRECTS FOR FINAL PANEL UFC PLACEMENT

**WBS 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).

**WBS Deliverable:**

Support for underground operations.

**WBS Assumptions:**

Indirects for periods w/o drilling/blasting derived from Hwozdyk Inc. 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.

**WBS Allowance Basis:**

10% allowance - Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 49      Finish Year: 55      Duration: 7 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$51,663,990	\$51,663,990	10%	\$56,830,389

WBS Specific Supporting Documentation:

560\_45\_50\_110.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

4-Aug-2010

2:09:35 PM

WEDS ID # 7028

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Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                                  Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                                  DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.50.120                                  MINING HEAT AND POWER

**WBS Description:**

Mine heating and electrical costs (other mining indirects are incorporated in EPC-basis per metre underground development costs).

**WBS Deliverable:**

Support for underground operations.

**WBS Assumptions:**

Propane heating (Sudbury climate norms as proxy): 3.2 M litres/annum of propane or equivalent. Mine electrical: 45 M kWhr/annum.

Electrical loads include:

- Main Ventilation Fans
- Hoisting
- Tramming
- Underground Auxiliary Ventilation Fans
- Mine Dewatering
- Miscellaneous Demand (small compressors, diamond drills, etc.)

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 16                                  Finish Year: 55                                  Duration: 40 year(s)                                  WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$187,052,403	\$187,052,403	10%	\$205,757,643

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Nov-2010

11:24:44 AM

WEDS ID #

7140

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.50.130 EXTENDED OPERATIONS (INC SUPPORT SERVICES)

### WBS Description:

Operation and management of the DGR facility for 70 years (Y56 to Y125, 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, preparation of the case for the closure of the DGR and the application for authority to close.

### WBS Deliverable:

- DGR-based organization which maintains the NWMO structure, facilities and knowledge base in anticipation of decommissioning and closure.
- Asset management to maintain DGR infrastructure and surface facilities integrity against the prevailing environment.

### WBS 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 plan includes:

- President (1 FTE)
- Engineering Manager (1 FTE)
- Facility Manager (1 FTE)
- Security Manager (1 FTE)
- Finance Manager (1 FTE)
- HR Manager (1 FTE)
- Procurement Manager (1 FTE)
- Admin Assist (5 FTE)
- Conventional Safety (2 FTE)
- Engineering Support (2 FTE)
- Finance Analyst (1 FTE)
- Housekeeping (8 FTE)
- I/T Support (2 FTE)
- Payroll (1 FTE)
- Nurse (1 FTE)
- Rad Safety (2 FTE)
- Security Guard (20 FTE)
- Security/Fire Supervisor (2 FTE)
- Tech Support (2 FTE)

Surface facility maintenance accounted for in an asset management expenditure of approximately \$3M/annum.

Power provided at an average annual consumption of 36M KWhr/yr.

Placeholder for annual taxes or payments in lieu of taxes carried at \$250,000 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 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.

**WBS Allowance Basis:**

25% allowance used to accommodate line items not detailed in estimate.

Start Year: 56                      Finish Year: 125                      Duration: 70 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$382,170,600		\$408,130,631	\$790,301,231	25%	\$987,876,538

WBS Specific Supporting Documentation:

NWMO Electrical Power Costs - Extended Monitoring Period.xls

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

3-Nov-2010

11:44:54 AM

WEDS ID #

7147

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.50.140 EXTENDED OPERATIONS EQUIP REPLACE/REFURB/MAINTAIN

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## **WBS Description:**

Maintenance of the DGR facility for 70 years (Y56 to Y125, inclusive) following the completion of UFC emplacement operations in conjunction with the corporate function defined in element .45.50.130.

## **WBS Deliverable:**

The ongoing maintenance and refurbishment of the DGR infrastructure and surface facilities to ensure their continued operability and integrity against the prevailing environment.

## **WBS Assumptions:**

The DGR site infrastructure, surface buildings and underground works will be held in a care and maintenance regime for 100 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.

.45.50.130 includes annual asset management allocations for major structural work.

Exclusive of contingency.

## **WBS Allowance Basis:**

Allowance of 30% has been applied to this activity to cover small equipment, incidentals and consumables.

Start Year: 56          Finish Year: 125          Duration: 70 year(s)          WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$79,438,800		\$1,891,075	\$81,329,875	30%	\$105,728,837

## **WBS Specific Supporting Documentation:**

### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

3-Sep-2010

1:19:39 PM

WEDS ID #

7052

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.50.150                      ROOM/TUNNEL/BOREHOLE EXCAVATION (FIFTH STAGE) PANEL E

**WBS Description:**

Excavate, furnish and prepare the fifth stage placement rooms (Panel E – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 35                      Finish Year: 40                      Duration: 6 year(s)                      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:

Crystalline PanelE3\_6.xls  
 waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls  
 Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

3-Sep-2010

2:07:35 PM

WEDS ID #

7053

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.45.50.160                      ROOM/TUNNEL/BOREHOLE EXCAVATION (SIXTH STAGE) PANEL F

**WBS Description:**

Excavate, furnish and prepare the sixth stage placement rooms (Panel F – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 38                      Finish Year: 44                      Duration: 7 year(s)                      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

WBS Specific Supporting Documentation:

Crystalline PanelF3\_6.xls  
 waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls



## Work Element Definition Sheet

3-Sep-2010

2:27:49 PM

WEDS ID #

7054

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.45.50.170 ROOM/TUNNEL/BOREHOLE EXCAVATION (SEVENTH STAGE) PANEL G

**WBS Description:**

Excavate, furnish and prepare the seventh stage placement rooms (Panel G – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 41      Finish Year: 46      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:

Crystalline PanelG3\_6.xls  
waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

3:01:51 PM

WEDS ID #

7055

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.45.50.180 ROOM/TUNNEL/BOREHOLE EXCAVATION (EIGHTH STAGE) PANEL H

**WBS Description:**

Excavate, furnish and prepare the eighth stage placement rooms (Panel H – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 6580 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 44      Finish Year: 49      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

**WBS Specific Supporting Documentation:**

Crystalline PanelH3\_6.xls  
waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

28-Jun-2010

11:46:44 AM

WEDS ID #

8029

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Organization Name: SNC-Lavalin Nuclear  
Prepared by: Bassam Ahmad      Reviewed by: Lloyd Lazic  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.55.40      ENVIRONMENTAL RESPONSE EQUIPMENT

**WBS Description:**

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Procurement, delivery, installation and commissioning of environmental response equipment

(Note that this element was formerly named "RAD & NON-RAD GROUNDWATER MONITORING". However, in the current cost estimate, NWMO costs for other cost elements include all necessary radiological and non-radiological groundwater monitoring.)

**WBS Deliverable:**

---

Procurement, installation and commissioning for the following items:

- Environmental Protection Control System
- Environmental Protection Control System Software
- Environmental Protection measuring devices
- Contamination kits
- Environmental cleaning kits
- Mobile rapid response units
- Environmental assessment laboratory

**WBS 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.

**WBS Allowance Basis:**

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10% allowance covers consumables and incidentals.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$5,850,000		\$5,850,000	10%	\$6,435,000

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls

RE ACTION REQUIRED Quotes .txt

## Work Element Definition Sheet

21-Jun-2010

3:23:29 PM

WEDS ID #

8009

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Organization Name:	SNC-Lavalin Nuclear		
Prepared by:	Bassam Ahmad	Reviewed by:	Lloyd Lazic
Modified by:	Last Modification Date: 4-Dec-2010		

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.55.50 RADIOLOGICAL MONITORING EQUIPMENT

### **WBS 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 poin.
- 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 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 )

### **WBS Deliverable:**

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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)
- Dosimetry device (4 per person/per year, 25 persons: 100)

- Electronic Dosimetry 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)

**WBS Assumptions:**

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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.

**WBS Allowance Basis:**

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10% allowance covers consumables and incidentals.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$6,431,000		\$6,431,000	10%	\$7,074,100

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls

RE ACTION REQUIRED Quotes .txt

# Work Element Definition Sheet

22-Jun-2010

1:45:43 PM

WEDS ID #

8011

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Organization Name: SNC-Lavalin Nuclear  
Prepared by: Bassam Ahmad      Reviewed by: Lloyd Lazic  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.55.60      NON RADIOLOGICAL MONITORING EQUIPMENT

## WBS Description:

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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.

(Note that this element was formerly named "NON - RAD BIOSPHERE MONITORING". However, in the current cost estimate, costs for other cost elements include all necessary non-radiological monitoring. For example, safety staff are included in .45.30, Operations Indirects )

## WBS Deliverable:

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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)

## WBS Assumptions:

---

Materials Costs Assumptions:

- 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.

**WBS Allowance Basis:**

10% allowance covers consumables and incidentals.

---

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,832,750		\$1,832,750	10%	\$2,016,025

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls

RE ACTION REQUIRED Quotes .txt

# Work Element Definition Sheet

31-Jul-2010

11:06:11 AM

WEDS ID #

2001

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Organization Name: SNC-Lavalin Nuclear  
Prepared by: Bob Brewer                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.10                      DECOMMISSIONING MANAGEMENT

---

## WBS Description:

NWMO operation and management of the DGR facility for 10 years (Y126 to Y135, inclusive) 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.

## WBS Deliverable:

DGR-based corporate organization which applies for necessary instruments, lets contracts and manages contract delivery to decommission underground works and major surface facilities.

## WBS Assumptions:

Staffing plan includes:

- President (1 FTE )
- Director of Engineering (2 FTE )
- Building Manager (1 FTE )
- Finance Manager (1 FTE )
- HR Manager (1 FTE )
- Maintenance Manager (2 FTE )
- Security Manager (1 FTE )
- Engineering Support (6 FTE )
- Finance Analyst (2 FTE )
- IT Support (2 FTE )
- Nurse (1 FTE )
- Conventional Safety and Health Physics Staff (6 FTE )
- Security Guard (20 FTE )
- Technical Support (3 FTE )
- Administrative Staff (10 FTE )
- Janitorial and Maintenance (8 FTE )

Power and utilities provided as approximately \$680K/annum; fleet assessed as \$120K/annum. Other incidentals and consumables allocated to allowance (25%).

Placeholder for taxes or payments in lieu of taxes at \$250,000 per annum.

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 NWMO's own engineering; contractor engineering is accounted for in turnkey (design-build) pricing for individual decommissioning actions.

Exclusive of contingency.

**WBS Allowance Basis:**

25% allowance used to accommodate line items not detailed in estimate.

Start Year: 126                      Finish Year: 135                      Duration: 10 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$68,002,200	\$1,200,000	\$9,300,000	\$78,502,200	25%	\$98,127,750

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 560.xlsx
- DC Manpower Plan (Surface Related and Operations) V2.xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

8:06:00 PM

WEDS ID #

2015

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.30.10 BACKFILL MATERIALS PLANT (SUPPLY AND OPERATE)

---

## WBS 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.

## WBS Deliverable:

The backfill materials plant includes a steel framed 4,000 m<sup>2</sup> 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.

## WBS Assumptions:

Facility design, construction, installation and commissioning will be on a turnkey contract basis. Management and operation will be done by contract labour as follows:

- Plant Admin (days only) (2 FTE )
- Plant Mgr - 1 per shift (5 FTE )
- Plant technical - 2 per shift (10 FTE )
- Operators - 8 per shift (40 FTE )
- Maintenance - 2 per shift (10 FTE )

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas incl services - 4000m<sup>2</sup> (\$7.2M, 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) (\$30M, turn-key).
- Spares and consumables (\$1.2M/year)
- Accommodation, travel and incidentals (\$2.2 M/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.

## WBS Allowance Basis:

An allowance of 20% is applied to provide for variations of requirements during decommissioning and closure.

---

Start Year: 126      Finish Year: 134      Duration: 9 year(s)      WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$133,250,400	\$37,200,000	\$30,546,000	\$200,996,400	20%	\$241,195,680

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx

DC Manpower Plan (Surface Related and Operations).xlsx

560 DC Workbook A 2010 Update BB November.xlsx

560 DC Workbook B 2010 Update BB Rev 2.xls

ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

8:49:19 PM

WEDS ID #

2016

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.30.20 WASTE PROCESSING AND HANDLING FACILITY

---

## WBS 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.

## WBS Deliverable:

The waste processing and handling facility includes an insulated pre-engineered 1,500 m<sup>2</sup> 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.

## WBS Assumptions:

Facility design, construction, installation and commissioning will be on a turnkey contract basis, with management and operation of the facility carried out using contract labour as follows:

- Plant Mgr (1 FTE)
- Plant Administrator (1 FTE)
- Tech Specialist/Quality assurance (1 FTE)
- Operators - Phase 1 (12 FTEs, first 5 years)
- Operators - Phase 2 (6 FTEs, second 5 years)
- Maintainer (1 FTE)

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas including services - 1500m<sup>2</sup> (\$11.251M, turn-key)
- Size reduction equipment (equipment for use within the facility and on site as needed for cropping, burning, crushing and compaction) (\$6M, turn-key).
- Materials handling equipment, including building crane, loaders and materials conveyors (\$2.4 M, turn-key)
- Ventilated enclosure for the sorting and packing of waste into ISO containers (\$900K, turn-key)
- Operating spares and consumable (\$300K/year)
- Accommodation, travel and incidentals (\$422K/year)

Transport, disposal and other operating costs are not included here, but are built into per tonne and per m<sup>3</sup> rates for waste disposal line items.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 20% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 126                      Finish Year: 135                      Duration: 10 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$28,458,000	\$23,551,000	\$4,220,000	\$56,229,000	20%	\$67,474,800

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xlsx  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

10:00:54 AM

WEDS ID #

2007

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.40 AUXILIARY SURFACE FACILITIES DECOMM

---

## **WBS 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.

## **WBS Deliverable:**

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.

## **WBS 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 - approximately \$2,046,000
- Pumphouse and intake - approximately \$221,000
- Water storage tank area - approximately \$19,000
- Water treatment plant - approximately \$66,000
- Process water settling pond - approximately \$29,000
- Service shaft water settling pond - approximately \$7,000
- Storm water run-off ponds - approximately \$29,000
- Sewage treatment plant - approximately \$81,000
- Administration building including firewall / cafeteria - approximately \$582,000
- Switchyard - approximately \$29,000
- Transformer areas - approximately \$90,000
- Auxiliary building - approximately \$528,000
- Quality control offices and laboratories - approximately \$110,000
- Garage building/warehouse/hazardous matls storage - approximately \$371,000
- Walkways and serviceways - approximately \$49,000
- Fuel storage tanks - approximately \$19,000
- Fire hall / security - approximately \$85,000
- Emergency power generation - approximately \$290,000
- Facility electrical distribution - approximately \$208,000
- Facility communication system (s) - approximately \$14,000
- Firewater system - approximately \$19,000
- Potable water system - approximately \$8,000
- Process water system - approximately \$7,000
- Sewerage system - approximately \$13,000
- Storm water and drainage system - approximately \$32,000

- Service air system - approximately \$123,000
- Breathing air system - approximately \$50,000
- Camp site remnants - approximately \$402,000

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 25% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 126                      Finish Year: 135                      Duration: 10 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$5,525,000	\$5,525,000	25%	\$6,906,250

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 560.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

## Work Element Definition Sheet

30-Aug-2010

9:31:14 PM

WEDS ID #

2017

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.50 USED FUEL PACKAGING PLANT (UFPP) DECOMM

### WBS Description:

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Used Fuel Packaging Plant.

### WBS Deliverable:

Used Fuel Packaging Plant site restored to a "green" state.

### WBS Assumptions:

It is assumed that post-operations clean out (POCO) is carried out after operations are complete.

Decommissioning is estimated as requiring approximately 1430 person-hours each for a decommissioning manager and an administrator. Decommissioning will be carried out with approximately 33,000 person-hours of direct labour and 5,800 person-hours of support. The cost estimate also includes a \$240K annual assignment for operating spares and consumables over a three-year period, as well as a \$526K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

### WBS Allowance Basis:

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. The UFPP is a particularly complex structure and has radiological decontamination aspects. For this reason an allowance of 30% has been attached to this activity.

Start Year: 128      Finish Year: 130      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$13,108,123	\$720,000	\$1,578,000	\$15,406,123	30%	\$20,027,960

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx



# Work Element Definition Sheet

30-Aug-2010

3:19:03 PM

WEDS ID #

2014

Organization Name: SNC-Lavalin

Prepared by: Bob Brewer

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.60.60 SEALING MATERIALS COMPACTION PLANT DECOMM

**WBS Description:**

Labour and equipment for the decommissioning, dismantling and removal of the Sealing Materials Compaction Plant.

**WBS Deliverable:**

Sealing Materials Compaction Plant site restored to a "green" state.

**WBS 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 (483 hours) supported by a technical specialist (928 hours). Decommissioning will be carried out using approximately 24,360 person-hours, an annual operating spares and consumables budget of \$120K and an annual allocation for accommodations, incidentals and travel of \$189K.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes of waste produced. The SMCP includes large, unique equipment. For this reason an allowance of 30% has been attached to this activity.

Start Year: 131      Finish Year: 132      Duration: 2 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,053,770	\$240,000	\$377,600	\$3,671,370	30%	\$4,772,780

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 560.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

9:55:41 PM

WEDS ID #

2018

Organization Name: SNC-Lavalin

Prepared by: Bob Brewer

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.60.70.10 ALWT

**WBS Description:**

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Active Liquid Waste Treatment Building.

**WBS Deliverable:**

The return of the ALWT building site to a 'green' state.

**WBS 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 \$33K annual assignment for operating spares and consumables over a three-year period, as well as a \$44K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. The ALWT is a nuclear facility with related radiological considerations. For this reason an allowance of 30% has been attached to this activity.

Start Year: 127      Finish Year: 129      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,080,523	\$99,000	\$133,200	\$1,312,723	30%	\$1,706,540

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 560.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

## Work Element Definition Sheet

30-Aug-2010

10:22:11 PM

WEDS ID #

2019

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.70.20                      LLLW STORAGE

### **WBS Description:**

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Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Liquid Waste Storage Building.

### **WBS Deliverable:**

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The return of the LLLW building site to a 'green' state.

### **WBS Assumptions:**

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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 \$14K annual assignment for operating spares and consumables over a three-year period, as well as a \$17K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

### **WBS Allowance Basis:**

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Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. For this reason an allowance of 30% is attached to this activity.

Start Year: 127                      Finish Year: 129                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$458,842	\$42,000	\$50,700	\$551,542	30%	\$717,004

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

10:33:28 PM

WEDS ID #

2020

Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.70.30 LLW STORAGE

## WBS Description:

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Waste (LLW) storage building.

## WBS Deliverable:

The return of the LLW storage building site to a 'green' state.

## WBS 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 \$33K annual assignment for operating spares and consumables over a three-year period, as well as a \$45K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

## WBS Allowance Basis:

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. For this reason a 30% allowance has been included.

Start Year: 127 Finish Year: 129 Duration: 3 year(s) WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,087,603	\$99,000	\$134,250	\$1,320,853	30%	\$1,717,109

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

3-Aug-2010

6:41:08 PM

WEDS ID #

4013

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.80 UFC HANDLING SYSTEMS

## WBS Description:

Labour and equipment for the decontamination, decommissioning, dismantling and removal of UFC Casks, Buffer Block Casks, In-room Emplacement Equipment, Locomotives, Rail Cars, Cask Parking Areas and the Surface Rail Link.

## WBS Deliverable:

The removal from site of UFC Casks, Buffer Block Casks, In-room Emplacement Equipment, Locomotives, Rail Cars, Cask Parking Areas and the Surface Rail Link.

## WBS Assumptions:

Estimate is based on the following actions:

- Decontaminate 3 UFC Casks
- Size reduce and load for disposal - 3 UFC casks
- Size reduce and load for disposal - 3 UFC transport trolley flatbed
- Size reduce and load for disposal - 2 trolley for Transfer Cask
- Size reduce and load for disposal - 3 UFC Buffer Block Casks
- Size reduce and load for disposal- 4 Locomotives
- Size reduce and load for disposal - 2 Trolleys for Placement Machine
- Size reduce and load for disposal - 2 Placement Machines
- Size reduce and load for disposal - 2 Borehole Shielding Barriers
- Size reduce and load for disposal - 2 Bentonite Recovery Equipment Trolley
- Size reduce and load for disposal - 10 Rail Cars
- Dismantle 400 m of rail track
- Haul the reduced equipment (scrap metal) to disposal - 422 tonne
- Scrap metal credit for salvage - 306 tonne
- Reinstate surface parking area - remove pavement and dispose (400 tonne), provide landscaping/hydroseed (1,000 m<sup>2</sup>)

Components will be size reduced and packaged in a form suitable for transport from site, to a facility for final disposal.

All arisings (348 m<sup>3</sup>) 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 elsewhere.

Exclusive of contingency.

## WBS Allowance Basis:

An allowance of 10% has been attached to this activity for components not captured in estimate line items.

---

Start Year: 127      Finish Year: 128      Duration: 2 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$217,120		\$48,944	\$266,064	10%	\$292,671

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xlsPremierRecycling.docLabourEquipmentCost 2010.xls

## Work Element Definition Sheet

30-Aug-2010

12:54:39 PM

WEDS ID #

2011

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer      Reviewed by:  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.90      PERM VENT FAN REMOVAL (DECOMMISSIONING)

---

### WBS 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.

### WBS Deliverable:

Complete (greenfield) decommissioning of ventilation systems.

### WBS Assumptions:

Costs estimated as 4000 hours of direct labour and a \$48K allocation for special materials and equipment.

Exclusive of contingency.

### WBS Allowance Basis:

An allowance of 20% is applied to provide for lack of design detail.

Start Year: 126      Finish Year: 126      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$472,000	\$48,000		\$520,000	20%	\$624,000

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

3-Aug-2010

11:48:04 AM

WEDS ID #

4002

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.100.10 ACCESS TUNNELS AND DRIFTS

## WBS Description:

Decommissioning of access tunnels and drifts to comprise:

- Removal of road bed and track ballast, 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 and drifts comprising the repository and underground shaft complexes.

## WBS Deliverable:

Tunnels backfilled with dense backfill (70% crushed granite, 25% glacial lake clay and 5% bentonite) from the tunnel floor elevation to a height of 2.4 m. The upper portion of the tunnels from 2.4 m to the full height of 5.0 m will be filled with light backfill (50% crushed granite and 50% bentonite). Tunnels to be sealed with an assemblage of sealing material blocks placed in conjunction with a concrete bulkhead at regular intervals and/or structural discontinuities approximately every 500 m of tunnel for an approximate total of 50 seals.

## WBS Assumptions:

Total length of tunnel to be backfilled to be 23,889 m. Initially the dense backfill will be placed utilizing placement, positioning and compaction utilizing load-haul-dump vehicles with suitable rollers. Light backfill will be placed by pneumatic placement methods. The combined density of the dense and light backfill will be 1.88 tonnes/m<sup>3</sup>. 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 6 years based on multi-face working.

Includes:

- Dense backfill, 70% crushed granite, 25% glacial lake clay and 5% bentonite - 411,400 m<sup>3</sup>
- Light backfill, 50% crushed granite and 50% bentonite- - 445,700 m<sup>3</sup>
- Concrete bulkhead in Access Tunnel
- 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
- Steel credit for salvage – 2,314 tonne
- Nonferrous metals credit for salvage - 50 tonne
- Copper from 4160 V cable for salvage - 264 tonne

Labour rates used include contractor indirects.

Exclusive of contingency.



**WBS Allowance Basis:**

An allowance of 10% will be applied as the technology for efficient backfilling (with 100% tight filling) requires development, but is relatively well understood.

Start Year: 126                      Finish Year: 130                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$19,220,076	\$111,788,200	\$5,786,405	\$136,794,681	10%	\$150,474,149

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

3-Aug-2010

1:14:58 PM

WEDS ID #

4003

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.100.20 SERVICE SHAFT

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## WBS Description:

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.

## WBS Deliverable:

A backfilled and sealed Service Shaft.

## WBS Assumptions:

No further requirement to access the underground facility. Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material. A new slick line will be installed in the Service Shaft for dense backfill placement. 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) - 2,755 m<sup>3</sup>
- Bentonite and Sand Seal – 17,910 m<sup>3</sup>
- Asphalt Seal – 2,296 m<sup>3</sup>
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 700 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.

Labour rates used include contractor indirects.

Exclusive of contingency.

## WBS Allowance Basis:

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 130                      Finish Year: 132                      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$12,058,184	\$8,217,840	\$1,799,190	\$22,075,214	10%	\$24,282,735

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

3-Aug-2010

2:31:02 PM

WEDS ID #

4004

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.100.30 MAIN SHAFT

## WBS Description:

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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.

## WBS Deliverable:

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A backfilled and sealed Main Shaft.

## WBS Assumptions:

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No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material.

A new slick line will be installed for dense backfill placement.

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) - 3,539 m3
- Bentonite and Sand Seal – 23,004 m3
- Asphalt Seal – 2,949 m3
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 700 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.

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 131                      Finish Year: 133      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$11,171,886	\$10,555,216	\$900,064	\$22,627,166	10%	\$24,889,883

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- 560.60 NWMO Cost Breakdown for Database-UG decommiss.xls
- NWMO UG-services- Seals.xls
- NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

3-Aug-2010

3:33:58 PM

WEDS ID #

4006

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.100.50 VENTILATION SHAFT DECOMM

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## WBS Description:

Install a sinking hoist and refurbish the Ventilation Shaft so that the shaft can be back filled in a retreat 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.

## WBS Deliverable:

A backfilled and sealed ventilation shaft.

## WBS Assumptions:

No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material.

A new slick line will be installed for dense backfill placement.

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) - 2,755 m<sup>3</sup>
- Bentonite and Sand Seal – 17,910 m<sup>3</sup>
- Asphalt Seal – 2,296 m<sup>3</sup>
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 173 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.

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 126                      Finish Year: 128                      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$8,918,912	\$8,217,840	\$1,610,857	\$18,747,609	10%	\$20,622,370

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

3-Aug-2010

3:51:36 PM

WEDS ID #

4007

Organization Name: SNC-Lavalin  
 Prepared by: Kris Hojka                      Reviewed by: Peter Keohane  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
 WBS Number: 560.60.110                      IN-TOWN DECOMMISSIONING

**WBS Description:**

Sell, transfer or dismantle/dispose of facility-related (obsolete) town site buildings and related facilities.

**WBS Deliverable:**

The bulk of the town site will remain to serve the permanent residents of the community.

The nature and extent of facilities subject to dismantling will depend, for example, on the selected host community and its economic base. No specific costs are included in the current estimate; however, NWMO assignment of contingency accommodates several options, including demolition of worker accommodations (motel).

**WBS Assumptions:**

N/A

**WBS Allowance Basis:**

N/A

Start Year: 135                      Finish Year: 135                      Duration: 1 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
			\$0		\$0

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- 560.60 NWMO Cost Breakdown for Database-UG decommiss.xls
- PremierRecycling.doc
- LabourEquipmentCost 2010.xls



# Work Element Definition Sheet

3-Aug-2010

4:41:38 PM

WEDS ID # 4008

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Modified by: Reviewed by: Peter Keohane  
Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.120 CRUSHER PLANT DEMO (DECOMM)

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## WBS Description:

Demolition and dispose of the rock crushing plant and concrete batch plant.

## WBS Deliverable:

Decommissioned rock crushing plant and concrete batch plant.

## WBS Assumptions:

Estimate includes:

- Dismantling of Concrete Batching Plant
- Dismantling of Rock Crushing Plant
- Haul and dispose of debris to disposal – 1,400 tonne
- Haul scrap steel - 300 tonne
- Salvage scrap metal (credit) - 300 tonne
- Landscaping (hydroseed) – 2,950 m2

Labour rates used include contractor indirects.

Exclusive of contingency.

## WBS Allowance Basis:

10% allowance to be applied to provide for variations to the requirements during decommissioning.

Start Year: 134 Finish Year: 134 Duration: 1 year(s) WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$76,700		\$133,759	\$210,459	10%	\$231,504

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xls  
PremierRecycling.doc  
LabourEquipmentCost 2010.xls

## Work Element Definition Sheet

30-Aug-2010

2:39:57 PM

WEDS ID #

2013

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer      Reviewed by:  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 560      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.130      SITE CLEANUP (DECOMM)

### **WBS 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.

### **WBS Deliverable:**

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.

### **WBS 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.

### **WBS Allowance Basis:**

An allowance of 25% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 134      Finish Year: 135      Duration: 2 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$788,240			\$788,240	25%	\$985,300

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 560.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

3-Aug-2010

5:43:19 PM

WEDS ID #

4011

Organization Name: SNC-Lavalin

Prepared by: Kris Hojka

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)

WBS Number: 560.60.150 DECOMM INDIRECTS (INC HEAT, CONSUMABLES)

**WBS 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.

**WBS Deliverable:**

Contractor plant indirects for decommissioning.

**WBS Assumptions:**

Estimate based on support costs modified from operations phase as follows:

- Mine Heating - \$1,403,000/year
- Surface Building Heat - \$924,000/year
- Electricity - \$1,289,000/year
- Water and Sewerage - \$9,125/year

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.

**WBS Allowance Basis:**

An allowance of 10% is applied to provide for varying requirements during decommissioning.

Start Year: 126      Finish Year: 135      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$2,450,000	\$33,809,875	\$36,259,875	10%	\$39,885,863

WBS Specific Supporting Documentation:

560.60 NWMO Cost Breakdown for Database-UG decommiss.xls

Revised .60.150 Indirects - Decom.xls

Multi Element Supporting Documentation:

# Work Element Definition Sheet

17-Nov-2010

8:27:52 AM

WEDS ID #

10000

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Organization Name: Golder Associates Ltd.  
Prepared by: RPC Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 560 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.160 DECOMM WASTE DISPOSAL

## WBS Description:

Packaging, transport and disposal of itemized conventional waste, very low level waste (VLLW) and low level waste (LLW) resulting from DGR decommissioning activities.

## WBS Deliverable:

- Containerization 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.

## WBS Assumptions:

Waste disposal costs include 1125 m3 of low level radioactive waste at \$1,400/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 Equipment in various areas assumed to be:
- 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 \$200/tonne (load/transport/dispose) over 10 years, from the following sources.

- Main (protected area) fence - 45 tonnes
- Perimeter security fence - 225 tonnes
- 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 \$100,000/annum in ISO containers, re-handling and temporary storage have been assumed.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 20% has been attached to this activity. Decommissioning and the transport of the resulting waste is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced.

Start Year: 126      Finish Year: 135      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,087,800		\$28,537,260	\$29,625,060	20%	\$35,550,072

WBS Specific Supporting Documentation:

Decomm Waste Arising rev1.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

3-Aug-2010

5:56:07 PM

WEDS ID #

4012

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka                      Reviewed by: Peter Keohane  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 560                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 3.6M)  
WBS Number: 560.60.170                      FINAL CLOSURE

## **WBS 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.

## **WBS Deliverable:**

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.

## **WBS 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, as follows:

- President (part-time), duties to include closure and public affairs (0.5 FTE )
- Technical Director (President part-time) (0.5 FTE )
- Pre closure/closure reports and license applications (2 FTE )
- Resources / Finance /Business Services (1 FTE )
- Secretarial / Clerical (2 FTE )
- QA / Safety Manager (1 FTE )
- Environmental monitoring / coordination / assessment (2 FTE )
- Site general helper / driver / medic (4 FTE )

Other costs include:

- Contracts for ecological restoration -\$3,750,000;
- Contracts for signage and landmarking - \$500,000;
- Contracts for final dismantling, removal, and disposals - \$2,000,000;
- Contracts for security - \$3,000,000;
- Contracts for final sealing of deep boreholes - \$2,500,000;
- Contracts for maintenance - \$1,875,000;
- Other contracts - \$2,000,000;
- Equipment, spares, and consumables - \$780,000;
- Vehicle leases - \$525,000;
- Energy consumption - \$750,000;
- Conventional Insurance - \$300,000;
- Vehicle Insurance - \$63,000; and
- Taxes or community compensation -725,000 per year

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance used for incidentals and consumables.

Start Year: 136      Finish Year: 150      Duration: 15 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$22,270,500		\$21,793,000	\$44,063,500	10%	\$48,469,850

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

# Work Element Definition Sheet

1-Sep-2010

11:21:10 AM

WEDS ID # 7038

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.10.30.10 UDF EQUIPMENT

## WBS 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.

(This element was formerly named "UCF Design" - Underground Characterisation Facility Design. 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 .40.10.30.20.70, "Tunnel and Service Area Excavation")

## WBS Deliverable:

Initial set of specialized UDF equipment as required for UDF research activities (support installations, such as maintenance shops, located in the main and service shaft complex, are included in work element .40.10.30.20.70, "Tunnel and Service Area Excavation")

## WBS Assumptions:

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

Exclusive of contingency.

## WBS Allowance Basis:

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$1,154,000	\$1,154,000	20%	\$1,384,800

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf



# Work Element Definition Sheet

8-Jul-2010

3:43:07 PM

WEDS ID # 5011

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Organization Name: Golder Associates Ltd.

Prepared by: Isaac Ahmed

Reviewed by: Chuck Steed

Modified by:

Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.10.30.20.20 CONCRETE PLANT

---

## WBS Description:

Construction and commissioning of a concrete batch plant.

The batch plant would include 3 binder storage silos to produce a low heat, high performance (LHHP) concrete. The binders include: cement T50, silica fume and silica flour.

The plant would be outfitted with admixture addition capacity to allow reduced water content LHHP concrete mix design.

Five storage domes are included.

## WBS Deliverable:

Concrete batch plant includes:

- 75 tonne Cement T50 & Silica Fume Silos
- 150 tonne Silica Flour Silo
- Binder Hopper
- Cement Batcher
- PD Blowers
- Hoppers (Coarse and Fine)
- Belt Feeder
- Short Hop Conveyor
- Internal Transfer Conveyors
- Aggregate Hopper
- Aggregate Batcher
- Hot Water Tank
- Admixture Tanks
- Long Field Conveyor to SMC Plant
- Ready-Mix Truck
- Trailers for Binder Storage
- Dust Collection System
- Heated Floor Slabs In Storage Domes
- Storage Domes (5)

## WBS Assumptions:

Batch plant to be 25 m<sup>3</sup> per hour capacity; sized on a basis of pouring concrete bulkheads at the placement room entrances. Pricing derived from commercially-available (quoted) BMH dry batch plant (9 m<sup>3</sup> scales; fills standard truck with single batch). 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.

Exclusive of contingency.

**WBS Allowance Basis:**

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

Start Year: 17                      Finish Year: 17                      Duration: 1 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$407,100	\$4,693,940	\$1,588,689	\$6,689,729	20%	\$8,027,675

WBS Specific Supporting Documentation:

BMH quote S-4453 - GOLDER (ONTARIO).pdf  
RE Quotation S-4453 - Dry Batch Plant (Labour).msg  
Re Ready Mix Truck Cost.msg

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx  
09-1117-0032 NWMO Equipment List R6.xlsx

# Work Element Definition Sheet

8-Jul-2010

3:36:29 PM

WEDS ID #

5010

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Organization Name: Golder Associates Ltd.  
Prepared by: Isaac Ahmed                      Reviewed by: Chuck Steed  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.10.30.20.30                      CRUSHING PLANT

## **WBS Description:**

Construction and commissioning of a crushing, screening and washing operation for the production of crystalline rock aggregate. This material will be used as raw material for the concrete batch and sealing materials compaction plants.

The aggregate plant is expected to produce an estimated 69,000 tonne of material per year and may be operated at a nominal capacity of 220 tonne/h. It would consist of a primary, secondary and tertiary crushing and screening circuit as well as a wash plant for producing manufactured concrete sand. The respective raw materials will be conveyed to the concrete batch plant and sealing materials compaction.

At the concrete batch plant the material will be stored in domes, while the material at the sealing materials compaction plant will be housed in silos.

## **WBS Deliverable:**

This includes equipment necessary to process aggregate:

- Vibratory Pan Feeder
- Vibratory Grizzly Feeder
- 50 tonne Dump Hopper
- Two Deck Screens
- Three Deck Wash Screen
- Primary Crusher
- Secondary Crusher
- Tertiary Crusher
- Short Hop Conveyor
- Internal Transfer Conveyor
- Field Conveyor
- Stacking Conveyor
- Crusher Feed Hopper
- 200 tonne Surge Hopper
- Classifying Tank
- Dewatering Screws
- Freshwater and Wastewater Pump
- Belt Magnets

## **WBS Assumptions:**

Sized to suit concrete batch plant and Sealing Materials Compaction 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.

Exclusive of contingency.

**WBS Allowance Basis:**

20% allowance included for miscellaneous charges related to procurement and installation of itemized equipment set.

Start Year: 17                      Finish Year: 17                      Duration: 1 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,260,830	\$7,546,200	\$2,106,162	\$10,913,192	20%	\$13,095,831

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx09-1117-0032 NWMO Equipment List R6.xlsx

# Work Element Definition Sheet

1-Jun-2010

3:42:57 PM

WEDS ID #

6093

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen  
 Modified by: Reviewed by: Peter Keohane  
 Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.10.30.20.40 CAMPSITE AND CAMPSITE OPERATIONS

**WBS Description:**

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

**WBS Deliverable:**

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.

**WBS Assumptions:**

Current project concept includes potential development of a Townsite to support DGR operations, subject to discussions between the NWMO and the community.

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 \$50 per person/per day (includes food, all camp indirects).

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance, due to unknown topography , soils information and source of water and power supply.

Start Year: 16                      Finish Year: 25                      Duration: 10 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$39,748,431	\$67,341,840	\$62,225,000	\$169,315,271	10%	\$186,246,798

WBS Specific Supporting Documentation:

- ATCO CONSTRUCTION CAMP.pdf
- ZCL ULC Petroleum storage tanks.msg
- MILLER PAVING EARTHWORKS.pdf
- CAT TOROMONT GEN SETS.pdf

Multi Element Supporting Documentation:

- WP2-5\_3-5 Cost Estimate October 26 Rev1.xls
- SLI TM5.xls

## Work Element Definition Sheet

1-Sep-2010

9:41:36 AM

WEDS ID #

7032

Organization Name:

Hwozdyk Inc.

Prepared by:

Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS

Number:

561.40.10.30.20.50

SERVICE SHAFT AND HEADFRAME

### WBS Description:

The construction of the shaft collar, erection of permanent headframe, installation of hoisting system, installation of ventilation fans, the sinking of the Service/Production Shaft and the excavation and construction of rock handling systems.

The shaft will serve as an exploration shaft during underground characterization in the UDF and be 6.5 m diameter. Upon completion of sinking the shaft, construct, install and commission a permanent headframe and hoist house for the shaft.

The work excludes installation of permanent ventilation fans at this facility, both of which is installed on surface.

Fan installation is covered by work element .40.60.40.

### WBS Deliverable:

A 6.5 m finished internal diameter, concrete-lined exploration shaft, complete with associated infrastructure.

### WBS Assumptions:

The collar is 30 m in depth.

Shaft sinking will utilize the permanent headframe, and the permanent double-drum hoist to be used for later skipping. There will be a tower-mounted Koepe hoist for the 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 550 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.

### WBS Allowance Basis:

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 16

Finish Year: 17

Duration: 2 year(s)

WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$92,737,744	\$92,737,744	20%	\$111,285,292

WBS Specific Supporting Documentation:

9036-01-ES01rA\_LRH.xls

All Shafts 9036-01 Hoisting Summary Rev 2.pdf

Service Shaft 9036-01-10-1000-SK1 10-1000 SK1 (1).pdf

Service Shaft 9036-01-ES01rA\_LRH.xls

Service Shaft Surface Fan Assemblage Design.pdf

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

1-Sep-2010

11:29:39 AM

WEDS ID # 7039

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.10.30.20.70                      TUNNEL AND SERVICE AREA EXCAVATION

**WBS Description:**

Excavation of the tunnels between the main and service shaft, tunnels interconnecting the services facilities, excavations for the UDF, excavations for support services and outfitting of support facilities.

**WBS Deliverable:**

Provision of tunnels and service areas, including:

- Trackless Maintenance Shop
- Locomotive and Rail Car Shop and Charging Station
- UDF Permanent Refuge Station
- UDF Office
- Main Detonator and Explosives Magazines
- Fuel Station
- UDF Latrine
- Main Dewatering Sump
- Main Storage Area
- Rockbreaker & Grizzly
- Bridge Cranes (5 & 15 tonne)
- Battery Chargers
- 7t Battery Racks
- 4t Battery Racks
- 3 Tonne Jib Crane
- Clear Water Pumps

Initial underground geosphere characterization assessment work. UFC placement equipment test area for design data gathering and design verification.

**WBS 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.

Exclusive of contingency.

**WBS Allowance Basis:**

20% allowance encompasses non-itemized equipment, including as-yet-to-be specified laboratory components of UDF.

Start Year: 18                      Finish Year: 21                      Duration: 4 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$78,904,981	\$78,904,981	20%	\$94,685,977

WBS Specific Supporting Documentation:

Infrastrurcture cost details.xls



TrackSwitchInstall.xls

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

31-May-2010

2:45:27 PM

WEDS ID #

6069

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.20      SITE IMPROVEMENTS

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## WBS Description:

Site preparation for surface facilities.

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## WBS Deliverable:

Preparation of the site, including:

- Site civil preparation (clearing, blasting, grading, initial landscaping)
- Allotment for permits
- Main (25 km) 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 (approx. 4.8 km)
- Road for vent shaft complex (approx. 5 km)
- Parking Lots (Paved, for up to 200 cars, 5 buses, 15 trucks: 120 m x 50 m/6000 m2)
- Two large bus shelters (30 person shelters: 15 m2 ea.)
- Six standard small bus shelters (6 m2)
- Truck weigh scale, scale house, and traffic lights.
- Helipad - 30 m dia., include drainage and lighting
- Rail line – up to 1.2 km from sealing materials compaction plant to the service shaft, including switchgear
- Off-site waste rock disposal area, including fencing, gate, access road and relief pond
- Outer perimeter fence, including 2 vehicle gates, 4 person gates, signage and lighting
- Protected area double fence (3 m high, 4 m offset, barbed wire), including signage, lighting and motion sensors.

## WBS Assumptions:

Site is a flat green area situated in the Canadian Shield, within 25 km of an existing highway. Access road will be 10 m wide and 25 km in length. Rail access to the site is not required.

Land acquisition is accounted for in other work elements as part of the siting process.

Surface preparation is calculated for surface facilities footprint only (0.5 km<sup>2</sup>). \$175,000 allotted for provincial/federal permits.

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

Exclusive of contingency.

## WBS Allowance Basis:

Layout of site facilities, preparation and provision of infrastructure are standard Civil Engineering works were benchmarking against similar works is possible. On this basis an allowance of 10% has been applied.

---

Start Year: 16      Finish Year: 24      Duration: 9 year(s)      WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$40,499,492	\$59,032,870	\$175,000	\$99,707,362	10%	\$109,678,098

WBS Specific Supporting Documentation:

Canadian Scale.msg

MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

RE TERRAFIX GEO HDPE.msg

SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

9:56:13 AM

WEDS ID #

6074

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.30      CONSTRUCTION PHASE INDIRECTS (INC FIRE & SECURITY)

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

Construction is on an EPC Basis - All conventional construction phase indirects are included in pricing for individual work elements. 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.

**WBS Allowance Basis:**

30 % allowance accounts for probable incidentals and miscellaneous charges given the conceptual state of design.

Start Year: 16      Finish Year: 25      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$14,512,200			\$14,512,200	30%	\$18,865,860

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

23-Sep-2010

10:42:07 AM

WEDS ID #

9021

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.10 UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION

## WBS Description:

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Project management, design, construction and commissioning management of the Used Fuel Processing Plant (UFPP), a multi-level structural steel framed building mounted on a reinforced concrete slab. The building will be a nuclear-grade, seismically qualified impact-resistant structure, containing radiation shielding cells (hot cells). All facilities within the building that are used to process nuclear materials will be clad with stainless steel, while other areas that may potentially become contaminated will be provided with high-quality surface finishes (for ease of decontamination and housekeeping). The building exterior will be constructed using blockwork and aluminum clad walls.

## WBS Deliverable:

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The provision of all resources required to supply a fully fitted and operable UFPP facility. These will include:

- Project management, design and engineering for all areas (i.e., building & civil, mechanical, construction engineering/inspection and process)
- The construction of the building together with all permanent fixtures
- The construction of the ventilation discharge stack
- The management of the building and its services commissioning

## WBS Assumptions:

---

The CTECH (2003) scope and cost model was reviewed and updated by SKB International and forms the basis for updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

The building design / contract / commissioning model and delivery scope were not changed from the CTECH assumed cost basis.

The building project management, design, construction and commissioning management will be let on a turnkey contract basis. The building design will comply with functional specifications provided by Architect Engineers included within the Program Management work element.

Although the building dimensions have changed from CTECH (2003), the volume reduction of the building (<4%) is assumed to be negligible and has no impact on the previous cost estimate.

Activity duration is 5 years (Y20-Y24), including a 4 year design and construction phase with an eighteen month year inactive / active commissioning period. This schedule will allow one year to accommodate a possible overrun.

Exclusive of contingency.

## WBS Allowance Basis:

---

Generally, the UFPP building is a conventional nuclear materials handling facility, albeit housing certain processes that require significant development. However, as these areas are small compared to the overall facility, any uncertainties in these areas should not have a significant effect on the total cost of the building. In addition, although the building layout is only at the conceptual stage all major process areas have been established. Therefore, should the building dimensions alter as a result of further design input these changes should be small and consequently have an equally small effect on the projected cost of the facility. On this basis an allowance of 25% has been placed on the design and construction of the UFPP.

Start Year: 20                      Finish Year: 24                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$37,800,000	\$63,490,000	\$101,290,000	25%	\$126,612,500

WBS Specific Supporting Documentation:  
APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.10.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

23-Sep-2010

12:57:15 PM

WEDS ID #

9023

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

---

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.20 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (RECEIVE & TRANSFER)

---

## WBS Description:

Detailed design, supply, installation and testing of all process equipment together with its local control and instrumentation (C&I) for the receipt and transfer area of the Used Fuel Processing Plant (UFPP), including the Irradiated Fuel Transport Cask (IFTC) receipt and unpackaging area.

## WBS Deliverable:

Equipment will comprise all the process equipment, together with its local C&I, in the following areas of the UFPP:

- Irradiated Fuel Transport Cask (IFTC) receiving and shipping area.
- Module handling cell.
- Module storage pool.
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International to form the basis of updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010. Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis (i.e., un-escalated), updated plant costs have increased by ~\$20 M compared to the 2003 CTECH cost model .

Contracts for major items of process equipment, together with their local C&I, will be let on a turnkey basis. Contractors, provided with functional specifications, will provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included. Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied, accommodating the aggregate distribution of off-the-shelf vs. new technology items.

---

Start Year: 20 Finish Year: 22 Duration: 3 year(s) WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$46,940,001	\$21,100,000	\$68,040,001	25%	\$85,050,001

WBS Specific Supporting Documentation:

APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.20.xlsx

Multi Element Supporting Documentation:



# Work Element Definition Sheet

23-Sep-2010

1:02:59 PM

WEDS ID #

9024

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.30 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (PACKAGE)

## WBS Description:

Detail design, supply, installation and testing of all process equipment, together with local control and instrumentation (C&I), for packaging used fuel in the Used Fuel Packaging Plant (UFPP).

## WBS Deliverable:

The process equipment together with local C&I for packaging used fuel in the following work areas in the UFPP:

- Empty UFC receiving area
- Empty UFC storage area (external non-zoned area)
- Used fuel handling cell
- UFC inerting cell.
- UFC welding cell
- UFC non-destructive testing (NDT) cell
- UFC machining and lid cutting cell.
- UFC transfer area (i.e., empty and filled UFC transfer)
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International to form the basis of updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010. Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis (i.e., un-escalated), updated plant costs have increased by ~\$20 M compared to the 2003 CTECH cost model .

Contracts for major items of process equipment, together with their local C&I, will be let on a turnkey basis. Contractors, provided with functional specifications, will provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included.

Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied, accommodating the aggregate distribution of off-the-shelf vs. new technology items.

Start Year: 20                      Finish Year: 22                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$75,320,001	\$35,320,000	\$110,640,001	25%	\$138,300,001

WBS Specific Supporting Documentation:  
APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.30.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

23-Sep-2010

1:08:13 PM

WEDS ID #

9025

---

Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

---

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.40 UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (DISPATCH)

## WBS Description:

Detailed design, supply, installation and testing of all process equipment, together with local control and instrumentation (C&I), for dispatching used-fuel containers in the Used Fuel Processing Plant (UFPP).

## WBS Deliverable:

The process equipment together with local C&I for dispatching used fuel containers in the UFPP, including:

- UFC monitoring and storage cell.
- UFC dispatch area.
- Mechanical workshop
- Waste management
- Electrical and ventilation facility for the above work areas.

## WBS Assumptions:

The CTECH (2003) scope and cost model was reviewed and updated by SKB International and forms the basis of the updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis, plant costs have decreased by ~\$20 M un-escalated against the CTECH (2003) cost model

Contracts for major items of process equipment together with their local C&I will be let on a turnkey basis. Contractors, provided with functional specifications, to provide design, manufacture, test and installation of the equipment.

Costs include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

Costs associated with the integration of individual items in terms of control systems and testing are also included. Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Cable reeling rooms and crane maintenance areas together with man access shield doors will be required; these are incorporated by means of a 5% charge on cell building costs.

Exclusive of contingency.

## WBS Allowance Basis:

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied.

---

Start Year: 20 Finish Year: 22 Duration: 3 year(s) WBS Type: Step Fixed

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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$84,680,001	\$28,880,000	\$113,560,001	25%	\$141,950,001

WBS Specific Supporting Documentation:

APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.40.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

23-Sep-2010

2:00:05 PM

WEDS ID #

9026

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.50 BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)

## WBS Description:

The detailed design, supply, installation and testing of all Used Fuel Processing Plant (UFPP) building services.

## WBS Deliverable:

All building services plant, equipment and systems, together with their local control and instrumentation, required to operate the UFPP. Services covered by this activity include:

- Mechanical Services, that comprise: heating and ventilation system; compressed air supply; steam supplies; vacuum system; domestic water supply; cold water; environmental monitoring system (EMS) pipework; inert gas delivery system; breathing air supply; drains (Low and High Active, and Plant Washings).
- Electrical, Control and Instrumentation, that comprise: three-phase power supply networks (normal, guaranteed interruptible, local guaranteed non-interruptible); lighting and small power supply; emergency lighting; security systems; criticality incident detection system (CIDAS); fire detection and alarm system; area monitoring systems (EMS, gamma, oxygen depletion); drain leak detection; lightening protection system; personnel monitoring; personnel announcement system.

## WBS Assumptions:

The CTECH (2003) supply scope and cost model was reviewed and updated by SKB International forms the basis of the updated costs. A 1.28 multiplier was used to bring 2002 costs forward to 2010.

Costs are distributed uniformly on an annualized basis for the duration of work (Y20 to Y22).

On a 2002 cost basis, plant costs have increased by ~\$11 M (un-escalated) vs. CTECH (2003).

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

Detail design of equipment and / or systems will be based on functional specifications provided by Architect Engineers included within Program Management.

Costs will include works testing of all equipment prior to delivery to the DGR. The necessary control equipment will be included with each item of equipment.

The integration of individual items of equipment and / or systems with the main control system, and their testing, is also included.

Final testing/commissioning of equipment are costed separately (in .40.40.10.60, Commissioning).

Procurement cost for turnkey services are included separately in program management costs (.90, Program Management).

Exclusive of contingency.

**WBS Allowance Basis:**

In general, equipment within the UFPP is based on conventional engineering practices. However, the equipment is currently only specified in outline form and will require varying degrees of development. Although certain items of equipment are complex and will require significant development an overall allowance of 25% has been applied.

Start Year: 20                      Finish Year: 23                      Duration: 4 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$23,670,000	\$16,600,000	\$40,270,000	25%	\$50,337,500

WBS Specific Supporting Documentation:

APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.50.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

23-Sep-2010

2:12:31 PM

WEDS ID #

9027

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.40.10.60 COMMISSIONING (UFPP)

## WBS Description:

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Commissioning of Used Fuel Packaging Plant (UFPP) building systems and services, in addition to the non-active and active functionality of all plant and equipment contained within the facility.

## WBS Deliverable:

- 
- Completed commissioning schedules signed and approved, covering all systems and services and items of plant and equipment, necessary to demonstrate their operability and safety function both under non-active and active operations.
  - Commissioned systems
  - Final UFPP Commissioning Report

## WBS Assumptions:

---

Costs are distributed uniformly on an annualized basis for duration of the work (Y23 to Y25).

Cost update is based on scope adjustments to the 2003 CTECH cost estimate, with escalation to \$2010.

All work carried out under this activity will be carried out by an Engineering Commissioning contractor. The activity will include all direct labour and resources required to complete the deliverables.

The UFPP commissioning estimate has been based on historical reference ratios identified by benchmarking costs from similar plants and functions. These ratios are based on commissioning costs taken as a percentage of the project design, build and installation costs. On this basis the ratios used for this activity are between 5 and 15% of the total UFPP design, build and installation costs.

The commissioning schedule is based on 18 months to commission the complete UFPP facility and assumes completed build scope can be commissioned during the UFPP construction either at site or at OEM's site, with minimal commissioning required for those items commissioned at OEM.

Commissioning management costs are excluded from this activity and are covered elsewhere in the conceptual cost estimate.

Exclusive of contingency.

## WBS Allowance Basis:

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Commissioning plant and equipment, and in particular remotely operated plant and equipment for nuclear materials, is a labour intensive activity liable to overrun. Traditionally the main causes are unforeseen issues revealed during commissioning, as well as complications that may have been previously identified but were not addressed at the time. For this reason an allowance of 50% has been applied to this activity.

---

Start Year: 23      Finish Year: 25      Duration: 3 year(s)      WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$2,560,000	\$48,020,000	\$50,580,000	50%	\$75,870,000

WBS Specific Supporting Documentation:

APM Master Estimate 561 D1 Rev. 10 (SKB) 40.40.10.60.xlsx

Multi Element Supporting Documentation:



# Work Element Definition Sheet

8-Jul-2010

4:36:00 PM

WEDS ID #

5012

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Organization Name: Golder Associates Ltd.  
Prepared by: Isaac Ahmed                      Reviewed by: Chuck Steed  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS  
Number: 561.40.40.20                      SEALING MATERIALS COMPACTION PLANT (SMCP)

## WBS 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.

## WBS Deliverable:

The design and construction of a multi-story structural steel-framed 80m x 60m x 20m 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
- Conveyors
- 150 tonne clay materials silo
- 150 tonne modified granular A silo
- 50 tonne fine sand silo
- Weigh hoppers
- Dust collector
- Mixers
- Vacuum pump
- Bentonite press
- Hydraulic power pack for bentonite press
- Dense Backfill (DBF) Press
- Hydraulic Power Pack for DBF Press
- Vacuum Lifting Device
- Locomotive
- Rail Cars

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.

## WBS 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 costs developed with press vendor (SMS MEER); vacuum lift costs developed with vacuum lifter vendor (Bradley Lifting); mixer costs developed with mixing vendor (Eirich).

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

Exclusive of contingency.

**WBS Allowance Basis:**

Conceptual cost estimate, major item such as DBF presses are not off-the-shelf items and can not be fully specified at this time. A 30% allowance has been assigned to compensate for incomplete design.

Start Year: 23      Finish Year: 25      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$4,050,940	\$250,557,000	\$60,839,243	\$315,447,183	30%	\$410,081,337

WBS Specific Supporting Documentation:

041022080\_DEV22\_DW29-4 Clay and Aggregate mixes.doc1371-7\_D-Type.pdfEM-002-2M\_D-Type.pdfAW Closed Die Forging Presses Power Packs 4.msgVacuum Ring And Disc Lifter Our Quote BQ-026910.msg

Multi Element Supporting Documentation:

NWMO Crystalline - WBS Info 18Oct2010.xlsx  
09-1117-0032 NWMO Equipment List R6.xlsx

## Work Element Definition Sheet

31-May-2010

3:03:57 PM

WEDS ID #

6070

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.10      TOWNSITE

**WBS Description:**

Development of a townsite to service the DGR.

**WBS Deliverable:**

Construction and commissioning of a townsite may be the subject of discussions between the NWMO and the community. Any future requirements would be drawn from contingency.

**WBS Assumptions:**

N/A

**WBS Allowance Basis:**

N/A

Start Year: 22      Finish Year: 25      Duration: 4 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
			\$0		\$0

WBS Specific Supporting Documentation:

TRANSFORMERS.msg  
 MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

9:51:58 AM

WEDS ID #

6057

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.50.20 ADMIN BLDG

## **WBS 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.

## **WBS Deliverable:**

Fully equipped, 2-storey administration building (2,200 m<sup>2</sup> foot print providing a total gross floor area of 4,400 m<sup>2</sup>).

## **WBS 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.

## **WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$7,632,240	\$20,190,060	\$27,822,300	10%	\$30,604,530

## WBS Specific Supporting Documentation:

## Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

10:19:31 AM

WEDS ID #

6058

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.30      AUXILIARY OFFICE BUILDING

**WBS 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.

**WBS Deliverable:**

Two-storey Auxiliary Building without basement with 1,040 m<sup>2</sup> foot print & total floor area of 2,080 m<sup>2</sup>.  
 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.

**WBS Assumptions:**

Building size based on assumed occupancy of 80 permanent DGR personnel, and 25 campaign mining personnel on an intermittent basis.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$521,560	\$25,270,251		\$25,791,811	10%	\$28,370,992

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

12:03:36 PM

WEDS ID #

6062

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.40      QC OFFICES & LABS

**WBS Description:**

Construction and commissioning of Quality Control Offices and Laboratory building.

**WBS Deliverable:**

Single-storey building with no basement, 825 m<sup>2</sup> 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.

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 22      Finish Year: 22      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$310,119	\$4,738,489		\$5,048,608	10%	\$5,553,469

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

12:10:27 PM

WEDS ID #

6063

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.50      GARAGE BUILDING / WAREHOUSE

**WBS 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.

**WBS Deliverable:**

Equipped single storey building, no basement, 1,920 m<sup>2</sup> total gross floor area.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,482,596	\$15,658,343		\$17,140,940	10%	\$18,855,033

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

1:07:37 PM

WEDS ID #

6064

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.60      WALKWAYS/SERVICeways

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

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

- 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,532,685	\$1,027,524		\$2,560,209	10%	\$2,816,230

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls



# Work Element Definition Sheet

31-May-2010

2:01:43 PM

WEDS ID #

6067

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.70      FUEL TANK AREA

**WBS 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.

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 24      Finish Year: 24      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$430,610	\$531,410		\$962,020	10%	\$1,058,222

WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

2:19:06 PM

WEDS ID #

6068

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.80      SECURITY CHECKPOINTS

**WBS Description:**

Construction and commissioning of security buildings and access control points.

[This work element was previously 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]

**WBS Deliverable:**

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 5 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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for items not itemized in estimate.

Start Year: 24      Finish Year: 24      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,065,127	\$6,970,666		\$8,035,793	10%	\$8,839,372

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

12-Aug-2010

1:56:26 PM

WEDS ID # 6100

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.50.90      EMERGENCY POWER GENERATION

**WBS Description:**

---

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

**WBS Deliverable:**

---

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 1.5 MW diesel generators.  
Electrical tie-ins to main camp facilities.

**WBS Assumptions:**

---

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

**WBS Allowance Basis:**

---

Use 10% allowance for items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,711,985	\$12,278,576		\$15,990,561	10%	\$17,589,617

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

10:32:29 AM

WEDS ID #

6059

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.100      PUMPHOUSE & INTAKE

**WBS Description:**

Construction and commissioning of a water intake of 200 m<sup>3</sup>/day capacity, pump house and pipeline Including an intake structure with screen

**WBS Deliverable:**

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:

- Pumphouse 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).

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,895,106	\$6,514,322		\$10,409,428	10%	\$11,450,371

WBS Specific Supporting Documentation:

MILLER PAVING EARTHWORKS.pdf

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

10:49:41 AM

WEDS ID #

6060

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.110      WATER STORAGE TANK AREA

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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 350 m3/hour plus 24 hours of raw water demand.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$146,249	\$739,059		\$885,308	10%	\$973,839

WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

11:55:14 AM

WEDS ID #

6061

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.120      WATER TREATMENT PLANT

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$59,000	\$2,869,886		\$2,928,886	10%	\$3,221,775

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

31-May-2010

3:37:37 PM

WEDS ID #

6072

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.130      PROCESS WATER SETTLING POND

**WBS Description:**

Construct and commission a Process Water Settling Pond to hold 24 000 m3 of water. Pond is located at Rock Crushing Plant with water recycled for use in cleaning raw stone and in production of sand.  
 Pond size = 60m x 130 m x 3 m depth with a freeboard of 0.4 m.

**WBS Deliverable:**

Pond for settling of process water.

**WBS Assumptions:**

Pond to be excavated in soil; no blasting required. Pond to be 24 000 m<sup>3</sup>. Includes geomembrane.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$943,785	\$580,923		\$1,524,708	10%	\$1,677,179

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

9:32:27 AM

WEDS ID #

6073

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.140      SERVICE SHAFT WATER SETTLING POND

**WBS 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 0.4 m  
 Pond volume = 5 500 m<sup>3</sup>  
 Pumps and piping included  
 Piping from Service Shaft to the pond and from the pond to Service Shaft.

**WBS Deliverable:**

Water settling pond for water discharged from Service Shaft.

**WBS Assumptions:**

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

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 17      Finish Year: 17      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$232,101	\$151,444		\$383,545	10%	\$421,899

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls



## Work Element Definition Sheet

31-May-2010

1:43:48 PM

WEDS ID #

6066

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.150      STORM RUN-OFF POND

**WBS Description:**

Construction and commissioning of three equal size stormwater run-off detention ponds to collect surface water runoff from across the DGR site. Ponds nominally designed for a 100-year storm event. For conceptual design, total volume of approximately 23,000 m3 assumed.

**WBS Deliverable:**

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

**WBS Assumptions:**

Ponds to be designed for 23 000 m<sup>3</sup> total stormwater flow over the site. Three ponds to be constructed in soils with no rock excavation. Pricing includes bedding and geomembrane.

Exclusive of contingency.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$947,469	\$599,166		\$1,546,635	10%	\$1,701,299

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 RE TERRAFIX GEO HDPE.msg  
 SLI TM5.xls

# Work Element Definition Sheet

31-May-2010

1:19:32 PM

WEDS ID #

6065

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.160      SEWAGE TREATMENT PLANT

**WBS Description:**

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

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$211,244	\$3,431,485		\$3,642,728	10%	\$4,007,001

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

5:52:29 PM

WEDS ID #

3004

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Organization Name: SNC-Lavalin  
Prepared by: Derek Elion  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.50.170 LOW LEVEL LIQUID WASTE STORAGE BUILDING

## WBS Description:

Detail design, construction, equipping and commissioning of a single storey low level liquid waste storage building with a total floor area of 500 m<sup>2</sup>.

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.

## WBS Deliverable:

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.

## WBS 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.

## WBS Allowance Basis:

Because of the conventional nature of the design and construction activities involved in this work element, and the relatively clear specification of deliverables, a 10% level of allowance has been applied.

---

Start Year: 24      Finish Year: 25      Duration: 2 year(s)      WBS Type: Step Fixed

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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,285,698	\$1,784,475	\$3,070,173	10%	\$3,377,190

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

# Work Element Definition Sheet

1-Jun-2010

6:12:04 PM

WEDS ID #

3009

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Organization Name: SNC-Lavalin  
Prepared by: Derek Elion  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.50.180 ACTIVE LIQUID WASTE TREATMENT (ALWT) SYSTEM

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## WBS 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 m<sup>2</sup>. It will not have a basement. The process within the building include evaporation system and associated tanks.

## WBS Deliverable:

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.

## WBS 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 m<sup>3</sup> of liquid effluent per annum. It is based on using 1 m<sup>3</sup> 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.

## WBS Allowance Basis:

The building and equipment that comprise the Active Liquid Waste Treatment Building will be a conventional nuclear/chemical plant. Although the plant requirements are well defined, its capacity is only indicative at this stage of the DGR design. Therefore, the major portion of the 10% allowance attached to this activity, results from the uncertainty in capital expenditure relating to the extent of equipment required.

---

Start Year: 24      Finish Year: 25      Duration: 2 year(s)      WBS Type: Step Fixed

---

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$880,000	\$2,064,893	\$2,944,893	10%	\$3,239,382

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

Bag Filter RF-080205-01.pdf

ENCON-SNC-041810R-MVC600.pdf

ENCON Drum Evaporator-Dryer 2010.pdf

ENCON-SNC-111810R-DE.pdf

ENCON-SNC-121810R-Thermal.pdf

NPxxVx-48 Specifications 2009 Rev 2.pdf

# Work Element Definition Sheet

1-Jun-2010

10:03:01 AM

WEDS ID #

6075

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.50.190      WASTE MANAGEMENT AREA

## **WBS Description:**

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Detail design, construct and commissioning of a Waste Management Area.

This area conceptualized as an approximate 10,000m<sup>2</sup> graveled yard with 2,500m<sup>2</sup> 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.

## **WBS Deliverable:**

---

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.

## **WBS 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 constructed using conventional methods.

Costs include:

- 10,000 m<sup>2</sup> graveled yard with 2500 m<sup>2</sup> concrete pads
- A 1200 m<sup>2</sup>, 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 .40.50.220.

Exclusive of contingency.

## **WBS Allowance Basis:**

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Because of the conventional nature of the design and construction activities involved in this work element, and the relatively clear specification of deliverables, a 10% level of allowance has been applied.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,057,162	\$7,861,887		\$8,919,049	10%	\$9,810,954

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls



# Work Element Definition Sheet

18-Jun-2010

5:07:11 PM

WEDS ID #

3020

Organization Name: SNC-Lavalin

Prepared by: Derek Elion

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.50.220 LOW LEVEL WASTE STORAGE BUILDING

### **WBS Description:**

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

Covering an area 1,000 m<sup>2</sup>, 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.

### **WBS Deliverable:**

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.

### **WBS 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.

### **WBS Allowance Basis:**

As the LLW storage facility will be constructed using conventional building methods, a 10% allowance level is appropriate for this cost estimate.

Start Year: 24                      Finish Year: 25                      Duration: 2 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,036,695	\$3,568,950	\$4,605,645	10%	\$5,066,210

### WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

WP2-9\_3-9 Cost Estimate\_October 26.xls

## Work Element Definition Sheet

1-Jun-2010

10:46:09 AM

WEDS ID #

6079

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.230      ELECTRICAL SWITCHYARD

**WBS 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.

**WBS Deliverable:**

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

**WBS Assumptions:**

2000 m<sup>2</sup> switchyard including 800 m<sup>2</sup> of concrete pads . Estimated cost includes site preparation, fencing and yard foundations.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 15% as electrical requirement is reasonably well-defined.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$830,956	\$674,946		\$1,505,902	15%	\$1,731,787

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

10:53:24 AM

WEDS ID # 6080

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.50.240

TRANSFORMER AREAS

**WBS Description:**

Construct and commission transformer area.

**WBS Deliverable:**

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

**WBS Assumptions:**

Estimated on the basis of 120 m<sup>2</sup> (10 m by 12 m) area with two 20 MW transformers.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 15% as electrical requirement is reasonably well-defined.

Start Year: 16                                  Finish Year: 16                                  Duration: 1 year(s)                                  WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$162,396	\$3,841,409		\$4,003,805	15%	\$4,604,376

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

3:11:21 PM

WEDS ID #

6090

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.50.250      VISITORS CENTRE

**WBS 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.

**WBS Deliverable:**

Fully equipped single storey visitors' centre (1,100 m<sup>2</sup> foot print).

**WBS 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.

**WBS Allowance Basis:**

Use 10% allowance for minor items not itemized in estimate.

Start Year: 16      Finish Year: 16      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$570,825	\$6,801,399		\$7,372,224	10%	\$8,109,446

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Sep-2010

9:53:49 AM

WEDS ID #

7033

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.60.20 MAIN SHAFT AND HEADFRAME

**WBS Description:**

Construction and commissioning of a shaft and associated infrastructure to convey used nuclear fuel 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 7.5 m (finished internal) diameter, concrete lined shaft, change-over from sinking to handling of used fuel in UFCs Waste Shaft hoist installation

[This element previously referred to as WASTE SHAFT(S) AND UFC HEADFRAME/HOIST]

**WBS Deliverable:**

A functional 500 m deep shaft of 7.5 m finished internal diameter complete with required services and accessories for transfer of used fuel in UFCs.

**WBS 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 525 m to allow for the overwind/underwind required for safety concerns.

Exclusive of contingency.

**WBS Allowance Basis:**

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 16                      Finish Year: 17                      Duration: 2 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$59,789,437	\$59,789,437	20%	\$71,747,324

WBS Specific Supporting Documentation:

- All Shafts 9036-01 Hoisting Summary Rev 2.pdf
- Main Shaft 9036-01-ES02rA\_LRH.xls
- Main UFC Shaft Surface Fan Assemblage Design.pdf
- Waste Shaft 9036-01-10-1100-SK1 9035-01-10-1100 (1).pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

1-Sep-2010

10:15:05 AM

WEDS ID #

7034

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk      Reviewed by:  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.60.30      VENTILATION SHAFT AND HEADFRAME

**WBS Description:**

Construction and commissioning of two ventilation shafts (exhaust shafts) to provide the DGR's main ventilation exhaust capacity.

The first shaft, installed during the construction phase, accomodates the initial set of placement panels. The second shaft, installed as the second "wing" of the repository is initiated approximately mid-way through the operational phase, accomodates the second set of placement panels.

Construction of each shaft comprises:

- Erecting a temporary headframe for sinking.
- Setting up temporary sinking hoists.
- Sinking a 6.5 m internal diameter, concrete lined shaft
- Installing associated equipment.

**WBS Deliverable:**

Two functional 500 m deep x 6.5 m finished internal diameter shafts complete with required services and accessories.

**WBS Assumptions:**

- The temporary headframe is 30 m in height.
- The collar is 35 m in depth.
- The shaft is nominally 500 m in length.

Exclusive of contingency.

**WBS Allowance Basis:**

Estimate contains an allowance of 20% based on incidentals and variances related to blind shaft sinking in (potentially) northern conditions.

Start Year: 18      Finish Year: 19      Duration: 2 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$81,753,602	\$81,753,602	20%	\$98,104,323

WBS Specific Supporting Documentation:

- 9036-01-ES03rA\_LRH.xls
- All Shafts 9036-01 Hoisting Summary Rev 2.pdf
- Vent Shaft 9036-01-10-1200-SK1 9036-01-10-1200\_SK1 (1).pdf
- Vent Shaft 9036-01-ES03rA\_LRH.xls
- Vent Shaft - Exhaust Ventilation Raise Surface Fan Assemblage Design.pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

1-Sep-2010

10:29:25 AM

WEDS ID #

7035

---

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

---

WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.60.40                      VENTILATION SYSTEM

---

## WBS Description:

Design, procure, install and commission :

- (1) main underground ventilation system, including fans for the main, service and vent shaft, as well as mine air heating
- (2) temporary auxiliary ventilation system(s) for the emplacement rooms

## WBS Deliverable:

Main Fans:

Service Shaft: 60 m3/sec throughput, one 60 HP fan on surface, with 60 m3/sec throughput, 60 HP fan underground. In addition; one spare surface fan one spare underground booster fan.

Ventilation Shaft: 340 m3/sec throughput, two 450 HP fans on surface, with 340 m3/sec throughput, two 400 HP booster fans underground. In addition: one spare surface fan, one spare underground booster fan. HEPA filtration capacity for facility exhaust on an as-as needed basis.

Main Shaft: 402 m3/sec throughput fan, two 500 HP exhausting on surface with 402 m3/sec throughput, two 400 HP booster fans underground.

In addition: one spare surface fan, one spare underground booster fan. Mine air heating (natural gas fired) of 32 MW (110Mbtu) capacity.

Auxiliary ventilation and development ventilation systems w/ fans and ducts. HEPA filtration for in-room placement auxiliary ventilation.

## WBS Assumptions:

Cost estimate assumes the following:

- Main Shaft fan package based on 10150 AMF 5000 Arr. #4 Mine Fan
- Service Shaft fan package based on 8400 AMF 3150 Arr. #4 Mine Fan
- Vent shaft fan package based on 10150 AMF 5000 Arr. #4 Mine Fan
- Burner (airflow 851,500 cfm @ 1" w.c; Burner Capacity 110 MMBTUH)
- Inlet bells, screens, discharge cones, ducting
- Manually operated fan brakes with limit switches.
- Spare running sections and fans
- Flow, pressure and vibration monitoring
- Control house, controls
- Allocation for in-room and exhaust complex HEPA filtration
- Prime, paint, install, commission

Repository-level ducting is included in per metre mine development costs and is not assessed in this cost element.

Exclusive of contingency.

**WBS Allowance Basis:**

The components of the emplacement room auxiliary ventilation system are “off the shelf items” utilizing known technologies, as are the main fans and associated system. A 10% allowance is required.

Start Year: 16                      Finish Year: 18                      Duration: 3 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$30,243,389	\$30,243,389	10%	\$33,267,728

WBS Specific Supporting Documentation:

- ACI Turn Key.pdf
- Fan System Quotes.pdf
- Quote PCL.pdf
- Surface Vent Sys Price Schedule (3).xls
- UFC Shaft Surface Fan Assemblage Heater RFP.pdf
- Overall DGR Ventilation Planning.pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf



# Work Element Definition Sheet

1-Sep-2010

12:03:55 PM

WEDS ID #

7041

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk      Reviewed by:  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.60.50      SUPPORT SERVICES AND FACILITIES

### WBS Description:

---

Underground excavation to accommodate ancillary infrastructure items to support the construction of the DGR. These ancillary items comprise the following:

- Sumps
- Electrical Substation
- Storage Area
- Magazines Access Drift
- Explosives Magazine
- Detonators Magazine

These items are not covered in the Tunnel and Service Area Excavation (.40.10.30.20.70).

### WBS Deliverable:

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Excavations to accommodate ancillary infrastructure to support underground construction.

### WBS Assumptions:

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All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model. Facilities constructed in two phases, corresponding to the two "wings" of the alternate case repository.

- Sumps (5 m W X 5 m H) : 2 x 60 metres
- Electrical Substation (6 m W X 4 m H) : 2 x 20 metres
- Storage Area (20 m W x 5 m H) : 2 x 30 metres
- Magazines Access Drift (5 m W X 5 m H) : 2 x 110 metres
- Explosives Magazine (7 m W X 7 m H) : 2 x 20 metres
- Detonator Magazine (5 m W X 4 m H) : 2 x 10 metres

Exclusive of contingency.

### WBS Allowance Basis:

---

Assigned allowance of 20%, as the requirements for these facilities are not fully defined. Allowance captures details of finish and equipment not captured in estimate line items.

Start Year: 17      Finish Year: 51      Duration: 35 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$5,328,662	\$5,328,662	20%	\$6,394,395

### WBS Specific Supporting Documentation:

waste rock reference table.xlsx

### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

1-Sep-2010

12:38:08 PM

WEDS ID #

7042

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.60.60 PERIMETER AND ACCESS DRIFTS/CROSS CUTS

**WBS Description:**

Excavation of the central, perimeter and panel access drifts comprising the DGR's "skeleton" of ventilation and panel access ways. The mining of these drifts will be by full face drill and blast technique employing control perimeter blasting to minimize creation of an excavation damage zone (EDZ). Central access drifts will be of 7.0 m width by 5.0 m height. Panel access drifts and perimeter drifts will be of 5.0 m width by 5.0 m height.

**WBS Deliverable:**

Approximately 26,466 m of tunnels comprising the "skeleton" of the DGR and access to the exhaust shafts.

**WBS Assumptions:**

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model. Facilities constructed in two phases, corresponding to the two "wings" of the alternate case repository.

- Perimeter Drift 1 (5 m W X 5 m H) : 2 x 2304.5 metres
- Perimeter Drift 2 (5 m W X 5 m H) : 2 x 2183.5 metres
- Perimeter X-Cut A (5 m W X 5 m H) : 2 x 845 metres
- Perimeter X-Cut B (7 m W X 5 m H) : 2 x 1690 metres
- Exhaust Ventilation Shaft Station (7 m W X 5 m H) : 2 x 350 metres
- Access Drift 1 (7 m W X 5 m H) : 2 x 2600 metres
- Access Drift 2 (7 m W X 5 m H) : 2 x 2600 metres
- Access 1 & 2 Crosscuts (7 m W X 5 m H) : 2 x 200 metres

Also includes 5400 linear metres of tracks and switches (installed), based on 110 lb (50 kg) rails with ties, concrete, fish plates, tie plates, spikes and frog switches. Pricing includes waste rock delivered and spread at waste rock pile. Per linear metre costs include conduit, etc.

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 17      Finish Year: 49      Duration: 33 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$249,241,884	\$249,241,884	10%	\$274,166,072

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls

## Work Element Definition Sheet

1-Sep-2010

2:50:52 PM

WEDS ID #

7043

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.60.70 INITIAL PLACEMENT ROOMS/BOREHOLES (PANEL A)

**WBS Description:**

Excavate, furnish and prepare the first panel of placement rooms (Panel A – 16 placement rooms). Excavation will proceed from the “east” side of Panel A and retreat westwards towards the central access drifts.

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed. As each room is developed it will be equipped with a ventilation system comprising ventilation duct, exhaust fan and portable HEPA filtration system.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install (includes concrete, track, switches): 6336 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 21      Finish Year: 25      Duration: 5 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$134,089,715	\$134,089,715	10%	\$147,498,687

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

## Work Element Definition Sheet

1-Jun-2010 10:57:49 AM WEDS ID # 6081

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen Reviewed by: Peter Keohane  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.10 FACILITY ELECTRICAL DISTRIBUTION

### WBS Description:

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

### WBS Deliverable:

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

### WBS 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.

### WBS Allowance Basis:

10% allowance - conventional (off-the-shelf) equipment.

Start Year: 20 Finish Year: 20 Duration: 1 year(s) WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$2,929,350	\$7,042,530		\$9,971,880	10%	\$10,969,068

### WBS Specific Supporting Documentation:

TRANSFORMERS.msg

### Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls



# Work Element Definition Sheet

1-Jun-2010 11:05:45 AM WEDS ID # 6082

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen Reviewed by: Peter Keohane  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.20 FACILITY COMMUNICATION SYSTEM(S)

**WBS Description:**

Design, installation and commissioning of DGR communication system on surface.

**WBS Deliverable:**

Communication system to include: Telephone and radio communication systems. Public address system, Clock system, Security system, Fire alarm system.

**WBS Assumptions:**

All process instrumentation and control systems are included:

- Data communication links and inter connections (5,000 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.

**WBS Allowance Basis:**

10% allowance - conventional (off-the-shelf) equipment.

Start Year: 20 Finish Year: 20 Duration: 1 year(s) WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$379,960	\$363,127		\$743,087	10%	\$817,395

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:36:25 AM

WEDS ID #

6086

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.30.10      FIRE WATER

**WBS 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.

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$670,830	\$340,775		\$1,011,605	10%	\$1,112,765

WBS Specific Supporting Documentation:

ZCL ULC Petroleum storage tanks.msg

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:43:39 AM

WEDS ID #

6087

Organization Name:

SNC-Lavalin

Prepared by:

Bernie Hagen

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561

DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.40.70.30.20

POTABLE WATER

## WBS 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.

## WBS Deliverable:

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

## WBS 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.

## WBS Allowance Basis:

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21          Finish Year: 21          Duration: 1 year(s)          WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$295,590	\$139,586		\$435,176	10%	\$478,693

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls



# Work Element Definition Sheet

1-Jun-2010

11:48:55 AM

WEDS ID #

6088

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.30.30      PROCESS WATER

**WBS 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.

**WBS Deliverable:**

Water system to distribute fresh water to surface buildings.

**WBS 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$216,825	\$153,522		\$370,347	10%	\$407,381

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:09:05 AM

WEDS ID #

6083

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.30.40      SEWERAGE

**WBS Description:**

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

**WBS Deliverable:**

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

**WBS 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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21      Finish Year: 21      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$584,100	\$148,423		\$732,523	10%	\$805,775

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

## Work Element Definition Sheet

1-Jun-2010

11:53:43 AM

WEDS ID # 6089

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen          Reviewed by: Peter Keohane  
 Modified by:                                  Last Modification Date: 4-Dec-2010

WBS Case: 561                                  DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.40.70.30.50                  STORMWATER AND DRAINAGE

### **WBS Description:**

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

### **WBS Deliverable:**

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

### **WBS Assumptions:**

No abnormal construction issues/problems. Designed based on nominal 100-year storm event.

Includes:

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

Exclusive of contingency.

### **WBS Allowance Basis:**

An allowance of 10% is used (conventional equipment and techniques)

Start Year: 21                                  Finish Year: 21          Duration: 1 year(s)                                  WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,206,550	\$520,274		\$1,726,824	10%	\$1,899,506

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010      11:16:40 AM      WEDS ID #      6084

Organization Name:      SNC-Lavalin  
 Prepared by:      Bernie Hagen      Reviewed by:      Peter Keohane  
 Modified by:      Last Modification Date:      4-Dec-2010

WBS Case:      561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number:      561.40.70.40.10      BREATHING AIR

**WBS Description:**

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

**WBS Deliverable:**

Breathing compressed air supply and distribution systems to UFPP and other surface facilities. Breathing Air at 0.15 m<sup>3</sup> /s (~300 cfm) surface and underground supplied by 2 compressors each supplying 0.15 m<sup>3</sup> /s (~300 cfm)@ 700 kPa .

**WBS Assumptions:**

Breathing Air requirements to be at 0.15 m<sup>3</sup> /s . Verbal quote received from Atlas Copco Mississauga Ontario. Includes:

- Breathing air supply units (0.15m<sup>3</sup>/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.

**WBS Allowance Basis:**

An allowance of 10% is used (off-the-shelf equipment)

Start Year:      21      Finish Year:      21      Duration: 1 year(s)      WBS Type:      Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$536,900	\$1,812,302		\$2,349,202	10%	\$2,584,122

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Jun-2010

11:26:52 AM

WEDS ID #

6085

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.40.70.40.20 SERVICE AIR

## WBS Description:

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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.

## WBS Deliverable:

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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 m<sup>3</sup> /s (~2,100 cfm) surface and underground supplied by 3 rotary screw type compressors each supplying 0.5 m<sup>3</sup> /s (~1,050 cfm) @ 900 kPa . Concrete block construction with insulation and cladding. Steel frame roof with sprayed insulation.

## WBS Assumptions:

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Service air requirements to be at 1.0 m<sup>3</sup> /s . Verbal quotation for equipment received from Atlas Copco of Mississauga Ontario.

Includes:

- One storey 20 m by 15 m building (300 m<sup>2</sup>, furnished and equipped)
- Service air supply units (0.5m<sup>3</sup>/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.

## WBS Allowance Basis:

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An allowance of 10% is used (off-the-shelf equipment)

Start Year: 21 Finish Year: 21 Duration: 1 year(s) WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$659,325	\$4,783,589		\$5,442,914	10%	\$5,987,206

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

WP2-5\_3-5 Cost Estimate October 26 Rev1.xls

SLI TM5.xls

# Work Element Definition Sheet

2-Dec-2010

2:13:15 PM

WEDS ID #

10001

Organization Name:

Prepared by: RPC

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.10 OPERATIONS PROGRAM MANAGEMENT (INC TAX)

**WBS Description:**

The management and administration of the DGR facility during the Operation Phase is encompassed by other work elements. This element has been reduced to an annual allocation for taxes or payments in lieu of taxes.

For the operations of the President`s Office, engineering, finance, purchasing, safety and facility management, see element .45.20 (Direct Operations Management).

**WBS Deliverable:**

Annual tax, payment in lieu of tax or associated payment.

**WBS Assumptions:**

Annual allocation of \$6M per year for the duration of operations (Y26 to Y85, inclusive)

Exclusive of contingency.

**WBS Allowance Basis:**

No additional allowance assigned.

Start Year: 26      Finish Year: 85      Duration: 60 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$360,000,000	\$360,000,000		\$360,000,000

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

# Work Element Definition Sheet

31-May-2010

3:07:25 PM

WEDS ID #

6071

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.20      DIRECT OPS MANAGEMENT (INC QA)

**WBS Description:**

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

**WBS Deliverable:**

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.

**WBS Assumptions:**

Management numbers determined on the basis of the staffing plan for site (Y26 to Y85, inclusive).

Includes management and engineering as follows:

- One President
- Five Vice Presidents (Engineering, HR/HD, Society & Sustainability, Finance & Legal, Operations)
- Two Directors of Engineering (Aboveground and Underground)
- Six Engineering Managers
- Six Non-Engineering Managers
- 90 Staff

Line staff for procurement, environmental management, security, fire, housekeeping, etc. are included under .45.30 (Operations Indirects). Line staff for maintenance are included under .45.40.40 (O&M of Auxiliary Surface Facilities).

Mine development, UFC placement, UFPP operations, SMCP, crushing plant 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 (UFC Transport and Place).

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.

**WBS Allowance Basis:**

A 10% allowance has been attributed to this activity to account for consumables and incidentals.

Start Year: 26      Finish Year: 85      Duration: 60 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$797,328,000			\$797,328,000	10%	\$877,060,800

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
SLI TM5.xls



# Work Element Definition Sheet

1-Jun-2010

3:46:57 PM

WEDS ID #

6094

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Organization Name: SNC-Lavalin  
Prepared by: Bernie Hagen      Reviewed by: Peter Keohane  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.30      OPERATIONS INDIRECTS (INC FIRE & SECURITY)

## WBS Description:

Indirect labour and equipment required to operate the DGR facility during the Facility Operations phase of the project (Y26 to Y85), excluding 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).

## WBS Deliverable:

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

## WBS Assumptions:

Based on staffing as follows:

- Visitor Centre Staff (5 FTE)
- Visitor Centre Manager (1 FTE)
- Finance Manager (3 FTE)
- Financial Analyst (6 FTE)
- Buyer (6 FTE)
- I/T Support (10 FTE)
- Procurement Manager (2 FTE)
- Environmental Manager (Technicians in .45.20) (2 FTE)
- Rad. Safety and Monitoring (12 FTE)
- Payroll Officer (4 FTE)
- Fire/Security Manager (2 FTE)
- Security Officer/ Fire Supervisor (6 FTE)
- Security Guard (80 FTE)
- Firemen (16 FTE)
- Paramedic/Doctor/Nurse (8 FTE)
- HR Manager (2 FTE)
- Conventional Safety (and Operations) (20 FTE)
- Administration Manager/Office Manager (2 FTE)
- Administration Support (6 FTE)
- Housekeeping, Janitor support (40 FTE)
- Mess hall staff, cook, cleaners, drivers (40 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.

**WBS Allowance Basis:**

A 10% allowance has been attributed to this activity to account for consumables and incidentals.

Start Year: 26                      Finish Year: 85                      Duration: 60 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,435,543,200		\$4,400,000	\$1,439,943,200	10%	\$1,583,937,520

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

23-Sep-2010

2:31:30 PM

WEDS ID #

9028

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Organization Name: NWMO - Nuclear Waste Management Organization  
Prepared by: A. Murchison Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.40.10 UFPP OPERATION

## WBS Description:

Direct labour and materials for the day-to-day operation of the Used-Fuel Packaging Plant.

## WBS Deliverable:

UFPP direct operational manpower for the following areas:

- Receipt and unloading of transport casks
- Transport cask unloading and transfer of bundles
- Surge storage of shipping modules
- Shielded cart transfer tunnel operations
- UFC loading cells
- UFC sealing cell
- UFC welding cell
- UFC weld inspection cell
- UFC Machining cell
- UFC receipt cells
- UFC dispatch cells
- UFC and basket storage
- UFC transfer to waste shaft
- ILW/LLW handling, packaging and transport
- Health physics
- Control room operations
- Maintenance activities

Direct plant and materials i.e. LLW and ILW containers, major and minor spares, consumables. ILW/LLW disposal costs.

## WBS Assumptions:

All costs 2010 dollars

Assume costs distributed uniformly on an annualized basis for duration

UFPP to operate 2 shifts/day; 230 days /year; 60 year operation (normally) Y26-Y85.

Estimate assumes 46 weeks of operation per year, 6 weeks shut down for Operators leave and maintenance periods.

Throughput: 522 bundles per day producing ~ 2 UFCs/day; 333 UFCs/year, 20,000 UFCs total.

Fuel modules are to be decontaminated to LLW standards and packaged within full height ISO containers prior to being returned to the fuel owner.

LLW operational arisings to be packages in 200 litre drums. Arising assumed to be 500 drums per year, including those containing encapsulated liquid waste arisings. Drums to be loaded into full height ISO containers and transported from the DGR to a separate facility.

LLW buffer storage is provided on site to accommodate LLW operations arisings

Operational ILW will be packed in to 500 liter drums and transferred to a separate facility from the DGR when it is generated. Arisings assumed to be 12 drums per year

LLW arisings will be transported from site in re-usable ISO containers. It is assumed that two containers per year are required (@10K per container) together with one trailer per year at \$150k per trailer).

A unit cost has been applied to cover the off-site transport, processing and disposal of both operational LLW and ILW arisings. The unit costs applied are \$1,400 per m3 of LLW and \$24,000 per m3 of ILW. See CTECH (2003) ED039, Annex 1.

Note: Waste arisings costs were not escalated from CTECH (2003) as the 2002 cost included a nominal 30 % contingency. See CTECH (2003) ED039, Annex 1.

Assumed job category for Operator Staff was OPG Cat 5 @ \$79.01 per hour Operational trades support based on EPSCA rates assumed to be \$118 per hour fully burdened, DB07

Exclusive of contingency.

**WBS Allowance Basis:**

Allowance adjusted to 22.5 % to bring UFPP costs in-line with SKB estimate. Slight discrepancy arises due to escalation factors in the SKB I cost update versus updating the labour rates in the CTECH table, which is the basis of the inputs for the cost estimate in the WED.

Start Year: 26                      Finish Year: 85                      Duration: 60 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$365,700,000	\$913,520,000	\$1,279,220,000	23%	\$1,567,044,500

WBS Specific Supporting Documentation:  
APM Master Estimate 561 D1 Rev. 10 (SKB) 45.40.10.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

23-Sep-2010

2:50:34 PM

WEDS ID #

9029

Organization Name: NWMO - Nuclear Waste Management Organization  
 Prepared by: A. Murchison Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.40.20 SUPPLY OF BASKETS AND UFCs

**WBS Description:**

Supply, packaging and delivery of the required number of UFCs and UFC baskets during the operational period.

**WBS Deliverable:**

- Supply of 333 UFCs per year over the 60 year operational period (total 20,000 UFCs).
- Supply of about 1,000 UFC baskets per year over the 60 year operational period (total 60,000 baskets).
- Reusable packaging for UFCs and baskets.
- Transport of UFCs and baskets from assembly plant to DGR facility.

**WBS Assumptions:**

All costs 2010 \$  
 Assume costs distributed uniformly on an annualized basis for duration  
 Duration of work: Y26 to Y85.

- A total cost per UFC of C\$250,000 excluding final delivery has been assumed. This value is the mid-point cost of a container (average of a nodular cast iron insert and roll formed inner vessel) and utilizes a 25 mm copper shell.
- UFCs and baskets will be manufactured and assembled off-site and shipped 1000km to the DGR as a completed item.

Two UFC assemblies to be shipped in one trip with empty packaging returning on return journey. Round trip to cost \$2,743.

UFC assembly transport frames are reusable and assumed to have a design life of 15 years and an average frame cost of \$20 K. It is assumed 400 frames will be required over the life of operation.

Licensing and approvals sought from relevant authorities will be obtained without significant delay to the agreed schedule.

Exclusive of contingency.

**WBS Allowance Basis:**

Defective container costs assumed to come out allowance (15%)

Start Year: 26 Finish Year: 85 Duration: 60 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$5,008,000,020	\$27,500,000	\$5,035,500,020	15%	\$5,790,825,023

WBS Specific Supporting Documentation:

APM Master Estimate 561 D1 Rev. 10 (SKB) 45.40.20.xlsx

Multi Element Supporting Documentation:

# Work Element Definition Sheet

2-Jun-2010

1:31:30 PM

WEDS ID #

6098

Organization Name: SNC-Lavalin  
 Prepared by: Bernie Hagen                      Reviewed by: Peter Keohane  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.40.40                      O&M OF AUXILIARY SURFACE FACILITIES

**WBS Description:**

Operation and maintenance of all surface buildings and associated facilities for the DGR.

**WBS Deliverable:**

Maintenance staff including management, building and civil, mechanical and electrical cover.

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).

**WBS Assumptions:**

Staffing includes 8 maintenance supervisors, 4 administrative staff and 70 maintenance crew. 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 \$9M/annum accounts for asset management and maintenance activities and materials.

Any townsite operations would be funded through revenues raised by property taxes and therefore no costs are included for these activities.

Exclusive of contingency.

**WBS Allowance Basis:**

A 10% allowance has been attributed to this activity to account for consumables and incidentals.

Start Year: 26                      Finish Year: 85                      Duration: 60 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$388,080,000		\$739,100,093	\$1,127,180,093	10%	\$1,239,898,102

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:  
 WP2-5\_3-5 Cost Estimate October 26 Rev1.xls  
 SLI TM5.xls

# Work Element Definition Sheet

1-Sep-2010

4:29:33 PM

WEDS ID #

7045

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.30 ROOM/TUNNEL/BOREHOLE EXCAVATION (SECOND STAGE) PANEL B

**WBS Description:**

Excavate, furnish and prepare the second stage placement rooms (Panel B – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 5940 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 26      Finish Year: 31      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$125,676,083	\$125,676,083	10%	\$138,243,692

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls  
 Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

1-Sep-2010

4:58:10 PM

WEDS ID #

7046

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.50.40 ROOM/TUNNEL/BOREHOLE EXCAVATION (THIRD STAGE) PANEL C

### WBS Description:

Excavate, furnish and prepare the third stage placement rooms (Panel C – 16 placement rooms).

### WBS Deliverable:

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

### WBS Assumptions:

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

### WBS Allowance Basis:

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 29      Finish Year: 34      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

### WBS Specific Supporting Documentation:

waste rock reference table.xlsx

### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls



## Work Element Definition Sheet

1-Sep-2010

5:19:04 PM

WEDS ID #

7047

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.50.50 ROOM/TUNNEL/BOREHOLE EXCAVATION (FOURTH STAGE) PANEL D

**WBS Description:**

Excavate, furnish and prepare the fourth stage placement rooms (Panel D – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

Pricing includes waste rock delivered and spread at waste rock pile.

Per linear metre costs include conduit, etc.

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 32      Finish Year: 37      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

## Work Element Definition Sheet

1-Sep-2010

5:31:43 PM

WEDS ID #

7048

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.50.60 UFC TRANSPORT & PLACE

### WBS 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.

### WBS Deliverable:

Tasks directly relating to the emplacement of UFCs include:

Personnel and material transfers to / from emplacement rooms including main and service shaft operation;  
Placement of 68 DBF blocks for each UFC;  
Placement of two DBF rings for each UFC;  
Placement of 4 HCB discs per UFC;  
Placement of 8 HCB rings per UFC;  
Placement of light backfill material;  
Removal of services and rails;  
Transfer placement equipment to new location;  
Routine maintenance.

These activities are carried out approximately 81 times per placement room, with a total of 124 placement rooms being filled over the 30-year operations period, equating to 333 operating cycles per year. As the UFCs are placed, removal of the rail and concrete plinth will be undertaken and the placement room filled with DBF blocks and light backfill.

Further deliverables included during UFC emplacement include:

Construction of approximately 4.1 placement room bulk heads per year (124 in total);  
The supply and installation of major replacement capital equipment;  
Supply of minor spares to service emplacement operations;  
Indirect NWMO staff i.e. Superintendents, Supervisors, Surveyors, Ventilation Technicians.  
Indirect plant and materials i.e. safety and first aid equipment, engineering and surveying supplies, fire protection, mine rescue supplies, training, small tools and shop supplies.

### WBS Assumptions:

An assumption has been made that 10% of the drilled boreholes will not be useable, therefore a total of 89 boreholes are to be drilled per placement room. An average of 80.5 UFCs will be placed in each placement room. Pricing based on full set of UFC retrieval equipment (on stand-by) and an all-inclusive per UFC emplacement rate. All-inclusive per UFC cost includes Aggregate Plant, Concrete Plant and SMCP costs such as:

- Average Power Plant Consumption
- Supervisors • Foremen
- Operators
- Parts & Supplies for Maintenance
- Maintenance Labour
- Loader Operating/Maintenance Cost

- Raw Material Cost (Cement T50, Silica Fume, Silica Flour, Superplasticizer, Concrete Stone, Concrete Sand, MX 80 Bentonite, Modified Granular A, Glacial Lake Clay, Granite Sand)

Per UFC cost also includes:

- Crews for UFC placement and room backfill
- Locomotives
- UFC Transport trollies - flatbed
- UFC Transfer Units
- Trollies for Transfer Unit
- Placement Machines
- Trollies for Placement Machine
- Borehole Shielding Barriers
- Bentonite Recovery Equipment Trollies
- Temporary Borehole Covers
- Specialised Backfill Placement Equipment
- Bulkhead Key & Placement Equipment

Exclusive of contingency.

**WBS Allowance Basis:**

Operating activities within the emplacement rooms have been identified and numbers of personnel assigned to each activity. Uncertainties relate to the possible omission of activities as well as incorrect personnel allocation. However, because of the detailed breakdown carried out, an Allowance level of 25% is considered to be appropriate.

Start Year: 26      Finish Year: 85      Duration: 60 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$2,452,326,920	\$2,452,326,920	25%	\$3,065,408,650

WBS Specific Supporting Documentation:

- Crystalline UFC Placement - Assumption List - Vertical.xls
- Crystalline Vertical Placement Equipment List.xls
- Sequencing for Vertical Placement Process.xls
- Vertical 9.dwg
- Vertical Placement Story Board.pdf

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

1-Sep-2010

10:46:02 AM

WEDS ID #

7037

Organization Name: Hwozydk Inc.  
 Prepared by: Leo Hwozydk                                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 561                              DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.100                              HOIST ROPE REPLACEMENT

**WBS Description:**

Replacement of the ropes in the Service Shaft and Main Shaft as often as every three years; set-aside for replacement of vent shaft rope (not scheduled for use) as often as every nine years.

**WBS Deliverable:**

Replacement hoist ropes: hoists ready for use.

**WBS 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 vent shaft hoist is not scheduled for use; emergency hoist capacity in the vent shaft will be maintained.

Exclusive of contingency.

**WBS Allowance Basis:**

Rope costs and frequency of replacement is well established from industry experience - allowance of 20% covers incidental costs related to inspection and procurement.

Start Year: 17                              Finish      85                              Duration: 69 year(s)                              WBS Type: Step Fixed  
    Year:

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$19,991,362	\$19,991,362	20%	\$23,989,634

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

6-Sep-2010

4:24:20 PM

WEDS ID #

7073

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.110 INDIRECTS FOR FINAL PANEL UFC PLACEMENT

**WBS 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).

**WBS Deliverable:**

Support for underground operations.

**WBS Assumptions:**

Indirects for periods w/o drilling/blasting derived from Hwozdyk Inc. 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.

**WBS Allowance Basis:**

10% allowance - Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 80      Finish Year: 85      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$44,283,420	\$44,283,420	10%	\$48,711,762

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
 Development Schedule - Crystalline Rev04.xls  
 Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

6-Sep-2010

4:27:20 PM

WEDS ID # 7074

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk      Reviewed by:  
Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.50.120      MINING HEAT AND POWER

### **WBS Description:**

Mine heating and electrical costs (other mining indirects are incorporated in EPC-basis per metre underground development costs).

### **WBS Deliverable:**

Support for underground operations.

### **WBS Assumptions:**

Propane heating (Sudbury climate norms as proxy): 3.2 M litres/annum of propane or equivalent. Mine electrical: 45 M kWhr/annum.

Electrical loads include:

- Main Ventilation Fans
- Hoisting
- Trammig
- Underground Auxiliary Ventilation Fans
- Mine Dewatering
- Miscellaneous Demand (small compressors, diamond drills, etc.)

Exclusive of contingency.

### **WBS Allowance Basis:**

10% allowance - Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 16      Finish Year: 85      Duration: 70 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$327,341,705	\$327,341,705	10%	\$360,075,876

### WBS Specific Supporting Documentation:

#### Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

# Work Element Definition Sheet

3-Nov-2010

3:35:53 PM

WEDS ID #

7164

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.50.130 EXTENDED OPERATIONS (INC SUPPORT SERVICES)

## WBS Description:

Operation and management of the DGR facility for 70 years (Y86 to Y155, 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, preparation of the case for the closure of the DGR and the application for authority to close.

## WBS Deliverable:

- DGR-based organisation which maintains the NWMO structure, facilities and knowledge base in anticipation of decommissioning and closure.
- Asset management to maintain DGR infrastructure and surface facilities integrity against the prevailing environment.

## WBS 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 plan includes:

- President (1 FTE)
- Engineering Manager (1 FTE)
- Facility Manager (1 FTE)
- Security Manager (1 FTE)
- Finance Manager (1 FTE)
- HR Manager (1 FTE)
- Procurement Manager (1 FTE)
- Admin Assist (5 FTE)
- Conventional Safety (2 FTE)
- Engineering Support (2 FTE)
- Finance Analyst (1 FTE)
- Housekeeping (8 FTE)
- I/T Support (2 FTE)
- Payroll (1 FTE)
- Nurse (1 FTE)
- Rad Safety (2 FTE)
- Security Guard (20 FTE)
- Security/Fire Supervisor (2 FTE)
- Tech Support (2 FTE)

Surface facility maintenance accounted for in an asset management expenditure of approximately \$3M/annum.

Power provided at an average annual consumption of 36M KWhr/yr.

Placeholder for annual taxes or payments in lieu of taxes carried at \$250,000 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 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.

**WBS Allowance Basis:**

25% allowance used to accommodate line items not detailed in estimate.

Start Year: 86                      Finish Year: 155                      Duration: 70 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$382,170,600		\$408,130,631	\$790,301,231	25%	\$987,876,538

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls  
Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf





# Work Element Definition Sheet

6-Sep-2010

3:08:34 PM

WEDS ID #

7066

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.50.150 ROOM/TUNNEL/BOREHOLE EXCAVATION (FIFTH STAGE) PANEL E

## WBS Description:

Excavate, furnish and prepare the fifth stage placement rooms (Panel E – 16 placement rooms).

## WBS Deliverable:

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

## WBS Assumptions:

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

## WBS Allowance Basis:

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 35 Finish Year: 40 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

## WBS Specific Supporting Documentation:

waste rock reference table.xlsx

## Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

6-Sep-2010

3:18:04 PM

WEDS ID #

7067

Organization Name: Hwozdyk Inc.

Prepared by: Leo Hwozdyk

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.45.50.160 ROOM/TUNNEL/BOREHOLE EXCAVATION (SIXTH STAGE) PANEL F

**WBS Description:**

Excavate, furnish and prepare the sixth stage placement rooms (Panel F – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 38      Finish Year: 44      Duration: 7 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc  
Development Schedule - Crystalline Rev04.xls

## Work Element Definition Sheet

6-Sep-2010

3:25:21 PM

WEDS ID #

7068

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk                      Reviewed by:  
 Modified by:    Last Modification Date: 4-Dec-2010

WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.170                      ROOM/TUNNEL/BOREHOLE EXCAVATION (SEVENTH STAGE) PANEL G

**WBS Description:**

Excavate, furnish and prepare the seventh stage placement rooms (Panel G – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 41                      Finish Year: 46                      Duration: 6 year(s)                      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

## Work Element Definition Sheet

6-Sep-2010

3:33:17 PM

WEDS ID #

7069

Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk      Reviewed by:  
Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.50.180      ROOM/TUNNEL/BOREHOLE EXCAVATION (EIGHTH STAGE) PANEL H

**WBS Description:**

Excavate, furnish and prepare the eighth stage placement rooms (Panel H – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 6580 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 44      Finish Year: 49      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

## Work Element Definition Sheet

3-Sep-2010

3:18:15 PM

WEDS ID #

7056

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.190 ROOM/TUNNEL/BOREHOLE EXCAVATION (NINTH STAGE) PANEL I

### WBS Description:

Excavate, furnish and prepare the ninth stage placement rooms (Panel I – 16 placement rooms).

### WBS Deliverable:

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

### WBS Assumptions:

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

### WBS Allowance Basis:

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 50 Finish Year: 55 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$134,089,715	\$134,089,715	10%	\$147,498,687

### WBS Specific Supporting Documentation:

waste rock reference table.xlsx

### Multi Element Supporting Documentation:

### Work Element Definition Sheet

3-Sep-2010 3:32:35 PM WEDS ID # 7057

Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.200 ROOM/TUNNEL/BOREHOLE EXCAVATION (TENTH STAGE) PANEL J

**WBS Description:**

Excavate, furnish and prepare the tenth stage placement rooms (Panel J – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 54 Finish Year: 59 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$125,676,083	\$125,676,083	10%	\$138,243,692

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

3:40:52 PM

WEDS ID #

7058

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Organization Name: Hwozdyk Inc.  
Prepared by: Leo Hwozdyk Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.45.50.210 ROOM/TUNNEL/BOREHOLE EXCAVATION (ELEVENTH STAGE) PANEL K

**WBS Description:**

Excavate, furnish and prepare the eleventh stage placement rooms (Panel K – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 58 Finish Year: 63 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:



waste rock reference table.xlsx

**Multi Element Supporting Documentation:**

- Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc
- Development Schedule - Crystalline Rev04.xls
- Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010 3:50:55 PM WEDS ID # 7059

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Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.220 ROOM/TUNNEL/BOREHOLE EXCAVATION (TWELFTH STAGE) PANEL L

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**WBS Description:**

Excavate, furnish and prepare the twelfth stage placement rooms (Panel L – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 62 Finish Year: 67 Duration: 6 year(s) WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$132,444,327	\$132,444,327	10%	\$145,688,760

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

3:58:41 PM

WEDS ID #

7060

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Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.45.50.230 ROOM/TUNNEL/BOREHOLE EXCAVATION (THIRTEENTH STAGE) PANEL M

---

**WBS Description:**

Excavate, furnish and prepare the thirteenth stage placement rooms (Panel M – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 66      Finish Year: 71      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$141,614,657	\$141,614,657	10%	\$155,776,123

WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

4:16:22 PM

WEDS ID #

7061

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Organization Name: Hwozdyk Inc.  
 Prepared by: Leo Hwozdyk Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS ROOM/TUNNEL/BOREHOLE EXCAVATION (FOURTEENTH STAGE) PANEL  
 Number: 561.45.50.240 N

---

**WBS Description:**

Excavate, furnish and prepare the fourteenth stage placement rooms (Panel N – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 69      Finish Year: 74      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
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		\$132,444,327	\$132,444,327	10%	\$145,688,760
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WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

4:23:25 PM

WEDS ID #

7062

Organization Name:	Hwozdyk Inc.	Reviewed by:	
Prepared by:	Leo Hwozdyk	Last Modification Date:	4-Dec-2010
Modified by:			

WBS Case:	561	DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)
WBS Number:	561.45.50.250	ROOM/TUNNEL/BOREHOLE EXCAVATION (FIFTEENTH STAGE) PANEL O

**WBS Description:**

Excavate, furnish and prepare the fifteenth stage placement rooms (Panel O – 16 placement rooms).

**WBS Deliverable:**

Construction of 16 placement rooms (~7,600 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 895 metres
- Panel A Rooms (5.5 m Elliptical) : 7520 metres
- UFC borehole drilling (pilot and ream): 1424 units
- Track install: 7231 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year:	72	Finish Year:	77	Duration:	6 year(s)	WBS Type:	Variable
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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
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		\$141,614,657	\$141,614,657	10%	\$155,776,123
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WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

3-Sep-2010

4:30:59 PM

WEDS ID #

7063

Organization Name:	Hwozdyk Inc.		
Prepared by:	Leo Hwozdyk	Reviewed by:	
Modified by:		Last Modification Date:	4-Dec-2010

WBS Case:	561	DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)
WBS Number:	561.45.50.260	ROOM/TUNNEL/BOREHOLE EXCAVATION (SIXTEENTH STAGE) PANEL P

**WBS Description:**

Excavate, furnish and prepare the sixteenth stage placement rooms (Panel P – 15 placement rooms).

**WBS Deliverable:**

Construction of 15 placement rooms (~7,050 m in total). Each placement room will contain 89 boreholes. Following borehole drilling the contractor will install track on concrete plinths in each of the placement rooms to facilitate UFC placement. As each room is developed, air, water and electrical power lines will be installed.

**WBS Assumptions:**

The rooms are semi-elliptical in shape, approximately 5.5 m high by 5.5 m wide, ~396 m in length. The entrance to each room will be at a 50m radius from the panel access drift and be rectangular in profile at 5m width by 5m height. The placement rooms and access 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. The UFC boreholes will be drilled by a purpose built blind boring machine. A total of 5 placement rooms will be under development at a time, therefore ventilation fans will be needed for the actively mined rooms. As each room is completed the ventilation fan will be transferred to the next room to be developed.

All-inclusive pricing for per linear metre of mine development as per Hwozdyk Inc. costing model:

- Panel Access Crosscut (5 m W X 5 m H) : 805 metres
- Rooms (5.5 m Elliptical) : 7050 metres
- UFC borehole drilling (pilot and ream): 1335 units
- Track install: 6745 m

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

**WBS Allowance Basis:**

10% allowance - drift dimensions and construction methods are conventional and well understood. Applied cost model based on actual costs for similar work under similar conditions.

Start Year: 75      Finish Year: 80      Duration: 6 year(s)      WBS Type: Variable

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
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		\$132,444,327	\$132,444,327	10%	\$145,688,760
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WBS Specific Supporting Documentation:

waste rock reference table.xlsx

Multi Element Supporting Documentation:

Crystalline conceptual design TM12A - September 10 CLEAN COPY.doc

Development Schedule - Crystalline Rev04.xls

Mining Cost Basis Model - Cstmdl\$Cdn\_Rev\_NWMO\_Rev04 edit.pdf

## Work Element Definition Sheet

28-Jun-2010

12:08:40 PM

WEDS ID #

8031

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Organization Name: SNC-Lavalin Nuclear  
 Prepared by: Bassam Ahmad      Reviewed by: Lloyd Lazic  
 Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.55.40      ENVIRONMENTAL RESPONSE EQUIPMENT

**WBS Description:**

Procurement, delivery, installation and commissioning of environmental response equipment

(Note that this element was formerly named "RAD & NON-RAD GROUNDWATER MONITORING". However, in the current cost estimate, NWMO costs for other cost elements include all necessary radiological and non-radiological groundwater monitoring.)

**WBS Deliverable:**

Procurement, installation and commissioning for the following items:

- Environmental Protection Control System
- Environmental Protection Control System Software
- Environmental Protection measuring devices
- Contamination kits
- Environmental cleaning kits
- Mobile rapid response units
- Environmental assessment laboratory

**WBS 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.

**WBS Allowance Basis:**

10% allowance covers consumables and incidentals.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$5,850,000		\$5,850,000	10%	\$6,435,000

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls

RE ACTION REQUIRED Quotes .txt

## Work Element Definition Sheet

25-Jun-2010

3:36:52 PM

WEDS ID #

8023

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Organization Name: SNC-Lavalin Nuclear  
 Prepared by: Bassam Ahmad      Reviewed by: Lloyd Lazic  
 Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.55.50      RADIOLOGICAL MONITORING EQUIPMENT

**WBS 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 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 )

**WBS Deliverable:**

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)
- Dosimetry device (4 per person/per year, 25 persons: 100)
- Electronic Dosimetry 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)

**WBS 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.

**WBS Allowance Basis:**

10% allowance covers consumables and incidentals.

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$6,431,000		\$6,431,000	10%	\$7,074,100

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls  
RE ACTION REQUIRED Quotes .txt



# Work Element Definition Sheet

25-Jun-2010

11:07:36 AM

WEDS ID #

8013

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Organization Name: SNC-Lavalin Nuclear  
Prepared by: Bassam Ahmad      Reviewed by: Lloyd Lazic  
Modified by:      Last Modification Date: 4-Dec-2010

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WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.55.60      NON RADIOLOGICAL MONITORING EQUIPMENT

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## WBS 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.

(Note that this element was formerly named "NON - RAD BIOSPHERE MONITORING". However, in the current cost estimate, costs for other cost elements include all necessary non-radiological monitoring. For example, safety staff are included in .45.30, Operations Indirects )

## WBS Deliverable:

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)

## WBS Assumptions:

Materials Costs Assumptions:

- 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.

**WBS Allowance Basis:**

10% allowance covers consumables and incidentals.

---

Start Year: 25      Finish Year: 25      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$1,832,750		\$1,832,750	10%	\$2,016,025

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

NWMO 100k items Table.xls

RE ACTION REQUIRED Quotes .txt

# Work Element Definition Sheet

31-Jul-2010

11:06:11 AM

WEDS ID #

2021

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Organization Name: SNC-Lavalin Nuclear  
Prepared by: Bob Brewer                      Reviewed by:  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.10                      DECOMMISSIONING MANAGEMENT

---

## WBS Description:

NWMO operation and management of the DGR facility for 10 years (Y156 to Y165, inclusive) 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 (Y166 to Y180), the anticipated period between the completion of major decommissioning work and obtaining the facility license to abandon.

## WBS Deliverable:

DGR-based corporate organisation which applies for necessary instruments, lets contracts and manages contract delivery to decommission underground works and major surface facilities.

## WBS Assumptions:

Staffing plan includes:

- President (1 FTE )
- Director of Engineering (2 FTE )
- Building Manager (1 FTE )
- Finance Manager (1 FTE )
- HR Manager (1 FTE )
- Maintenance Manager (2 FTE )
- Security Manager (1 FTE )
- Engineering Support (6 FTE )
- Finance Analyst (2 FTE )
- IT Support (2 FTE )
- Nurse (1 FTE )
- Conventional Safety and Health Physics Staff (6 FTE )
- Security Guard (20 FTE )
- Technical Support (3 FTE )
- Administrative Staff (10 FTE )
- Janitorial and Maintenance (8 FTE )

Power and utilities provided as approximately \$680K/annum; fleet assessed as \$120K/annum. Other incidentals and consumables allocated to allowance (25%).

Placeholder for taxes or payments in lieu of taxes at \$250,000 per year.

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.

**WBS Allowance Basis:**

25% allowance used to accommodate line items not detailed in estimate.

Start Year: 156                      Finish Year: 165                      Duration: 10 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$68,002,200	\$1,200,000	\$9,300,000	\$78,502,200	25%	\$98,127,750

WBS Specific Supporting Documentation:

- Multi Element Supporting Documentation:  
DC Reformat of Estimate BB OCT 2010 561.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

8:06:00 PM

WEDS ID # 2027

Organization Name: SNC-Lavalin

Prepared by: Bob Brewer

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.60.30.10 BACKFILL MATERIALS PLANT (SUPPLY AND OPERATE)

**WBS 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.

**WBS Deliverable:**

The backfill materials plant includes a steel framed 4,000 m<sup>2</sup> 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.

**WBS Assumptions:**

Facility design, construction, installation and commissioning will be on a turnkey contract basis. Management and operation will be done by contract labour as follows:

- Plant Admin (days only) (2 FTE )
- Plant Mgr - 1 per shift (5 FTE )
- Plant technical - 2 per shift (10 FTE )
- Operators - 8 per shift (40 FTE )
- Maintenance - 2 per shift (10 FTE )

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas incl services - 4000m<sup>2</sup> (\$7.2M, 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) (\$30M, turn-key).
- Spares and consumables (\$1.2M/year)
- Accommodation, travel and incidentals (\$2.2 M/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.

**WBS Allowance Basis:**

An allowance of 20% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 156      Finish Year: 164      Duration: 9 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$133,250,400	\$37,200,000	\$30,546,000	\$200,996,400	20%	\$241,195,680

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 561.xlsx

DC Manpower Plan (Surface Related and Operations).xlsx

560 DC Workbook A 2010 Update BB November.xlsx

560 DC Workbook B 2010 Update BB Rev 2.xls

ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

8:49:19 PM

WEDS ID #

2028

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.30.20 WASTE PROCESSING AND HANDLING FACILITY

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## WBS 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.

## WBS Deliverable:

The waste processing and handling facility includes an insulated pre-engineered 1,500 m<sup>2</sup> 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.

## WBS Assumptions:

Facility design, construction, installation and commissioning will be on a turnkey contract basis, with management and operation of the facility carried out using contract labour as follows:

- Plant Mgr (1 FTE)
- Plant Administrator (1 FTE)
- Tech Specialist/Quality assurance (1 FTE)
- Operators - Phase 1 (12 FTEs, first 5 years)
- Operators - Phase 2 (6 FTEs, second 5 years)
- Maintainer (1 FTE)

Non-labour costs include:

- Design and construct steel framed, insulated building with office, process, storage and personnel areas including services - 1500m<sup>2</sup> (\$11.251M, turn-key)
- Size reduction equipment (equipment for use within the facility and on site as needed for cropping, burning, crushing and compaction) (\$6M, turn-key).
- Materials handling equipment, including building crane, loaders and materials conveyors (\$2.4 M, turn-key)
- Ventilated enclosure for the sorting and packing of waste into ISO containers (\$900K, turn-key)
- Operating spares and consumable (\$300K/year)
- Accommodation, travel and incidentals (\$422K/year)

Transport, disposal and other operating costs are not included here, but are built into per tonne and per m<sup>3</sup> rates for waste disposal line items.

Exclusive of contingency.

## WBS Allowance Basis:

An allowance of 20% is applied to provide for variations of requirements during decommissioning and closure.

---

Start Year: 156      Finish Year: 165      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$28,458,000	\$23,551,000	\$4,220,000	\$56,229,000	20%	\$67,474,800

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 561.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xlsx  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx



# Work Element Definition Sheet

30-Aug-2010

10:00:54 AM

WEDS ID #

2022

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Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer  
Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.40 AUXILIARY SURFACE FACILITIES DECOMM

---

## WBS 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.

## WBS Deliverable:

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.

## WBS 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 - approximately \$2,046,000
- Pumphouse and intake - approximately \$221,000
- Water storage tank area - approximately \$19,000
- Water treatment plant - approximately \$66,000
- Process water settling pond - approximately \$29,000
- Service shaft water settling pond - approximately \$7,000
- Storm water run-off ponds - approximately \$29,000
- Sewage treatment plant - approximately \$81,000
- Administration building including firewall / cafeteria - approximately \$582,000
- Switchyard - approximately \$29,000
- Transformer areas - approximately \$90,000
- Auxiliary building - approximately \$528,000
- Quality control offices and laboratories - approximately \$110,000
- Garage building/warehouse/hazardous matls storage - approximately \$371,000
- Walkways and serviceways - approximately \$49,000
- Fuel storage tanks - approximately \$19,000
- Fire hall / security - approximately \$85,000
- Emergency power generation - approximately \$290,000
- Facility electrical distribution - approximately \$208,000
- Facility communication system (s) - approximately \$14,000
- Firewater system - approximately \$19,000
- Potable water system - approximately \$8,000
- Process water system - approximately \$7,000
- Sewerage system - approximately \$13,000
- Storm water and drainage system - approximately \$32,000

- Service air system - approximately \$123,000
- Breathing air system - approximately \$50,000
- Camp site remnants - approximately \$402,000

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 25% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 156                      Finish Year: 165                      Duration: 10 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
		\$5,525,000	\$5,525,000	25%	\$6,906,250

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

9:31:14 PM

WEDS ID #

2029

Organization Name: SNC-Lavalin  
 Prepared by: Bob Brewer Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.60.50 USED FUEL PACKAGING PLANT (UFPP) DECOMM

**WBS Description:**

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Used Fuel Packaging Plant.

**WBS Deliverable:**

Used Fuel Packaging Plant site restored to a "green" state.

**WBS Assumptions:**

It is assumed that post-operations clean out (POCO) is carried out after operations are complete.

Decommissioning is estimated as requiring approximately 1430 person-hours each for a decommissioning manager and an administrator. Decommissioning will be carried out with approximately 33,000 person-hours of direct labour and 5,800 person-hours of support. The cost estimate also includes a \$240K annual assignment for operating spares and consumables over a three-year period, as well as a \$526K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. The UFPP is a particularly complex structure and has radiological decontamination aspects. For this reason an allowance of 30% has been attached to this activity.

Start Year: 158      Finish Year: 160      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$13,108,123	\$720,000	\$1,578,000	\$15,406,123	30%	\$20,027,960

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

3:19:03 PM

WEDS ID #

2026

Organization Name: SNC-Lavalin

Prepared by: Bob Brewer

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.60.60 SEALING MATERIALS COMPACTION PLANT DECOMM

**WBS Description:**

Labour and equipment for the decommissioning, dismantling and removal of the Sealing Materials Compaction Plant.

**WBS Deliverable:**

Sealing Materials Compaction Plant site restored to a "green" state.

**WBS 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 (483 hours) supported by a technical specialist (928 hours). Decommissioning will be carried out using approximately 24,360 person-hours, an annual operating spares and consumables budget of \$120K and an annual allocation for accommodations, incidentals and travel of \$189K.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes of waste produced. The SMCP includes large, unique equipment. For this reason an allowance of 30% has been attached to this activity.

Start Year: 161      Finish Year: 162      Duration: 2 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$3,053,770	\$240,000	\$377,600	\$3,671,370	30%	\$4,772,780

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

9:55:41 PM

WEDS ID #

2030

Organization Name: SNC-Lavalin  
Prepared by: Bob Brewer Reviewed by:  
Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.70.10 ALWT

## WBS Description:

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Active Liquid Waste Treatment Building.

## WBS Deliverable:

The return of the ALWT building site to a 'green' state.

## WBS 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 \$33K annual assignment for operating spares and consumables over a three-year period, as well as a \$44K 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

## WBS Allowance Basis:

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. The ALWT is a nuclear facility with related radiological considerations. For this reason an allowance of 30% has been attached to this activity.

Start Year: 157 Finish Year: 159 Duration: 3 year(s) WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,080,523	\$99,000	\$133,200	\$1,312,723	30%	\$1,706,540

## WBS Specific Supporting Documentation:

### Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 561.xlsx  
DC Manpower Plan (Surface Related and Operations).xlsx  
560 DC Workbook A 2010 Update BB November.xlsx  
560 DC Workbook B 2010 Update BB Rev 2.xls  
ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

10:22:11 PM

WEDS ID # 2031

Organization Name: SNC-Lavalin  
 Prepared by: Bob Brewer Reviewed by:  
 Modified by: Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.60.70.20 LLLW STORAGE

**WBS Description:**

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Liquid Waste Storage Building.

**WBS Deliverable:**

The return of the LLLW building site to a 'green' state.

**WBS 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 \$14K annual assignment for operating spares and consumables over a three-year period, as well as a \$17K annual assignment for accomodation, 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. For this reason an allowance of 30% is attached to this activity.

Start Year: 157 Finish Year: 159 Duration: 3 year(s) WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$458,842	\$42,000	\$50,700	\$551,542	30%	\$717,004

WBS Specific Supporting Documentation:Multi Element Supporting Documentation:

DC Reformat of Estimate BB OCT 2010 561.xlsx  
 DC Manpower Plan (Surface Related and Operations).xlsx  
 560 DC Workbook A 2010 Update BB November.xlsx  
 560 DC Workbook B 2010 Update BB Rev 2.xls  
 ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

30-Aug-2010

10:33:28 PM

WEDS ID #

2032

Organization Name: SNC-Lavalin

Prepared by: Bob Brewer

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.60.70.30 LLW STORAGE

**WBS Description:**

Labour and equipment for the decontamination, decommissioning, dismantling and removal of the Low Level Waste (LLW) storage building.

**WBS Deliverable:**

The return of the LLW storage building site to a 'green' state.

**WBS 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 \$33K annual assignment for operating spares and consumables over a three-year period, as well as a \$45K annual assignment for accomodation, 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 (.60.30.20). The cost of waste containers, transport and disposal is also covered elsewhere.

Exclusive of contingency.

**WBS Allowance Basis:**

Decommissioning is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced. For this reason a 30% allowance has been included.

Start Year: 157      Finish Year: 159      Duration: 3 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,087,603	\$99,000	\$134,250	\$1,320,853	30%	\$1,717,109

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

4-Aug-2010

11:58:59 AM

WEDS ID #

4022

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.80 UFC HANDLING SYSTEMS

## WBS Description:

Labour and equipment for the decontamination, decommissioning, dismantling and removal of UFC Casks, Buffer Block Casks, In-room Emplacement Equipment, Locomotives, Rail Cars, Cask Parking Areas and the Surface Rail Link.

## WBS Deliverable:

The removal from site of UFC Casks, Buffer Block Casks, In-room Emplacement Equipment, Locomotives, Rail Cars, Cask Parking Areas and the Surface Rail Link.

## WBS Assumptions:

Estimate is based on the following actions:

- Decontaminate 3 UFC Casks
- Size reduce and load for disposal - 3 UFC casks
- Size reduce and load for disposal - 3 UFC transport trolley flatbed
- Size reduce and load for disposal - 2 trolley for Transfer Cask
- Size reduce and load for disposal - 3 UFC Buffer Block Casks
- Size reduce and load for disposal- 4 Locomotives
- Size reduce and load for disposal - 2 Trolleys for Placement Machine
- Size reduce and load for disposal - 2 Placement Machines
- Size reduce and load for disposal - 2 Borehole Shielding Barriers
- Size reduce and load for disposal - 2 Bentonite Recovery Equipment Trolley
- Size reduce and load for disposal - 10 Rail Cars
- Dismantle 400 m of rail track
- Haul the reduced equipment (scrap metal) to disposal - 422 tonne
- Scrap metal credit for salvage - 306 tonne
- Reinstate surface parking area - remove pavement and dispose (400 tonne), provide landscaping/hydroseed (1,000 m<sup>2</sup>)

Components will be size reduced and packaged in a form suitable for transport from site, to a facility for final disposal.

All arisings (348 m<sup>3</sup>) 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 elsewhere.

Exclusive of contingency.

## WBS Allowance Basis:

An allowance of 10% has been attached to this activity for components not captured in estimate line items.

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Start Year: 157      Finish Year: 158      Duration: 2 year(s)      WBS Type: Step Fixed

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Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$217,120		\$48,944	\$266,064	10%	\$292,671

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xlsPremierRecycling.doc

# Work Element Definition Sheet

30-Aug-2010

12:54:39 PM

WEDS ID #

2024

Organization Name: SNC-Lavalin  
 Prepared by: Bob Brewer      Reviewed by:  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.60.90      PERM VENT FAN REMOVAL (DECOMMISSIONING)

**WBS 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.

**WBS Deliverable:**

Complete (greenfield) decommissioning of ventilation systems.

**WBS Assumptions:**

Costs estimated as 4000 hours of direct labour and a \$48K allocation for special materials and equipment.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 20% is applied to provide for lack of design detail.

Start Year: 156      Finish Year: 156      Duration: 1 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$472,000	\$48,000		\$520,000	20%	\$624,000

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

4-Aug-2010

10:12:01 AM

WEDS ID #

4014

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.100.10 ACCESS TUNNELS AND DRIFTS

## WBS Description:

Decommissioning of access tunnels and drifts to comprise:

- Removal of road bed and track ballast, 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 and drifts comprising the repository and underground shaft complexes.

## WBS Deliverable:

Tunnels backfilled with dense backfill (70% crushed granite, 25% glacial lake clay and 5% bentonite) from the tunnel floor elevation to a height of 2.4 m.

The upper portion of the tunnels from 2.4 m to the full height of 5.0 m will be filled with light backfill (50% crushed granite and 50% bentonite). Tunnels to be sealed with an assemblage of sealing material blocks placed in conjunction with a concrete bulkhead at regular intervals and/or structural discontinuities approximately every 500 m of tunnel for an approximate total of 50 seals.

## WBS Assumptions:

Total length of tunnel to be backfilled to be 243,183 m. Initially the dense backfill will be placed utilizing placement, positioning and compaction utilizing load-haul-dump vehicles with suitable rollers. Light backfill will be placed by pneumatic placement methods. The combined density of the dense and light backfill will be 1.88 tonnes/m<sup>3</sup>. 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 6 years based on multi-face working.

Includes:

- Dense backfill, 70% crushed granite, 25% glacial lake clay and 5% bentonite - 632,983 m<sup>3</sup>
- Light backfill, 50% crushed granite and 50% bentonite- 685,732 m<sup>3</sup>
- Concrete bulkhead in Access Tunnel
- 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
- Steel credit for salvage – 4,050 tonne
- Nonferrous metals credit for salvage - 70 tonne
- Copper from 4160 V cable for salvage - 462 tonne

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 10% will be applied as the technology for efficient backfilling (with 100% tight filling) requires development, but is relatively well understood.

Start Year: 156                      Finish Year: 160                      Duration: 5 year(s)                      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$167,934,650	\$174,140,056	\$9,913,775	\$351,988,481	10%	\$387,187,329

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

4-Aug-2010

10:40:28 AM

WEDS ID #

4015

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.100.20 SERVICE SHAFT

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## WBS Description:

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.

## WBS Deliverable:

A backfilled and sealed Service Shaft.

## WBS Assumptions:

No further requirement to access the underground facility. Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material. A new slick line will be installed in the Service Shaft for dense backfill placement.

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) - 2,755 m<sup>3</sup>
- Bentonite and Sand Seal – 17,910 m<sup>3</sup>
- Asphalt Seal – 2,296 m<sup>3</sup>
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 700 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.

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 160                      Finish Year: 162                      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$12,058,184	\$8,217,840	\$1,799,190	\$22,075,214	10%	\$24,282,735

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

4-Aug-2010

10:45:39 AM

WEDS ID #

4016

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.100.30 MAIN SHAFT

---

## WBS Description:

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.

## WBS Deliverable:

A backfilled and sealed Main Shaft.

## WBS Assumptions:

No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shaft will be filled with a compacted dense backfill material.

A new slick line will be installed for dense backfill placement.

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) - 3,539 m<sup>3</sup>
  - Bentonite and Sand Seal – 23,004 m<sup>3</sup>
  - Asphalt Seal – 2,949 m<sup>3</sup>
  - Removal, haulage and disposal of hazardous and non-hazardous waste materials
  - Removal and haulage of salvageable metals.
  - Steel credit for salvage - 700 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.
- Labour rates used include contractor indirects.

Exclusive of contingency.

## WBS Allowance Basis:

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-

mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 161                      Finish Year: 163      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$11,171,886	\$10,555,216	\$900,064	\$22,627,166	10%	\$24,889,883

WBS Specific Supporting Documentation:

- Multi Element Supporting Documentation:  
561.60 NWMO Cost Breakdown for Database-UG decommiss.xls  
NWMO UG-services- Seals.xls  
NWMO Shafts UG Tunnels Decomm.xls



# Work Element Definition Sheet

3-Aug-2010

3:33:58 PM

WEDS ID #

4046

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka  
Reviewed by: Peter Keohane  
Modified by: Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.100.50 VENTILATION SHAFT DECOMM

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## WBS Description:

Install a sinking hoist and refurbish the Ventilation Shafts so that the shafts can be back filled in a retreat fashion, including the removal of all concrete and damaged rock annulus, then remove the sinking hoists and headframes. Install a backfill slick line for shaft sealing.

## WBS Deliverable:

Backfilled and sealed ventilation shafts (two).

## WBS Assumptions:

No further requirement to access the underground facility.

Upon removal of the concrete and damaged rock annulus, the shafts will be filled with a compacted dense backfill material.

Slick lines will be installed for dense backfill placement.

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) -2 x 2,755 m<sup>3</sup>
- Bentonite and Sand Seal – 2 x 17,910 m<sup>3</sup>
- Asphalt Seal – 2 x 2,296 m<sup>3</sup>
- Removal, haulage and disposal of hazardous and non-hazardous waste materials
- Removal and haulage of salvageable metals.
- Steel credit for salvage - 2 x 173 tonne
- Non-ferrous credit for salvage - 2 x 10 tonne
- Hoist credits for salvage (Credit)
- Dismantling of dewatering, electrical, compressed air, water, alarm and IT systems.
- Dismantling of headframe production hoists, service hoists, auxiliary hoists, service cranes and ventilation systems.

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

A 10% allowance is applied. Although the scope is well defined, allowances must be considered for geo-mechanical issues developing in the shaft during the concrete annulus reaming/stripping and placement of strategically placed bulkheads across the shaft opening.

Start Year: 156                      Finish Year: 158                      Duration: 3 year(s)                      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$17,837,824	\$16,435,680	\$3,221,714	\$37,495,218	10%	\$41,244,740

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls

NWMO UG-services- Seals.xls

NWMO Shafts UG Tunnels Decomm.xls

# Work Element Definition Sheet

4-Aug-2010

10:56:56 AM

WEDS ID # 4018

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka                      Reviewed by: Peter Keohane  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.110                      IN-TOWN DECOMMISSIONING

**WBS Description:**

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Sell, transfer or dismantle/dispose of facility-related (obsolete) town site buildings and related facilities.

**WBS Deliverable:**

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The bulk of the town site will remain to serve the permanent residents of the community.

**WBS Assumptions:**

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N/A

**WBS Allowance Basis:**

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N/A

Start Year: 165      Finish Year: 165      Duration: 1 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
			\$0		\$0

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls

PremierRecycling.doc

## Work Element Definition Sheet

4-Aug-2010                      12:34:04 PM                      WEDS ID #      4023

Organization Name:                      SNC-Lavalin  
 Prepared by:                                  Kris Hojka                                  Reviewed by:      Peter Keohane  
 Modified by:    Last Modification Date:      4-Dec-2010

WBS Case:              561                                  DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number:      561.60.120                                  CRUSHER PLANT DEMO (DECOMM)

**WBS Description:**

Demolition and dispose of the rock crushing plant and concrete batch plant.

**WBS Deliverable:**

Decommissioned rock crushing plant and concrete batch plant.

**WBS Assumptions:**

Estimate includes:

- Dismantling of Concrete Batching Plant
- Dismantling of Rock Crushing Plant
- Haul and dispose of debris to disposal – 1,400 tonne
- Haul scrap steel - 300 tonne
- Salvage scrap metal (credit) - 300 tonne
- Landscaping (hydroseed) – 2,950 m2

Labour rates used include contractor indirects.

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance to be applied to provide for variations to the requirements during decommissioning.

Start Year:	164	Finish Year:	164	Duration:	1 year(s)	WBS Type:	Fixed
Labour Costs		Material Costs		Other Costs	Subtotal	Allowance	Total Cost
\$76,700				\$133,759	\$210,459	10%	\$231,504

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls  
 PremierRecycling.doc

## Work Element Definition Sheet

30-Aug-2010

2:39:57 PM

WEDS ID #

2025

Organization Name: SNC-Lavalin  
 Prepared by: Bob Brewer      Reviewed by:  
 Modified by:      Last Modification Date: 4-Dec-2010

WBS Case: 561      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
 WBS Number: 561.60.130      SITE CLEANUP (DECOMM)

**WBS 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.

**WBS Deliverable:**

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.

**WBS 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.

**WBS Allowance Basis:**

An allowance of 25% is applied to provide for variations of requirements during decommissioning and closure.

Start Year: 164      Finish Year: 165      Duration: 2 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$788,240			\$788,240	25%	\$985,300

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

- DC Reformat of Estimate BB OCT 2010 561.xlsx
- DC Manpower Plan (Surface Related and Operations).xlsx
- 560 DC Workbook A 2010 Update BB November.xlsx
- 560 DC Workbook B 2010 Update BB Rev 2.xls
- ASF - Aux Surface Buildings Demolition Rev 0.xlsx

# Work Element Definition Sheet

4-Aug-2010

11:21:43 AM

WEDS ID #

4020

Organization Name: SNC-Lavalin

Prepared by: Kris Hojka

Reviewed by: Peter Keohane

Modified by:

Last Modification Date: 4-Dec-2010

WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.60.150 DECOMM INDIRECTS (INC HEAT, CONSUMABLES)

**WBS 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.

**WBS Deliverable:**

Contractor plant indirects for decommissioning.

**WBS Assumptions:**

Estimate based on support costs modified from operations phase as follows:

- Mine Heating - \$1,403,000/year
- Surface Building Heat - \$924,000/year
- Electricity - \$1,289,000/year
- Water and Sewerage - \$9,125/year

Other work elements and the labour rates used for specific decommissioning tasks include all other contractor indirects, such as:

- Waste Disposal
- Telecom/Office Expences
- 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.

**WBS Allowance Basis:**

An allowance of 10% is applied to provide for varying requirements during decommissioning.

Start Year: 156      Finish Year: 165      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
	\$2,450,000	\$33,809,875	\$36,259,875	10%	\$39,885,863

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls  
 Indirects - Decom.xls

# Work Element Definition Sheet

2-Dec-2010

2:14:55 PM

WEDS ID #

10003

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Organization Name:

Prepared by: RPC

Reviewed by:

Modified by:

Last Modification Date: 4-Dec-2010

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WBS Case: 561 DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)

WBS Number: 561.60.160 DECOMM WASTE DISPOSAL

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## WBS Description:

Packaging, transport and disposal of itemised conventional waste, very low level waste (VLLW) and low level waste (LLW) resulting from DGR decommissioning activities.

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## WBS Deliverable:

- 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.
- 

## WBS Assumptions:

Waste disposal costs include 1125 m3 of low level radioactive waste at \$1,400/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
- Equipment in various areas assumed to be:
  - 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 \$200/tonne (load/transport/dispose) over 10 years, from the following sources.

- Main (protected area) fence - 45 tonnes
- Perimeter security fence - 225 tonnes
- 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 \$100,000/annum in ISO containers, re-handling and temporary storage have been assumed.

Exclusive of contingency.

**WBS Allowance Basis:**

An allowance of 20% has been attached to this activity. Decommissioning and the transport of the resulting waste is a labour intensive activity, with an inherent uncertainty as to the volumes and category of the waste produced.

Start Year: 156      Finish Year: 165      Duration: 10 year(s)      WBS Type: Step Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$1,087,800		\$28,537,260	\$29,625,060	20%	\$35,550,072

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:



# Work Element Definition Sheet

4-Aug-2010

11:24:51 AM

WEDS ID #

4021

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Organization Name: SNC-Lavalin  
Prepared by: Kris Hojka                      Reviewed by: Peter Keohane  
Modified by:    Last Modification Date: 4-Dec-2010

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WBS Case: 561                      DEEP GEOLOGICAL REPOSITORY (Crystalline, "In-Floor", 7.2M)  
WBS Number: 561.60.170                      FINAL CLOSURE

## **WBS 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.

## **WBS Deliverable:**

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.

## **WBS 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, as follows:

- President (part-time), duties to include closure and public affairs (0.5 FTE )
- Technical Director (President part-time) (0.5 FTE )
- Pre closure/closure reports and license applications (2 FTE )
- Resources / Finance /Business Services (1 FTE )
- Secretarial / Clerical (2 FTE )
- QA / Safety Manager (1 FTE )
- Environmental monitoring / coordination / assessment (2 FTE )
- Site general helper / driver / medic (4 FTE )

## Other costs include:

- Contracts for ecological restoration - \$3,750,000;
- Contracts for signage and landmarking - \$500,000;
- Contracts for final dismantling, removal, and disposals - \$2,000,000;
- Contracts for security - \$3,000,000;
- Contracts for final sealing of deep boreholes - \$2,500,000;
- Contracts for maintenance - \$1,875,000;
- Other contracts - \$2,000,000;
- Equipment, spares, and consumables - \$780,000;
- Vehicle leases - \$525,000;
- Energy consumption - \$750,000;
- Conventional Insurance - \$300,000;

- Vehicle Insurance - \$63,000; and
- Taxes or community compensation -725,000 per year

Exclusive of contingency.

**WBS Allowance Basis:**

10% allowance used for incidentals and consumables.

Start Year: 166      Finish Year: 180      Duration: 15 year(s)      WBS Type: Fixed

Labour Costs	Material Costs	Other Costs	Subtotal	Allowance	Total Cost
\$22,270,500		\$21,793,000	\$44,063,500	10%	\$48,469,850

WBS Specific Supporting Documentation:

Multi Element Supporting Documentation:

561.60 NWMO Cost Breakdown for Database-UG decommiss.xls  
 WBS Final Closure.xls