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Radioactive Materials Management

Cost Estimate for a Deep Geologic Repository for Used Nuclear Fuel

Report of a Study carried out for Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited

September 2003

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Notice to the Reader

“This document has been prepared by CTECH Radioactive Materials Management, a joint venture of Canatom NPM Inc. and RWE NUKEM Ltd. (“Consultant”), to update the conceptual design and cost estimate for a deep geologic repository (DGR) for long term disposal of used nuclear fuel. The scope is more fully described in the body of the document. The Consultant has used its professional judgement and exercised due care, pursuant to a purchase order dated October 2001 (the “Agreement”) with Ontario Power Generation Inc. acting on behalf of the Canadian nuclear fuel owners (“the Client”), and has followed generally accepted methodology and procedures in updating the design and estimate. It is therefore the Consultant’s professional opinion that the design and estimate represent a viable concept consistent with the intended level of accuracy appropriate to a conceptual design, and that, subject to the assumptions and qualifications set out in this document, there is a high probability that actual costs related to the implementation of the proposed design concept will fall within the specified error margin.

This document is meant to be read as a whole, and sections or parts thereof should not be read or relied upon out of context. In addition, the report contains assumptions, data, and information from a number of sources and, unless expressly stated otherwise in the document, the Consultant did not verify those items independently. Notwithstanding this qualification, the Consultant is satisfied that the updated conceptual design and cost estimate was carried out in accordance with generally accepted practices in a professional manner.

This document is written solely for the benefit of the Client, for the purpose stated in the Agreement, and the Consultant’s liabilities are limited to those set out in the Agreement.

Summary

This report presents a cost estimate for a Deep Geologic Repository (DGR) for used nuclear fuel from Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited. The estimate is based on a conceptual design developed by CTECH on behalf of the Joint Waste Owners and is based on the 'in-room' emplacement of used fuel containers (UFCs) at a nominal depth of 1000m on the Canadian Shield.

It is assumed that the siting process will begin in Year 1 and that the in-service date for the repository facility will be Year 30. The estimate includes the cost of siting, design and construction of the DGR, operation of the facility including packaging of used fuel bundles in containers, monitoring the DGR for a 70-year period after the completion of UFC emplacement and decommissioning and closure of the facility. The estimate excludes the cost for preparing the used fuel for transport following interim storage and transportation of the used fuel bundles to the DGR facility.

This cost estimate is for a stand-alone self sufficient DGR facility located 40 kilometres (25 miles) from the closest highway. The estimate also includes for the construction and operation of a dedicated townsite to service the facility.

The total life cycle cost for this DGR facility that can accept 3.6 million used fuel bundles over a 30 year operating period, is approximately $12.675 Billion (2002 constant dollars).

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1 Introduction

This report presents a cost estimate for a Deep Geologic Repository (DGR) that can accept used nuclear fuel from Ontario Power Generation, New Brunswick Power, Hydro-Québec and Atomic Energy of Canada Limited. This estimate is based on a conceptual design developed by CTECH [1] on behalf of the Joint Waste Owners and is based on the 'in-room' emplacement of used fuel containers at a nominal depth of 1000m on the Canadian Shield and meets the specified cost estimating requirements stated in [2].

Costs are based in January 2002 dollars and have not been discounted. Contingencies consistent with the level of engineering undertaken have been included in the cost estimate.

1.1 PURPOSE OF COST ESTIMATE

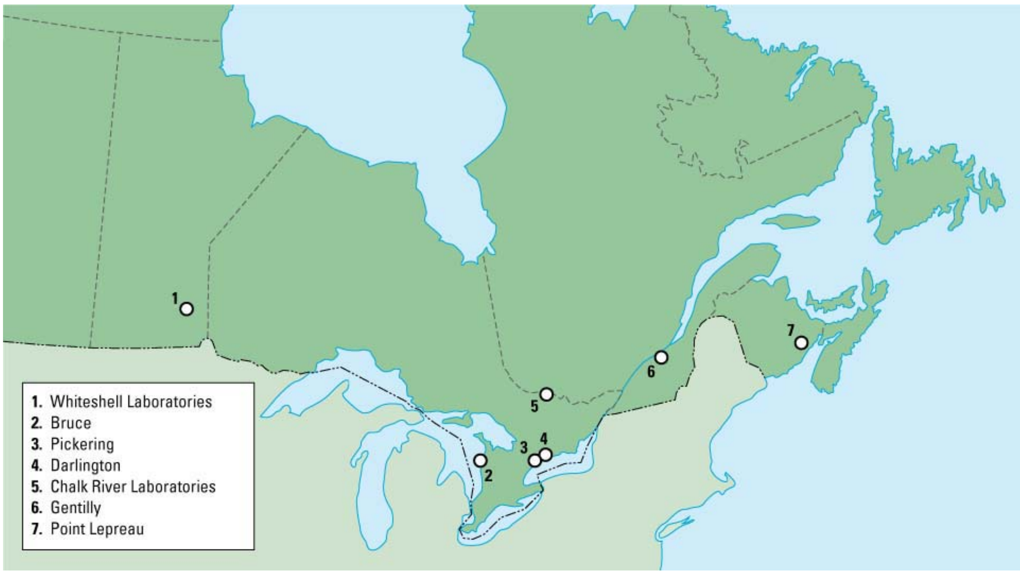
The purpose of this report is to document a realistic cost estimate for an assumed program to site, develop, construct, operate, monitor, decommission and close a DGR facility that will accept all Canadian used nuclear fuel.

1.2 STORAGE OF USED FUEL

The used fuel from Canada's power reactors is currently stored by the owners in water-filled pools (wet storage), or concrete structures (dry storage). Most of the fuel is stored at the locations where it has been produced. Storage locations are shown in Figure 1 and assumed inventory data are presented in Section 3.2 of this report.

Handling and transport costs from storage locations to the DGR are excluded from this cost estimate. These costs are reported elsewhere.

Figure 1: Existing Fuel Storage Locations in Canada



1.3 ESTIMATING ASSUMPTIONS

To estimate future costs for a program to site, design, construct, operate, monitor and decommission and close a facility for the emplacement of used fuel, the following high-level assumptions were made. Changing any of these assumptions has the potential for altering the final project cost obtained. Therefore, for the estimate to remain valid these assumptions require regular scrutiny, and any change in the assumptions will necessitate the estimate to be reviewed.

Siting Phase

1. All DGR technical development work will be completed at the time when site characterisation work is complete in the Underground Characterisation Facility (UCF).
2. The estimate considers only costs relating to the implementation of a stand-alone DGR located on the Canadian Shield.
3. The estimate assumes the program will be continuous with no hold points or abnormal periods of inactivity whilst awaiting say, funding approvals, management reviews or licensing decisions. However, the cost estimate has assumed reasonable time periods for the completion of various siting tasks.
4. Used fuel container (UFC) design optimised and prototype container built prior to submission of CNSC licence and federal EA hearing for preferred site (i.e. container design 95% complete while whole facility design will be 50% complete).

Construction Phase

5. Detailed final design and the preparation of working drawings for the facility will commence immediately following the completion of in-situ testing of the preferred site in the UCF.
6. The DGR will be sufficiently remote to require the construction of a townsite to service the facility.
7. The underground repository will be a network of horizontal tunnels and emplacement rooms excavated at a depth of 1000 m in plutonic rock, with vertical shafts extending to surface. It is assumed that during construction of the underground facilities, unsuitable rock conditions will not be encountered.
8. The repository will accommodate underground characterisation, technology demonstration and monitoring tests during operations and extended monitoring until the site is ready for decommissioning.

Operations Phase

9. The DGR operations will commence following the construction of the surface facilities, shafts, underground infrastructure and initial emplacement room panels.
10. The design throughput of the DGR will be 120,000 used fuel bundles per year resulting in the disposal of 371 UFCs/annum.
11. All used fuel will be delivered to the DGR via road. The cost of transportation to the DGR facility is excluded from this estimate.
12. The DGR will have all necessary staff and equipment to unload a transportation cask from the transport vehicle, conduct radiological surveys, unload nuclear fuel waste from the cask and to prepare the empty cask for the return journey. The cost of these facilities and activities is included in the DGR estimate.
13. The used fuel packaging plant is located at the DGR facility site.

14. All used fuel delivered to the DGR will be received at the packaging plant in transportation casks and then packaged for emplacement underground.
15. Prior to completion of the townsite all site labour will be deemed migrant and eligible to receive allowances and enhancements/living/travelling expenses. Following the construction of the townsite all labour will be deemed indigenous and will not receive disruption payments. However, it will be assumed housing and facilities will be provided free of charge in lieu of disruption payments.
16. The UFC copper container and inner vessel will be fabricated at an unspecified off-site location(s) and then shipped 1000 km to the DGR site. The cost of the copper container and inner vessel will include the cost of transportation to the site.
17. Used fuel bundles will be delivered to the DGR site at annual rates shown in Table 1.
18. The DGR site infrastructure, surface buildings and underground works will be held in a care and maintenance regime for 70 years (extended monitoring) following the completion of UFC emplacement operations. After this time the site infrastructure and surface buildings will be made good for use during the decommissioning of the overall facility. By adopting this philosophy, all facilities will also be available for use should monitoring of the DGR identify the need to retrieve emplaced UFCs at any time during extended monitoring.

Decommissioning and Closure Phases

19. Shaft linings and any damaged rock will be removed and all shafts will be sealed to prevent the migration of contaminants via repository shafts to ground surface. Permanent construction materials such as reinforced concrete floors in access tunnels and emplacement rooms will not be removed prior to closure, except for sections of the concrete floors, which are removed and replaced with clay-based sealing materials across the width of the tunnels and emplacement rooms.
20. All mechanical and electrical services including rails will be re-used where appropriate and removed prior to closure.
21. Closure activities will commence 70 years following the completion of UFC emplacement operations. During this pre-closure period the emplacement rooms will be sealed but the tunnels and shafts will remain open so that access to the emplacement rooms is maintained.
22. When all tunnels, shafts and exploratory boreholes are sealed, it is assumed that the closed repository will be passively safe; that is long-term safety will <u>not</u> depend on institutional controls during the post closure period
23. After a Site Abandonment licence has been secured from CNSC there are no longer any licenced activities on the site. At such time the implementing organisation no longer has to fund any activities on the site.

General

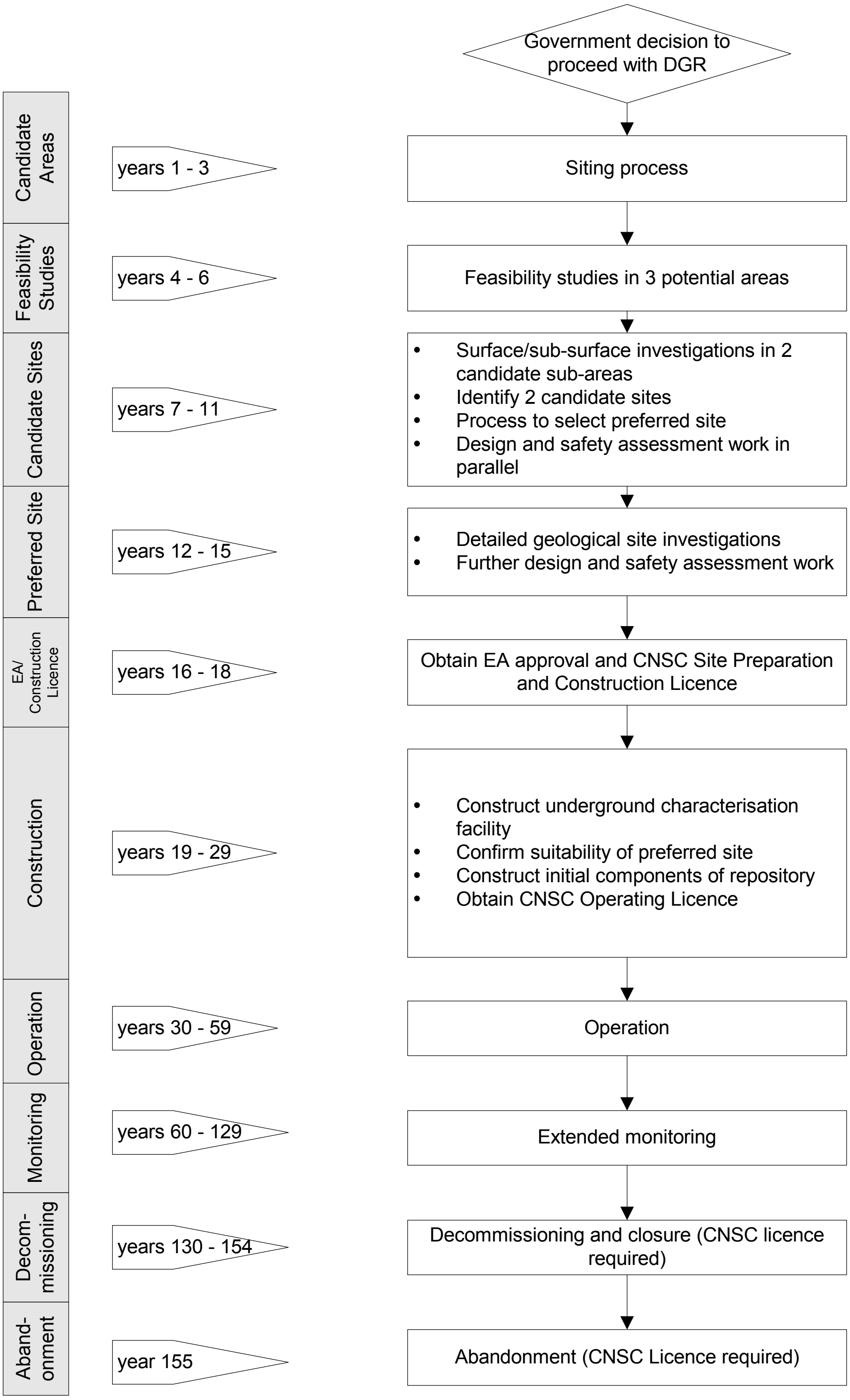
24. All labour, equipment and material costs are inclusive of any profit.
25. The estimate is based on a DGR design that only receives CANDU used fuel bundles from OPG, NBP, HQ and AECL.
26. The DGR is designed to accommodate all the CANDU fuel waste owned by OPG, NBP, HQ and AECL. The scope of this study excludes consideration of non-standard fuels, however, an allowance is made in the repository capacity to account for the volume required to dispose of a small existing inventory of non-standard used fuel.

27. Allowances for property tax for the DGR and provincial sales tax are included in the cost estimate.
28. All costs reflect the cost of local labour and materials.
29. The estimate is prepared and budgeted in current dollars, base January 2002, and will be scheduled in elapsed time.

The more detailed estimating assumptions associated with the lower levels of the WBS are included on work element definition sheets (WEDS) for each individual activity - see Annex 2.

Figure 2 illustrates the assumed sequence of activities and their durations through the phases of siting, construction, operation, decommissioning and closure.

Figure 2: DGR Flowchart of Activities – for Cost Estimating Purposes



1.4 LEVEL OF COST ESTIMATION

The ‘in-room’ emplacement DGR design is at a conceptual level of development. The program to site and develop the facility is in outline only, and no specific site has been identified. The estimates are therefore approximations, based on the level of detail, experience and judgement of the estimators, at the time of preparation, in 2002/2003.

The DGR program is still in the early stages of planning, and thus the facility design and other elements of the program will require further development, should the approach be selected by the federal government. Therefore, the DGR conceptual cost estimate is based on incomplete design information, information about technology that is in the early stages of development, and many assumptions about the program and how it will be executed. As a result there is uncertainty associated with various elements of the estimate. However, as the DGR program develops, so the uncertainty in future estimates will be reduced and the accuracy of the estimates increased.

To compensate for these inherent inaccuracies in the estimate due to uncertainties in the DGR program, a contingency has been assigned to the cost of each work element of the estimate. Further discussion on the level of contingency and its exclusions are covered in Section 5.4.4 and Appendix F.

2 Overview of a Deep Geologic Repository Work Program

2.1 OVERVIEW

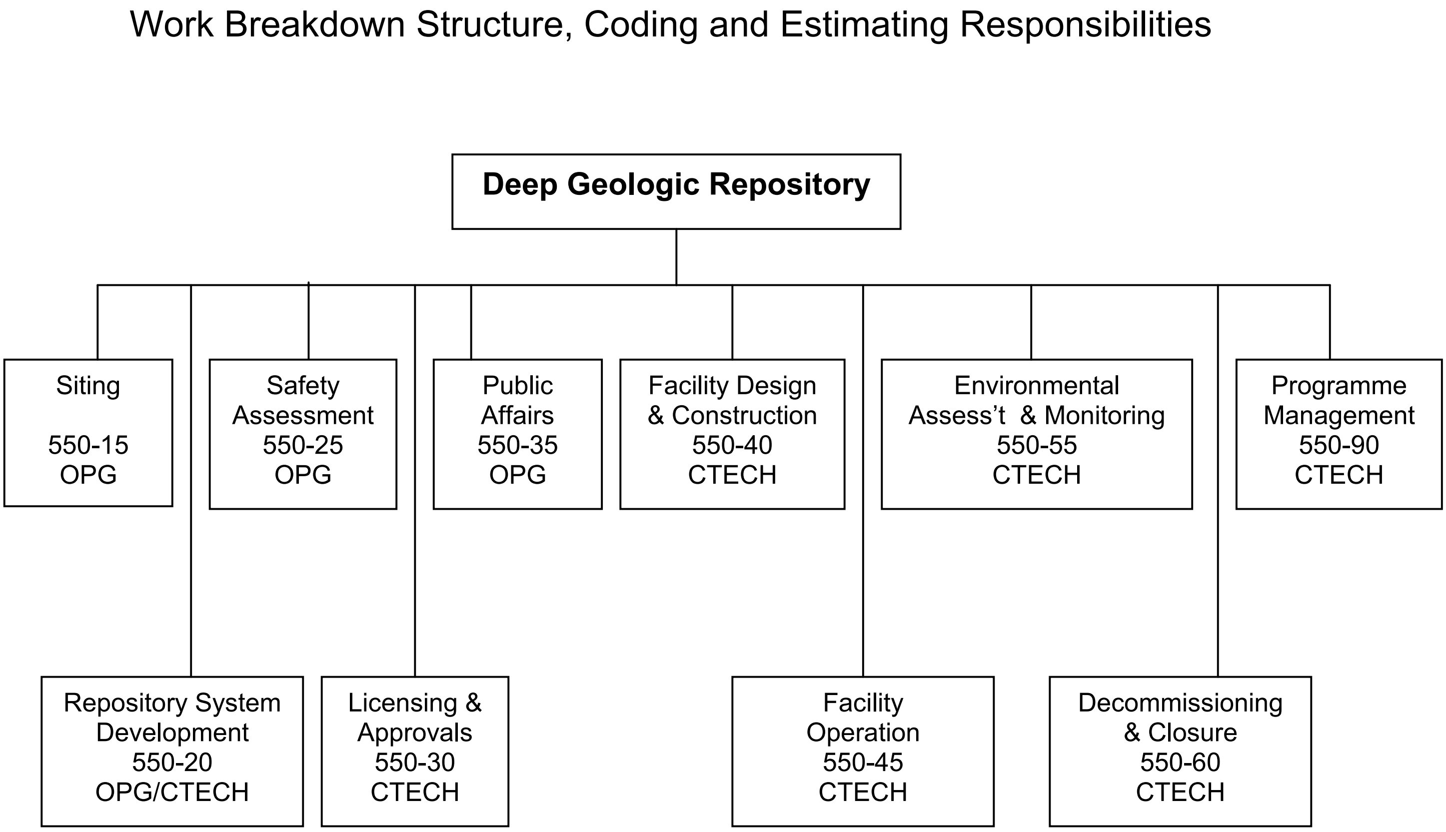
The DGR design process that has led to the facility description provided in this report, has involved the application of design parameters and specifications set by previous development work [3]. Using these parameters and specifications together with information from existing repository design experience drawn from the international sphere, a conceptual DGR design was produced and analysed. This procedure was an iterative process, resulting in the design presented being based on current engineering practices as well as theoretical assessments.

The amended conceptual design developed by CTECH [1], adopts the ‘in-room’ emplacement of UFCs within a repository constructed at a depth of approximately 1000m on the Canadian Shield.

2.2 LEVEL 2 WORK BREAKDOWN STRUCTURE

Figure 3 shows the DGR Project work elements at Level 2 of the program WBS. There are 10 Level 2 work elements which cover all the aspects of a program to site, develop, construct, operate, monitor, decommission and close a DGR facility for used fuel. A listing of all subordinate levels of this WBS are given in Appendix B.

Figure 3: DGR Level Two Work Breakdown Structure



2.2.1 550-15 Siting

Siting includes all activities related to planning and implementation of a siting program for the DGR facility. Siting occurs during the period Y1 to Y18. Planning activities include development of a siting strategy, development of siting process, development of siting criteria and public consultation. Implementation activities include site screening, environmental studies, geological characterisation and site investigations at candidate sites and at the preferred site. Costs for the construction of an Underground Characterisation Facility (UCF) are included under Facility Design and Construction (550-40).

2.2.2 550-20 Repository System Development

Repository System Development includes all activities related to the development of conceptual, feasibility and preliminary designs for the DGR. The work activities include the research, development and demonstration of repository system technology, preparation of drawings, descriptions, material lists, manning levels, equipment requirements, technical specifications and associated calculations. Work activities also include UFC development work including the manufacturing, sealing and testing of prototype containers. The output of these activities will become progressively more detailed as the facility design evolves.

System development excludes final design for the DGR. It also excludes engineering support during the construction, operations, decommissioning and closure phases of the facility.

2.2.3 550-25 Safety Assessment

Safety Assessment includes all activities related to the preclosure (including operations) and postclosure safety assessment of the DGR. Safety assessments will be required in support of all licence applications, and their renewal. Therefore, safety assessments will be carried through all phases of development, operation, extended monitoring and closure of the DGR.

Safety assessment includes R&D in support of the concept and assessment methodologies prior to the receipt of the operations licence (not engineering R&D and not site characterisation). It also includes a small ongoing research program during the operations and extended monitoring period in order to continuously test and improve the models used for predicting long-term safety, and to respond to any issues that may arise. The validation of these latter models against the actual repository performance during the extended monitoring period is likely to be a significant factor in the timing of a decision to close the repository (for example, peak temperatures are expected to occur within 30 years after UFCs are emplaced).

Also included in this WBS category is the geoscience monitoring program after completion of the siting phase. This monitoring program includes maintenance of the site hydrogeological monitoring network and maintenance of the reference site geosphere numerical model, which is a critical part of the postclosure safety assessment.

2.2.4 550-30 Licensing & Approvals

Licensing and Approvals includes interactions with all provincial and federal regulators, preparation and submission of licence applications for site preparation, construction, operations, decommissioning and abandonment.

2.2.5 550-35 Public Affairs (Years 1>>29)

Public Affairs work includes the development of a public affairs strategy to support the development and implementation of the public affairs strategy. The public affairs program is implemented through the phases of siting and construction (Y1 to Y29). Following Y29 the public affairs work program has been subsumed into Facility Operations (550-45) and Facility Decommissioning and Closure (550-60). A public affairs program provides information to key decision-makers, stakeholders, potential host communities, employees, media and the general public.

The scope of the public affairs program would include the following:

- Public involvement program
- Volunteer/host community program
- Impact management program
- Aboriginal affairs program
- Community information program
- Socio-economic impact assessment program

- Government relations program
- Interest group program
- Employee program

2.2.6 550-40 Facility Design and Construction

This includes the construction of all surface facilities, shafts, Underground Characterisation Facility (UCF), access tunnels and initial repository emplacement rooms at the preferred site, as well as the evaluation of subsurface conditions for construction purposes.

Construction includes all activities that are required to prepare the detailed final design drawings and to complete initial construction of the DGR. The scope of the work excludes on-going construction and equipment acquisition during facility operations. Construction will begin with the receipt of a Construction Licence.

2.2.7 550-45 Facility Operation

Facility Operation includes all activities required to operate the DGR including:

- Operation of the Used Fuel Packaging Plant (UFPP)
- Operation of the Sealing Materials Compaction Plant (SMCP)
- Operation of Underground Facilities (including emplacement of UFCs)
- Operation of auxiliary surface facilities and areas
- On-going construction of emplacement rooms and equipment acquisition
- Extended Operations (Monitoring) and Program Management (70 years)
- Site maintenance

2.2.8 550-55 Environmental Assessment and Monitoring

This includes the preparation of environmental assessment documents to support applications for a Construction Licence and a Decommissioning Licence. Work includes compilation of data, preparation of documents, document printing and attendance at Hearings.

Environmental monitoring provides the tools and processes for monitoring the environmental performance of the DGR facility. The monitoring program would be directed by the DGR's Environmental Management System (EMS), and the EMS would ensure that the implementing organisation's environmental policy is managed, implemented, checked and periodically reviewed within the overall context of continual improvement. It would provide both the process, and assurance, to ensure that the policy is improving the environmental performance of the DGR facility, while also demonstrating management's due diligence with respect to managing the corporation's environmental impacts.

For the purpose of the DGR cost estimate it shall be assumed that the EMS is based on ISO 14001. ISO 14001 describes a system based on continual improvement in the following five key areas: environmental policy; planning; implementation and operation; checking and corrective actions; and management review.

The EMS would require monitoring and continually improving environmental performance. The EMS encompasses all environmental aspects of the DGR facility including monitoring of radiological and non-radiological emissions to:

- Air
- Surface water and groundwater
- Soil
- Flora and Fauna
- Produce

The program would also include on-going monitoring of human health of the population in the vicinity of the DGR.

It is assumed that the implementing organisation's staff will manage and co-ordinate the overall EMS program. However, a specialised consultant will prepare the EMS plan. Specialised consultants will also carry out the collection, analyses and reporting of all data.

The scope of environmental monitoring is restricted to monitoring the potential environmental impacts due to the day-to-day operations of the DGR facility. The scope of this work element excludes monitoring of the groundwater regime at depths greater than 100 m (included in 550-15 and 550-25). Scope also excludes repository performance and seismicity monitoring (included in 550-45)

2.2.9 550-60 Facility Decommissioning and Closure

Decommissioning includes all activities that are required to prepare detailed decommissioning plans and then to complete the decommissioning activities at the DGR facility. An environmental assessment (EA) would be carried out in advance of the decommissioning work in support of an application for a Decommissioning Licence (see 550-55). Closure includes all activities required to complete final closure of the DGR facility. Closure activities include the removal of remaining facilities, sealing of monitoring wells, installation of permanent site markers and preparation of archive documents.

2.2.10 550-90 Program Management (Years 1>>29)

Program Management includes senior-level staff direction to the program, as well as, project management and financial and business support for the program up to the point where operations commence. Apart from program management activities all duties within the scope of Program Management will be carried out by the implementing organisation, whereas project management will be undertaken by contract Architect Engineers. Community compensation, property taxes, insurance costs and human resource services throughout the program are also included.

3 Description of the DGR

3.1 GENERAL

The DGR will include surface facilities for the receipt and packaging of used fuel in corrosion resistant containers, together with a series of underground emplacement rooms served by access shafts and tunnels all excavated in plutonic rock as illustrated in Figure 4. The DGR facility will be self-contained, except for the supply of materials and UFCs and their components, and will be located on a suitable rock body in the Ontario portion of the Canadian Shield. The DGR facility has been designed to receive, package and emplace CANDU used-fuel bundles at a rate of 120,000 bundles per annum. The design assumes that these used fuel bundles have been discharged from reactors and stored for 30 years prior to receipt at the DGR facility.

During operation, the used fuel will be received at the DGR used fuel packaging plant (UFPP) in road transportation casks that contain the used fuel bundles held in storage modules or in storage baskets. In the UFPP, the used-fuel bundles will be transferred from the storage modules or storage baskets to carbon steel fuel baskets with a capacity of 108 bundles. Three of these baskets will be loaded into a UFC.

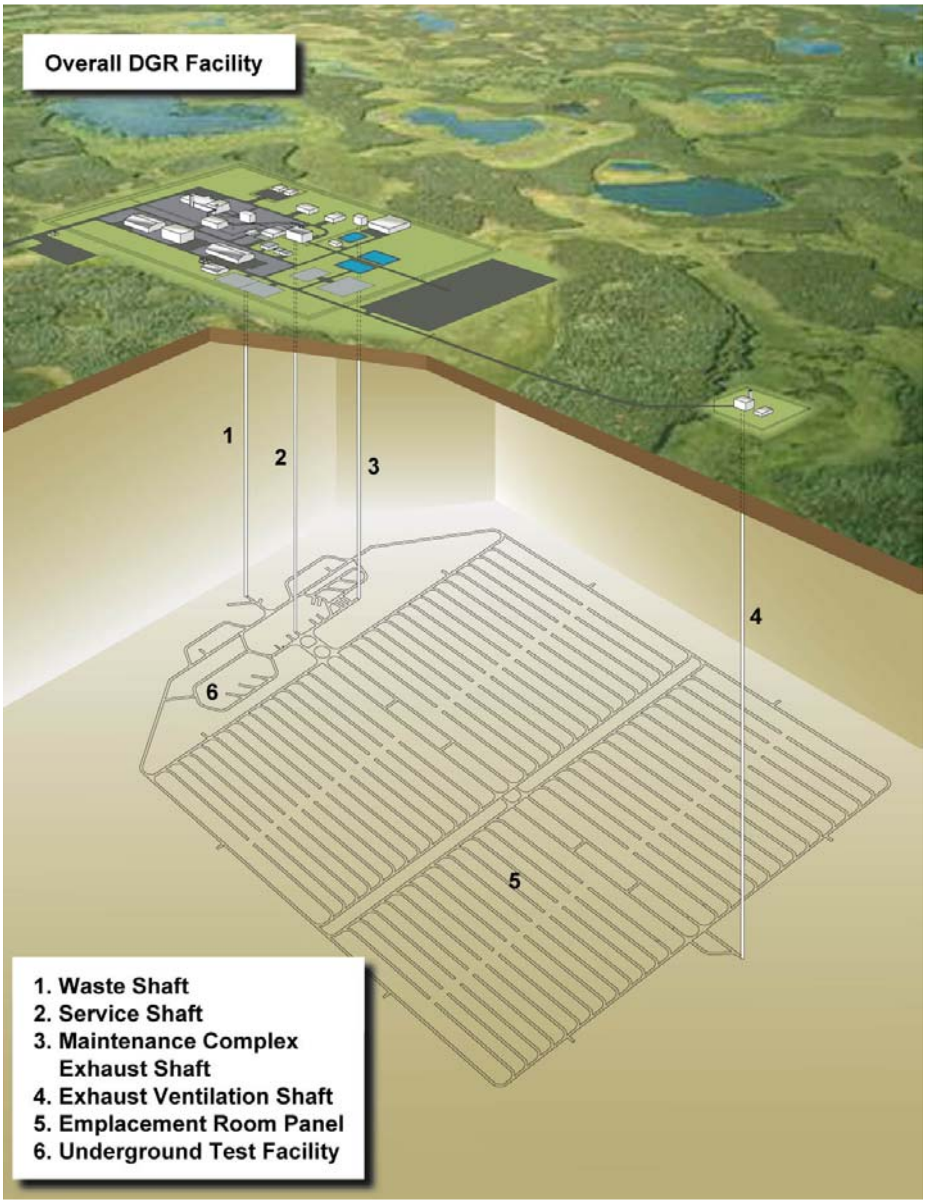
The UFC will be encased in a bentonite jacket and the entire assembly will be placed into a rail mounted, shielded UFC cask. Each loaded UFC cask will be transferred underground using a dedicated shaft (waste shaft) and will be driven by locomotive to either a surge storage area or directly to an emplacement room.

Emplacement rooms will be single-level, room-and-pillar type excavations designed for ‘in-room’ emplacement of individual UFCs. The layout of the emplacement rooms together with their access tunnels are assumed to be essentially square with a plan area of approximately 2 km^2.

The emplacement rooms will be excavated by the drill and blast method. A low-heat, high performance concrete floor structure will be laid and rails installed for rail-mounted equipment. Ventilation and utilities will also be installed. The concrete floor will provide a uniform base for the accurate placement of pre-compacted blocks of dense backfill and buffer sealing materials that will form the UFC emplacement structure.

As used fuel emplacement is carried out in one section, excavation of further emplacement rooms will be undertaken in the adjacent section on the opposite side of the DGR central access tunnels. In addition, sealing material blending and mixing and block compaction will be simultaneously performed in the sealing materials compaction plant (SMCP) located on the surface adjacent to the waste shaft complex. All transportation will be provided by rail-mounted equipment and will utilise the waste shaft for transfers underground.

Figure 4: General Arrangement of the DGR



3.2 DESCRIPTION OF USED FUEL INVENTORY

The cost estimates are based on a DGR design with a capacity to accept 3.6 million used fuel bundles. This projected used fuel inventory is based on the assumption that the Pickering, Bruce and Darlington reactors will operate 40 years, and that New Brunswick Power's Point Lepreau reactor will operate 25 years and Hydro-Québec's Gentilly reactor will operate 30 years. The actual assumed inventory is shown in Table 1 and the overall figure has been rounded up to the nearest 100,000 bundles to provide conservatism. This means that there is a small in-built contingency within the cost estimate due to the 1.2% rounding up of the predicted inventory. Although this may equate to approximately 130 containers or one emplacement room, it is considered that this will allow for any minor changes in the predicted volume of used fuel that may arise as inventory predictions are refined.

Table 1: DGR Assumed Used Fuel Bundle Inventory

Nominal Year	Year	OPG Wet Storage	OPG Dry Storage	NBP	HQ	AECL	Total
30	2035	113,565					113,565
31	2036	118,534					118,534
32	2037	118,534					118,534
33	2038	118,534					118,534
34	2039	119,373					119,373
35	2040	89,360		17,072	12,960		119,392
36	2041	87,858	2,000	17,072	12,960		119,890
37	2041	87,354	2,000	17,072	12,960		119,386
38	2043	64,275	23,860	17,072	12,960		118,168
39	2044	64,275	23,860	17,072	12,960		118,168
40	2045	34,709	53,999	17,072	12,960		118,740
41	2046	34,709	53,999	17,068	12,960		118,736
42	2047	11,174	94,738		12,960		118,872
43	2048		105,649		12,960		118,609
44	2049		105,894		12,960		118,854
45	2050		115,362		3,238		118,600
46	2051		119,010				119,010
47	2052		119,010				119,010
48	2053		119,010				119,010
49	2054		119,010				119,010
50	2055		119,010				119,010
51	2056		119,010				119,010
52	2057		119,010				119,010
53	2058		119,010				119,010
54	2059		119,010				119,010
55	2060		112,991			6,137	119,128
56	2061		112,991			6,137	119,128
57	2062		112,991			6,137	119,128
58	2063		113,211			6,137	119,348
59	2064		107,547			6,134	113,681
		1,062,253	**2,212,178**				
Totals		**3,274,431**		**119,500**	**132,838**	**30,682**	**3,557,451**
Percentage			**92.045**	**3.359**	**3.734**	**0.862**	**100.000**

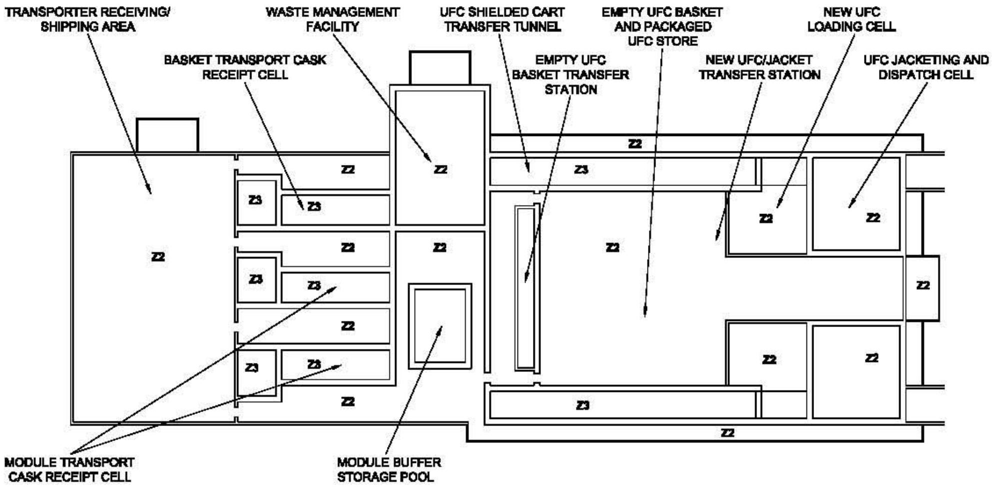
3.3 USED FUEL CONTAINER AND PACKAGING PLANT

During operation, it is assumed that the used fuel will be received at the DGR Used Fuel Packaging Plant (UFPP) in road-weight transportation casks that contain the used fuel bundles held in storage modules or in storage baskets. Two UFPP process lines will be provided to unload modules from their casks in receipt cells and a third line will allow storage baskets to be processed. In the fuel handling cells, the used fuel bundles will be transferred from the storage modules or storage baskets to carbon steel fuel baskets with a capacity of 108 bundles. Three of these baskets will be loaded into a UFC. Each bundle and UFC is monitored and accounted for nuclear material safeguards purposes during all transfer and emplacement operations. Plan layouts showing the main areas of the UFPP are shown in Figure 5.

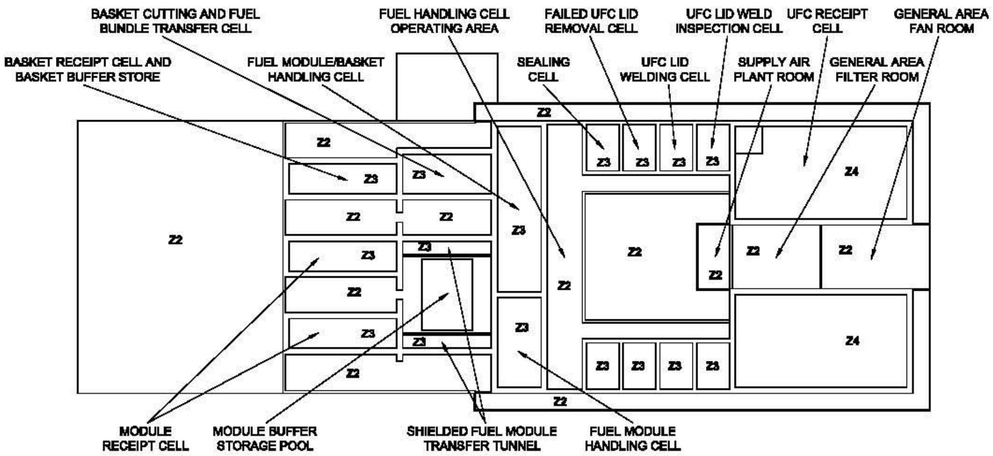
The UFC outer shell will be fabricated from oxygen-free, phosphorous doped (OFP) copper and has a wall thickness of 25 mm. The inner steel shell will be fabricated from carbon steel with a minimum shell thickness of 96 mm. Fuel baskets and complete UFC assemblies are assumed to be fabricated off-site and shipped to the DGR facility when required. The loaded UFC inner vessel will be fitted with a bolted lid, the air evacuated and replaced with inert gas, then sealed. Subsequently, the lid will be placed on the copper outer shell and assumed to be electron-beam welded to the body. The electron-beam weld will constitute the permanent containment seal of the UFC.

Following non-destructive testing of the UFC electron-beam seal weld using two independent techniques, the outer surface of each UFC will be monitored for contamination and decontaminated if required. Then, the UFC will be encased in a bentonite jacket and the entire assembly will be placed into a rail mounted, shielded UFC cask. The main parameters of the UFC are shown in Figure 6.

Figure 5: Plan Layouts of Used Fuel Packaging Plant

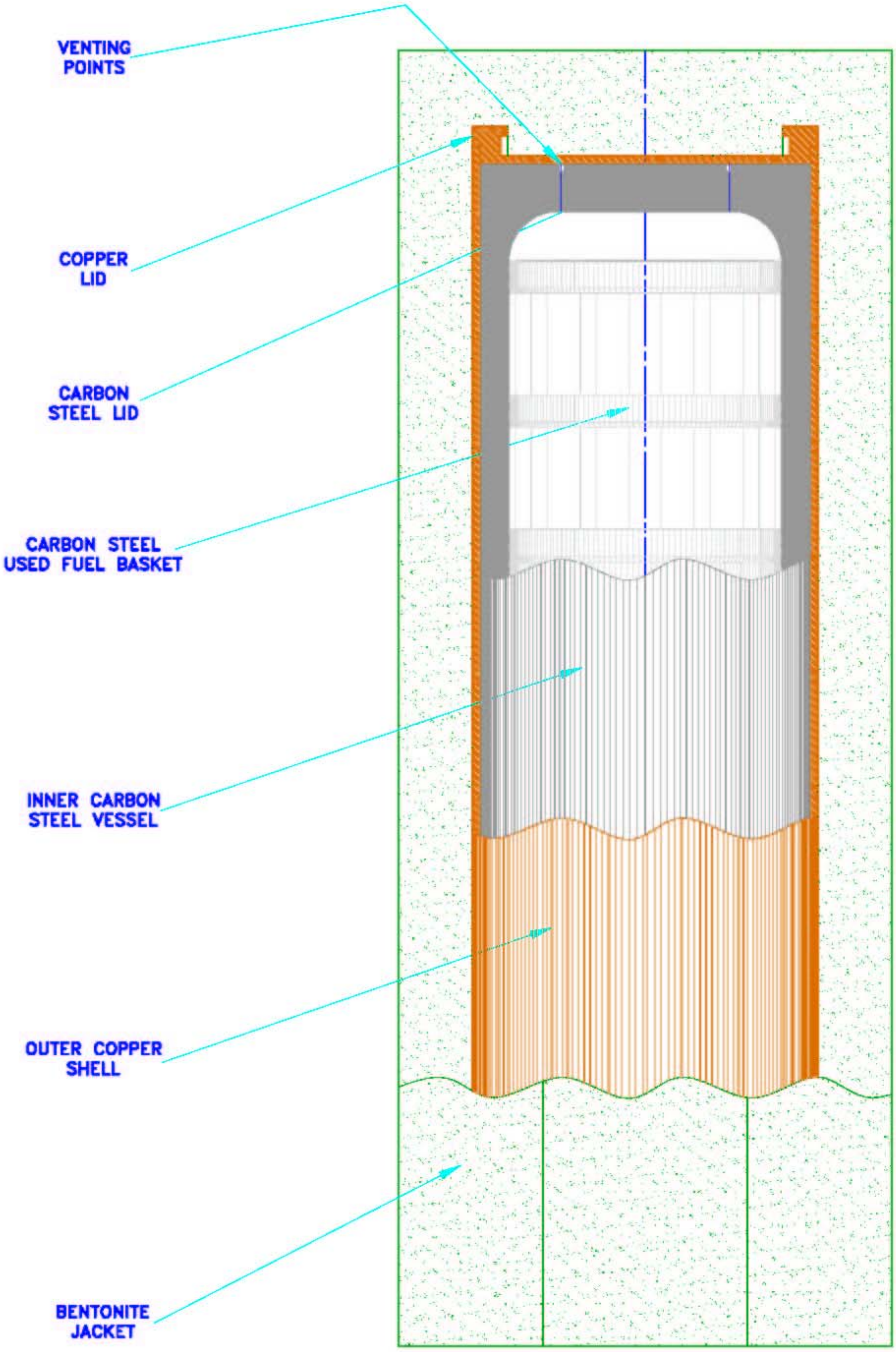


PLAN @ 0.00M LEVEL



PLAN @ O.OO, 4.10 & 12.05M LEVELS

Figure 6: Section through Used Fuel Container



3.4 UNDERGROUND FACILITIES

The major underground features are described in this section and include the shafts, component test area, access tunnels and emplacement rooms.

3.4.1 Shafts

The design of the repository incorporates four shafts, divided into two groups: the service shaft complex and the upcast shaft complex. The service shaft complex includes the service shaft (downcast), the waste shaft (upcast), maintenance complex exhaust shaft (upcast), UFC storage area, empty rail car storage area, loaded car storage area, UFC transport repair facility, central underground warehouse and stores, trackless excavation equipment maintenance complex, refuge station and other underground facilities. The upcast shaft complex is the location for the upcast ventilation shaft.

The finished shaft diameters are:

Waste Shaft	6.15 m diameter
Service Shaft	7.30 m diameter
Maintenance Complex Exhaust Shaft	3.96 m diameter
Upcast Ventilation Shaft	3.66 m diameter

3.4.2 Tunnel and Service Area

The component test area and maintenance facilities are located within the service complex and consist of a series of access tunnels similar to those described below with appropriate enlarged areas to allow for all routine maintenance activities and component testing to be undertaken. The total length of tunnels involved is approximately 3700 m.

3.4.3 Panel and Perimeter Access Tunnels

The access tunnels to the emplacement rooms will be sized to accommodate the UFC transport cask, transport of material and room-to-room transport of equipment. In addition, consideration has been given to the size of the underground mining equipment that will be used to develop the tunnels resulting in an access tunnel that is 7.0 m wide and 4.2 m high. The access tunnels will be rectangular in cross-section with an arched back. The total length of access tunnels required will be approximately 14,500 m.

3.4.4 Emplacement Rooms

Each loaded UFC cask will be transferred underground using a dedicated shaft (waste shaft). This shaft will also be used to transfer pre-compacted blocks of sealing materials underground on route to the emplacement rooms. The loaded wagon (or rail car) will be removed from the shaft at the emplacement room level to allow an empty rail mounted cask to be returned to the surface. Underground the loaded wagons will be driven by locomotive to either a surge-storage area or directly to an emplacement room.

Emplacement rooms will be single-level, room-and-pillar type excavations designed for in-room emplacement of individual UFCs. The layout of the emplacement rooms together with their access tunnels will be essentially square with a plan area of approximately 2 km^2 as shown in Figure 7. The layout will consist of 104 emplacement rooms arranged within 4 sections, each containing two panels, each comprising 13 rooms, serviced by approximately 14.5 km of access tunnels. Each emplacement room will have an elliptical shaped cross-section, nominally 4.2 m high and 7.14 m wide, and a length of 315 m. Each room will contain 108 containers, placed horizontally, two abreast at 2.52 m centre-to-centre spacing and at a longitudinal centre-to-centre spacing of 5.13 m.

UFCs encased within their bentonite jacket assemblies will be located within a mass of pre-compacted buffer and dense backfill blocks and associated sealing materials and structures. The centre-to-centre spacing between emplacement rooms is 45 m. The layout presented represents the minimum area that the DGR could be contained within, while satisfying the design parameters, and assumes that it will be located within a uniform sparsely fractured plutonic rock mass in the Canadian Shield. The actual configuration of the repository will be a function of the characteristics of the rock mass, and particularly, the presence of any structural discontinuities or other geological features that would require the relative location and geometry of the panels and access tunnels to be adjusted.

The emplacement rooms will be excavated by the drill and blast method. A low-heat, high performance concrete floor structure will be laid and rails installed for rail-mounted equipment. Ventilation and utilities will also be installed. The concrete floor will provide a uniform base for the accurate placement of pre-compacted blocks of dense backfill and buffer sealing materials that will form the UFC emplacement structure. The rails will provide a horizontal datum for alignment of the UFC cask with the emplacement room mobile shielding gamma gate. This shielded ‘port’ will provide access to the unshielded UFC emplacement equipment, comprising a central transfer/traversing table and two UFC insertion carts. Connection of the UFC cask to the gamma gate will allow a bentonite jacketed UFC to be passed through to the transfer/traversing table. From this location the UFC will be traversed to one of the two insertion carts designed to place the bentonite jacketed UFC in its final location. The insertion carts will be guided using slots located in the concrete floor to ensure accurate placement of the jacketed UFCs.

Before a UFC cask is received in an emplacement room, notionally 42 specially shaped precompacted blocks of dense backfill and 54 precompacted blocks of buffer will be placed along a 5.13 m long section of the room. The shape and arrangement of blocks provide two horizontal, octagonal key shaped slots, each capable of receiving a UFC and bentonite jacket assembly, followed by two shielding/sealing plugs of buffer material. The gap between the dense backfill blocks and the walls and roof of the room will be filled with a pneumatically placed light backfill, prior to placement of the UFCs.

With the blockwork emplacement structure in place, a UFC cask will be positioned in front of the emplacement area shield wall to allow the jacketed UFC to be withdrawn from the cask and onto a horizontal transfer/traversing table behind the shield wall. With the empty UFC cask removed from the emplacement room a loaded shielding/sealing plug cask will be positioned at the shield wall. Two shielding/sealing plugs will then be transferred from the cask and positioned behind the jacketed UFC on the transfer/traversing table. This table will allow the jacketed UFC and shielding/sealing plugs to be traversed across the room to the centreline of the emplacement location and onto an insertion cart. With the jacketed UFC and shielding/sealing plugs in place on the insertion cart the cart will be moved forward into the emplacement location within the emplacement structure. This procedure will be repeated for a second UFC that will be located in the other key shaped slot (emplacement location) within that emplacement room. With both jacketed UFC assemblies in position in the blockwork structure the insertion carts will be lowered simultaneously. The insertion carts will then be withdrawn and the remaining slot beneath the two jacketed UFCs will then be filled with pre-compacted dense backfill and buffer blocks, utilising lifting attachments mounted on the front of the insertion carts. Any void between the UFC jacket and the buffer mass will be filled using dry granular bentonite and rounded sand mixture. This material will be installed pneumatically through a hollow lance inserted into the top gap formed between the buffer plugs and pre-placed blocks. The cross-section of a filled emplacement room showing the emplaced UFCs, sealing material blocks, concrete floor and light backfill is shown in Figure 8. The temporary equipment, such as rails, ventilation ducting and mechanical and electrical services will be removed from the area to be utilised for placement of the next two UFCs.

The container emplacement operational sequence described above is repeated until the room is full, following which the room is sealed by a concrete bulkhead. Normally, four repository rooms will be worked on in parallel on a two-shift per day, five-day per week basis.

As used fuel emplacement is carried out in one section, excavation of further emplacement rooms will be undertaken in the adjacent section on the opposite side of the DGR central access tunnels. In addition, sealing material blending and mixing and block compaction will be simultaneously performed in the buffer and dense backfill preparation and block compaction plant located on the surface adjacent to the waste shaft complex. All transportation will be provided by rail-mounted equipment and will utilise the waste shaft for transfers underground.

Figure 7: Layout of Underground Facilities

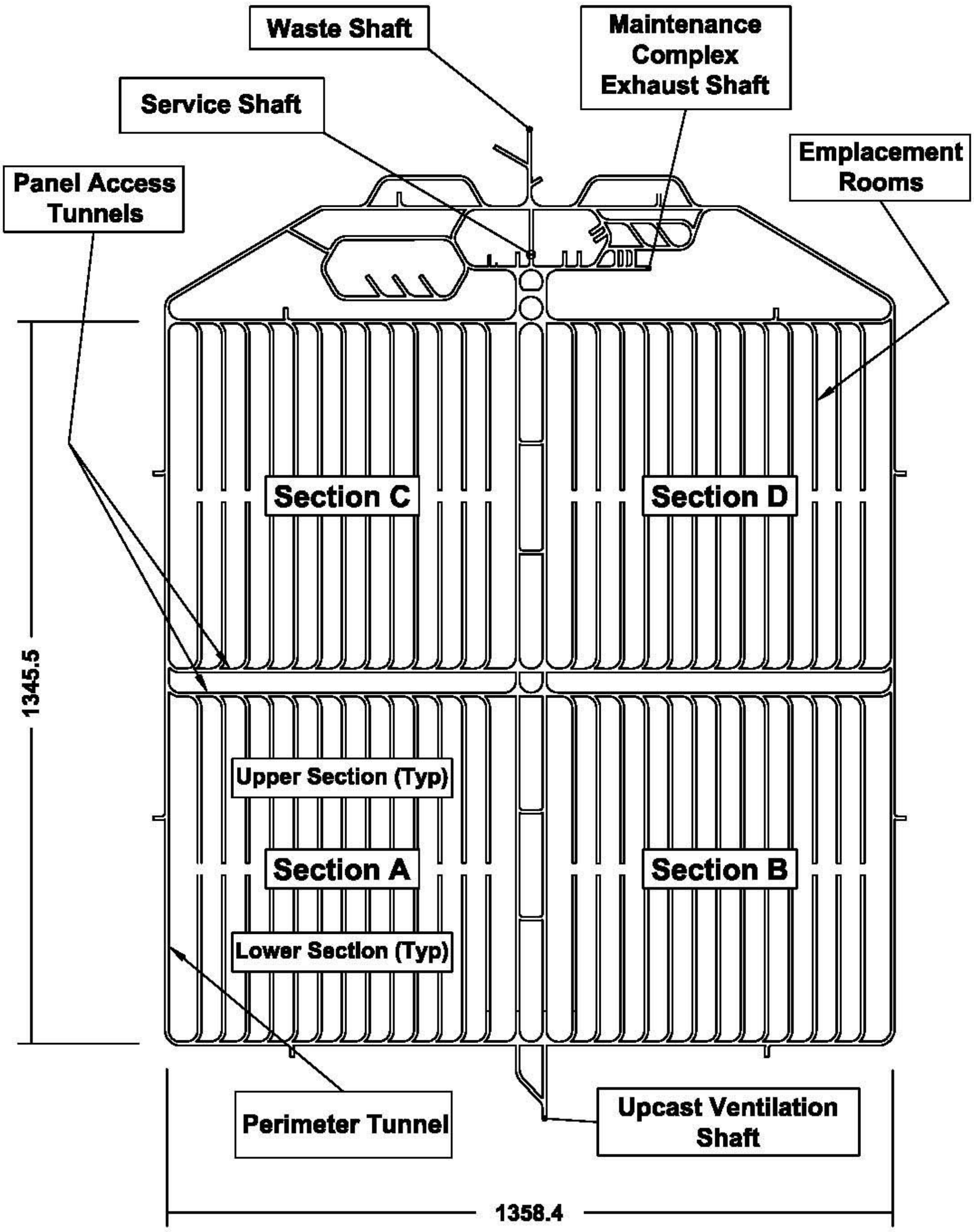
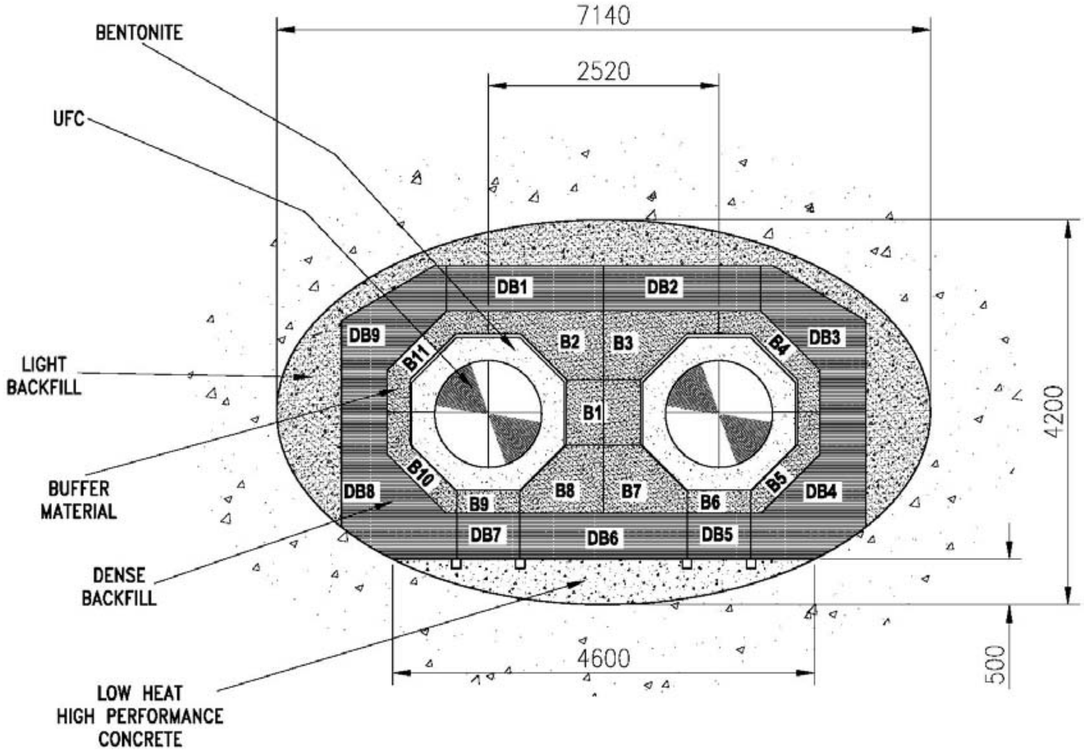


Figure 8: Cross-section of an Emplacement Room



3.5 AUXILIARY SURFACE FACILITIES

The DGR facility is assumed to be a remotely located, self-contained facility. The UFPP and a Sealing Materials Compaction Plant (SMCP) are assumed to be located at the site as well as all the other ancillary buildings, utilities and services to make the facility self-sufficient -see Figure 9. These include the following:

Description	WBS Reference for Design and Construction
Concrete Plant	550 40 05 40 20 20
Crushing Plant	550 40 05 40 20 25
Service / Production Shaft	550 40 05 40 20 40
Maintenance Complex Exhaust Shaft	550 40 05 40 20 41
Administration Building	550 40 30 10
Auxiliary Building	550 40 30 12
Firehall and Security Building (Guard House)	550 40 30 13
Active Liquid Waste Treatment Building	550 40 30 15
Garage /Warehouse	550 40 30 16
Sewage Treatment Plant	550 40 30 17
Water Treatment Plant	550 40 30 18
Emergency Power Generation	550 40 30 19
Pump House and Intake	550 40 30 20

QC Offices and Labs	550 40 30 21
Hazardous Materials Storage Building	550 40 30 22
Waste Management Area	550 40 30 25
Low Level Liquid Waste Storage Building	550 40 30 26
Service Shaft Water Settling Pond	550 40 30 27
Electrical Switchyard	550 40 30 28
Transformer Areas	550 40 30 29
Water Storage Tank Area	550 40 30 31
Process Water Settling Pond	550 40 30 32
Townsite	550 40 30 39
Overhead Corridor	550 40 30 41
Low Level Waste Storage Building	550 40 30 42
Fuel Tank Area	550 40 30 43
Storm Run-off Pond	550 40 30 44
Dust Collection Baghouse	550 40 30 45
Waste Shaft	550 40 40 20
Upcast Ventilation Shaft	550 40 40 40
Ancillary Facilities	550 40 40 65
Electrical Distribution	550 40 50
Communication System	550 40 60
Common Process Services Water Systems	550 40 70 10
Sewage Drainage and Treatment	550 40 70 20
Compressed Air (Surface and Underground)	550 40 70 30
Ventilation Systems	550 40 70 35

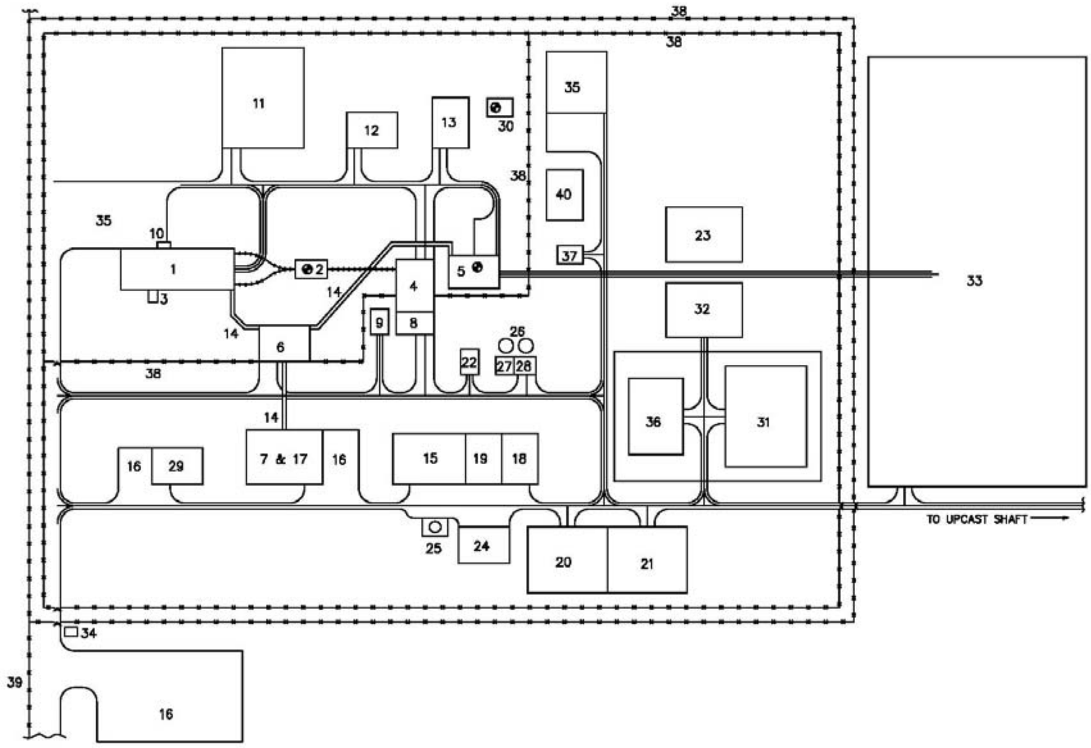
The UFPP is described in [1]. Descriptions of conventional ancillary buildings, utilities and services given in the estimate have not been described in detail since they are expected to be standard structures or facilities. The Townsite and the SMCP are described in the following sections.

3.5.1 Town Site

The estimate includes for the construction of a new townsite sized to accommodate a population of 3000 people. The following facilities will be provided:

Housing
Education
Health and Public Services
Municipal Services
Recreation Services
Commercial Services
Government Services
General Services.

Figure 9: Surface Layout of the DGR



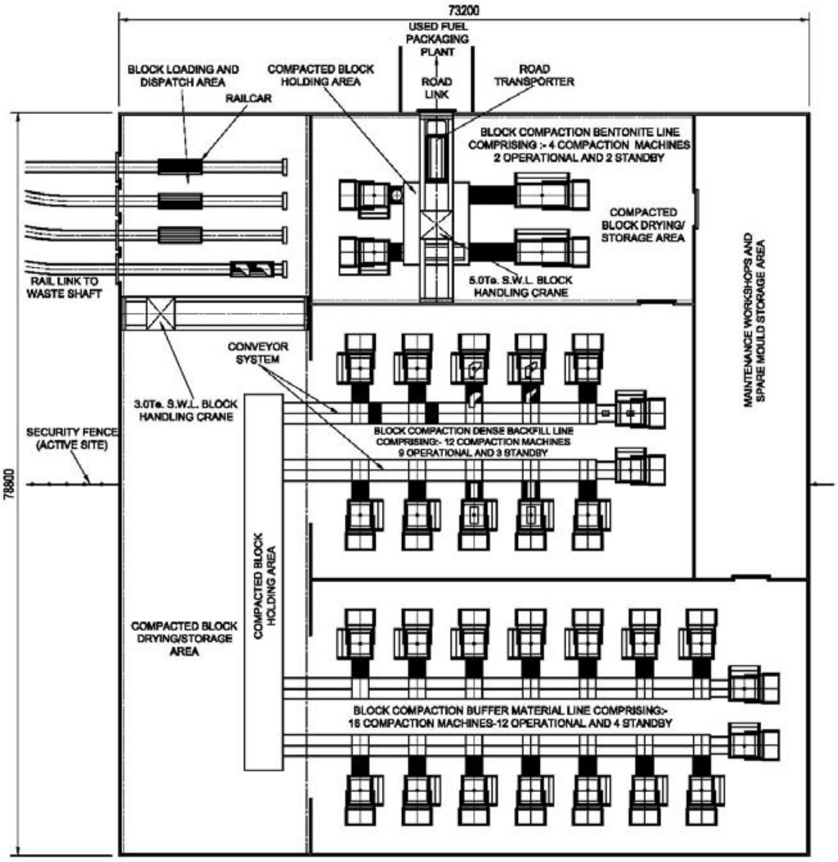
List of Buildings and Facilities:

1 Used Fuel Packaging Plant
2 Waste Shaft Headframe
3 Ventilation Stack
4 Sealing Materials Compaction Plant
5 Service Shaft Complex
6 Auxiliary Building
7 Administration Building
8 Sealing Materials Storage Bins
9 Dust Collection Bag House
10 Active Solid Waste Handling Facility
11 Waste Management Area incorporating Low Level Waste Storage Building
12 Active Liquid Waste Treatment Building
13 Low Level Liquid Waste Storage Area
14 Overhead Corridor
15 Garage
16 Parking Area
17 Cafeteria
18 Storage Yard
19 Warehouse
20 Switchyard
21 Transformer Area
22 Air Compressors
23 Storm Run-off Pond
24 Emergency Power Generation
25 Fuel Tanks
26 Water Storage Tanks
27 Water Treatment Plant
28 Pumphouse
29 Quality Control Offices and Laboratory
30 Maintenance Complex Exhaust Shaft
31 Rock Crushing Plant Area
32 Process Water Settling Pond
33 Waste Rock Disposal Area
34 Firehall & Security Building (Guard House)
35 Hazardous Materials Storage Building
36 Concrete Batching Plant Area
37 Sewage Treatment Plant
38 Main Security Fence
39 Perimeter Fence
40 Service Shaft Water Settling Pond

3.5.2 Sealing Materials Compaction Plant

The SMCP accepts raw materials for the sealing materials to be incorporated in the emplacement rooms, and manufactures a number of different sized pre compacted blocks in different materials. The plant incorporates a number of large presses to form the sealing material blocks together with raw material and finished block handling equipment. A proposed arrangement of the SMCP is shown in Figure 10, showing the layout of the presses required and how finished blocks could be handled within the plant.

Figure 10: Layout of the Sealing Materials Compaction Plant

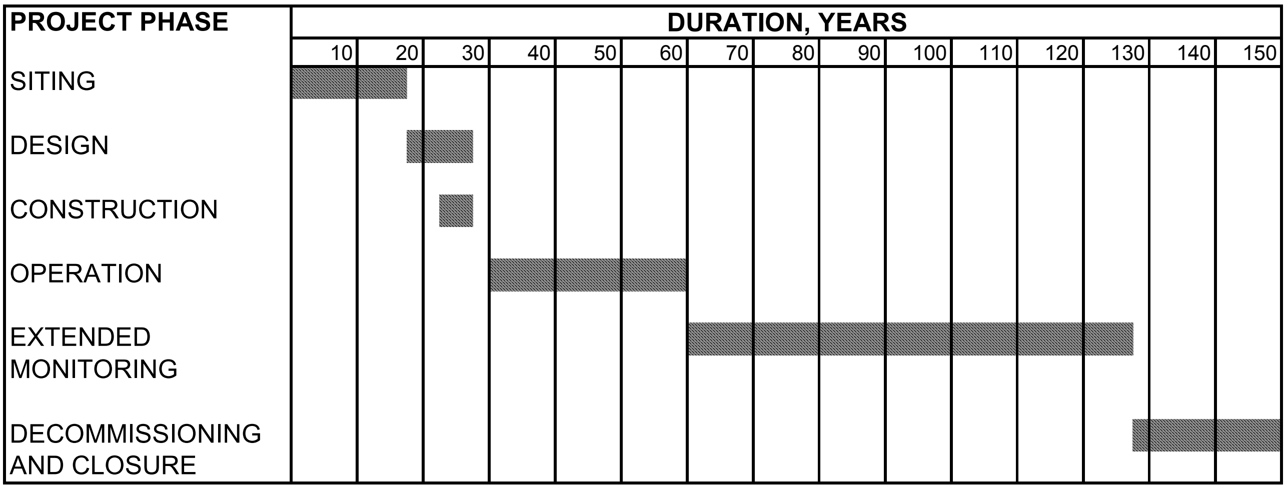


4 Schedule Estimate

4.1 OVERVIEW

This section presents a schedule estimate for the implementation of the project to site, develop, construct, operate, monitor, decommission and close a DGR for the emplacement of used fuel. The overall schedule for the work program is shown in Figure 11.

Figure 11: Overall Work Schedule for the DGR



The DGR program can be divided into two distinct periods; the pre-closure period and the post-closure period. The pre-closure period (Year 1-154) is the implementation of the DGR facility that includes all activities from siting through to decommissioning and closure of all components of the repository system. The costs for DGR activities during the pre-closure period are presented in this report. For the purposes of this estimate it has been assumed that the repository has been sealed and the site closed, and regulatory approval will be received to abandon the site; i.e. the DGR cost estimate does not include any post-closure costs.

The pre-closure period is divided into five major phases and the work activities to be completed in each phase are summarised below. More detailed information about the schedule estimate for work elements can be found on the work element definition sheets (WEDS) found in Annex 2.

The pre-closure period is divided into project phases as follows:

- Siting phase (Year 1-18)
- Construction phase (Year 19-29)
- Operation phase, including a 70 year extended monitoring period (Year 30-129)
- Decommissioning phase (Year 130-141)
- Closure phase(Year 142-154)

4.2 SITING PHASE

The siting phase covers the time period in which a suitable location for a DGR is being sought. It begins after a formal decision is made to start the process of finding a suitable site and would end when regulatory approval is received to construct the facility at the preferred site (assumed to be Years 1 - 18).

The siting phase would involve developing a siting process and site screening criteria, site screening and site evaluations, preparation of safety assessment and environmental impact documents, participation in public consultations and hearings, and the preparation of licence applications.

The implementing agency would be required to demonstrate, during the Environmental Assessment process, that there would be no adverse impact on the environment resulting from the construction, operation, decommissioning and closure of the DGR, and during the post-closure period. Whilst there would inevitably be much focus on the radiological component on the environment, the more conventional environmental concerns would also be addressed. A comprehensive environmental survey to measure and record the current background conditions at the proposed site would be conducted.

Site characterisation activities during the Siting Phase would involve an iterative process of investigation. Initially, non-invasive surface-based feasibility studies would be conducted at three candidate areas. These reconnaissance studies would then be followed by invasive surface-based studies at selected candidate sites (two) and the final preferred site. These activities would provide an understanding of site specific geosphere and biosphere conditions necessary to assess and communicate possible site suitability to host a DGR. These site characterisation activities would be coupled with stakeholder consultation to gain consensus and to select a preferred repository site.

During the siting phase, preliminary conceptual DGR designs would be prepared for each site being evaluated. Design work would be completed for the surface and underground facilities primarily to establish the access, utility and infrastructure requirements. These requirements would be assessed during site screening to ensure that they could be met at potentially suitable site locations in the areas selected for detailed evaluation. Details of the environmental and DGR monitoring program would also be developed, and the plan to incorporate this program into subsequent site evaluation activities would be prepared during site screening. Following the selection of a preferred site, a preliminary DGR design specific for the site would be completed prior to entering into the Environmental Assessment process.

The end point of the siting phase would be the receipt of a Construction Licence giving regulatory approval to begin construction of the DGR facility on the preferred site. It is anticipated that this would be a staged licence, with the first stage being construction of the UCF.

4.3 CONSTRUCTION PHASE

The construction phase (Years 19-29) in the life cycle of the DGR is the period when the underground characterisation facility, the functional surface and underground facilities and infrastructure are created for the purpose of used fuel emplacement. The phase begins with the receipt of regulatory approval to begin construction and ends when the inactive and active commissioning of the facilities are completed prior to receiving the first formal shipment of used fuel for emplacement.

The construction phase would involve constructing the infrastructure and surface facilities needed to emplace used fuel, the underground access ways and service areas, and a portion of the underground emplacement rooms. However prior to the start of full-scale construction there would be a period of underground evaluation in the UCF. Data gathered in the UCF would be used to confirm suitability of the site and to gather additional information for the detailed design of the DGR.

Underground investigations in the UCF will provide improved definition of the geotechnical parameters determined from surface investigations. As the underground evaluation proceeds, the design of the underground DGR would evolve as the geologic structures and characteristics of the site become better defined.

After the underground evaluation studies have been carried out and the final designs completed the construction of the full-scale DGR facility can begin. The purpose of the construction is to build all the facilities necessary for the operation of the DGR and its components. Provision is made in the design for concurrent excavation during the operations phase to provide further emplacement rooms at the required time.

4.4 OPERATION PHASE

The operation phase (Years 30-129) includes the 30 year period from Year 30 to 59, during which used fuel is placed into the DGR emplacement rooms, as well as a period of extended monitoring.

The operation phase would involve receiving used fuel transported to the DGR facility, sealing it in corrosion resistant UFCs, placing and sealing the UFCs in emplacement rooms, and constructing and preparing additional emplacement rooms. After the last UFC has been placed in the DGR there would be a period of extended monitoring.

The extended monitoring (Years 60 – 129) would involve monitoring and assessing the conditions in the vicinity of the DGR prior to decommissioning and closure of the DGR. The extended monitoring program makes use of the shafts and underground access tunnels while they are still available prior to DGR sealing in the decommissioning phase. Extended monitoring activities would include environmental monitoring, monitoring UFC performance and monitoring rock mass behaviour. The monitoring data would be used to confirm the long-term safety assessment of the sealed DGR.

Security is required during facility operations. The required level of security would depend on the security risk during the various periods of operation i.e. fuel packaging versus extended monitoring. [Note: The cost of security has been based on the best information available at the time of preparing the DGR estimate.]

The operation phase ends when approval is given to start decommissioning the DGR facility.

4.5 DECOMMISSIONING PHASE

The decommissioning phase is the period (Years 130-141) in the life cycle of the DGR, during which the surface facilities are decontaminated, dismantled and removed. The underground facilities are decontaminated (if necessary) and dismantled, with tunnels and shafts backfilled and sealed. At the end of the decommissioning stage the site will be in a state suitable to allow public use of the surface. However, access will still be denied by maintenance of fencing securing ongoing monitoring activities.

4.6 CLOSURE PHASE

Closure activities (Years 142-154) include dismantling the borehole monitoring instruments and sealing of the characterisation and monitoring boreholes that are surface based and which may compromise the integrity of the DGR system over the long term. The remaining surface facilities serving these ongoing monitoring activities will be removed together with all security measures. The objective is to return the site to greenfield conditions.

5 Cost Estimate

5.1 BASIS OF ESTIMATE

A conceptual cost estimate has been developed for the siting, design and construction of a DGR, its operation, including packaging of used fuel bundles in containers, the monitoring of the facility for a 70-year period following the emplacement of the used fuel, and its decommissioning and closure. The estimate is based on a conceptual design for a DGR facility, developed by CTECH in 2002 [1] and described in Section 3. For the purposes of this cost estimate it is assumed that the facility is stand-alone and self-sufficient, and that it has the capacity to receive the equivalent of approximately 3.6 million used fuel bundles over a 30-year period. The estimate is based on January 2002 costs and is prepared in constant dollars.

The cost estimate has been compiled by CTECH with input from OPG, specifically in the work elements relating to the Siting, Repository System Design, Safety Assessment and Public Affairs. Elements of the estimate undertaken by the various parties within CTECH are summarised below:

- Repository System Development – RWE NUKEM and OPG
- Licensing and Approvals – Canatom and OPG
- Facility Design and Construction – RWE NUKEM for all nuclear aspects of the surface facilities with SNC Lavalin for conventional surface buildings and all underground construction activities including ventilation.
- Facility Operation – RWE NUKEM for all surface facilities with nuclear implications, plus the Sealing Materials Compaction Plant and for underground emplacement activities. SNC Lavalin for ongoing underground construction and ventilation and remaining surface facilities.

- Facility Decommissioning and Closure - RWE NUKEM for all nuclear aspects of the surface facilities, SNC Lavalin for conventional surface buildings and supporting services and sealing of all underground openings.

- Environmental Assessment and Monitoring – RWE NUKEM and OPG

- Program Management – RWE NUKEM

The overall estimate has been co-ordinated and verified by RWE NUKEM in close liaison with SNC Lavalin and the other contributing parties.

5.2 MAJOR EXCLUSIONS

The costs for the following activities are not included in this estimate:

- Retrieval of used fuel or fuel-like materials from interim wet or dry storage, including retrieval of fuel from dry storage containers, silos and vaults
- Transportation of the used fuel and fuel-like materials from interim storage to the DGR
- Disposal of non-standard fuels within the DGR
- Retrieval of UFCs emplaced within the DGR
- Cost allowance for Goods and Services Tax
- Allowance for escalation in costs
- Reserve to deal with natural disasters, industrial disputes, changes in government policy and other major events or conditions that are beyond the control of management
- Provision of Performance Bonds.

The estimate is based on a design that assumes fuel will be delivered to the DGR site via road. It is possible that some fuel could be transported in OPG dry storage containers, via ship or rail, with a road link to the DGR site. In this scenario an auxiliary facility would be required on or near the DGR site to unload the dry storage containers and to transfer the fuel modules to the UFPP, or into an on-site transfer cask. This auxiliary facility would be costed separately from the DGR. It is assumed that the UFPP design and estimate would not be affected significantly if the assumed transportation mode was changed to either rail or water, and a transfer facility was introduced into the overall system design.

5.3 METHODOLOGY

This section describes the methodology by which costs for the various work elements of the project were established.

On the basis of the DGR design update [1] and the perceived life cycle of the project, a WBS was developed whose level two work elements described the full implementation of the project, from siting to final closure. During the construction of the estimate a number of the lower levels of this WBS were developed to reflect the most appropriate method of presenting the estimated costs. The final form of this WBS is presented in section 2.2.

As all parameters relating to the implementation of the project are not known, it was necessary to remove this uncertainty and develop a set of high level assumptions to enable the boundaries of the estimate to be established. These assumptions, set out in section 1.3, were factors that effected more than one level two work element of the WBS.

The importance of these assumptions and their effect on the final estimated cost was appreciated during their formulation. Therefore, to ensure that the estimate did not provide an overall cost with an unjustifiable high upside margin, a policy was pursued of not adopting a predominance of overly conservative assumptions.

In addition to the high level assumptions, further assumptions were made to allow lower level work elements to be estimated. These assumptions together with the work element descriptions, delivery and basis for the contingency chosen, for each lower level work element, are recorded on WEDS. All WEDS prepared for the estimate, are presented in Annex 2.

The scope, schedule and cost information relating to each lower level work element identified in the WBS has been compiled using data entry transfer sheets (DETS). The DETS, in the form of Excel spread sheets, identify the type of resource required for each work element, it's quantity, rate, duration and total cost. In addition, DETS also list any references from where estimating data may have originated. Work element descriptions, delivery, assumptions and contingency basis as well as cost data listed on the DETS have been transferred on to a Microsoft Access Database from which WEDS are produced.

Information compiled on the DETS provides a valuable source of background information on the construction of the estimate and its costs. However, not all this information is included on the Database. Therefore, as part of the estimates auditable trail, all the project DETS have been compiled into a separate reference document and presented as Annex 3 to the Cost Estimate report. Further supporting information to the cost estimate has also been compiled and presented as Annex 1 of the Cost Estimate report, with the contents of Annex 1 listed in Appendix I.

The costs included in the estimate have been established using various methods. The particular method adopted depending upon the work element under consideration. Typical estimating techniques adopted and sources of information include:

- Previous experience i.e. to estimate Licensing and Approval costs, nuclear facilities construction and decommissioning, mining facilities construction
- Bulk material take-offs and suppliers quotations
- Published Rates per building volume/floor area [4]
- Quotations for major capital equipment costs i.e. building cranes, nuclear handling and containment equipment.
- Existing established databases i.e. SNC-Lavalin and RWE NUKEM
- Comparison with similar facilities
- Research i.e. UFC procurement costs

- Construction from base levels i.e. identification of individual process activities to establish resource levels.

The overall management structure and staffing levels were determined and cross-checked with comparable facilities were possible.

5.4 COST CATEGORIES

This section describes the four major cost categories that have been used in the cost estimate for each work element i.e. labour, materials and equipment, other and contingency.

5.4.1 Labour Costs

Labour cost is the salary plus labour burden. Implementing organisation labour cost does not include overhead costs, which are estimated separately. Purchased services labour cost includes overhead costs where applicable.

The labour resources used within the DGR conceptual estimate and the basis for the calculation rates are given in Appendix E. To simplify the number of different resources to be attributed to the project a selection of composite resources have been identified for each of the organisations involved in the project. These organisations can be summarised as:

Waste Management Organisation (WMO)
Purchased Services
Architect Engineer
Design and Build Contractor

The manning levels for each activity were estimated using differing methods depending on the activities being considered, details of these are given on the WEDS for each lower level activity.

5.4.2 Material and Equipment Costs

Material and Equipment Cost is the procurement costs of materials for construction, materials for the underground repository, permanent equipment and materials, including heavy equipment and plant to be used during operations e.g. UFPP facilities, sealing materials compaction equipment, laboratory and office equipment.

5.4.3 Other Costs

Other costs include items such as overheads, consumables (fuel, utilities and non-permanent materials), taxes, insurance, compensation, communication costs, and travel and accommodation expenses.

5.4.4 Contingency

The purpose of contingency is to improve accuracy of the cost estimate by compensating for the inherent inaccuracies due to uncertainties in the DGR program. Contingency has been assigned so that it is sufficient to compensate for the maximum range of inaccuracy associated with the work element estimate. The total DGR cost estimate is equal to the sum of all work element estimates and their associated contingencies.

Contingency has been assigned to the estimate by work element at the lowest level of the WBS (Appendix B). This approach was adopted to highlight any activities in the estimate subject to significant risk or estimating error, and to enable future work to be more focused.

The contingency levels that were applied are discussed in detail in Appendix F.

Contingency does not address the following:

- Cost of major delays in the program due to unforeseeable major events I.e. industrial disputes, natural disasters
- Cost of major scope or quality changes i.e. more extensive siting program, different UFC material, change in size of the underground layout
- Cost due to possible regulatory changes regarding disposal
- Cost due to policy decisions by federal or provincial governments regarding disposal.

5.5 ASSUMPTIONS

The major high level assumptions are listed in Section 1.3. More detailed assumptions are compiled in the WEDS presented in Annex 2.

5.6 STAFFING

The required staffing levels for each Level 2 element of the WBS have been estimated and are recorded on the individual DETS. To ensure that there was no overlap or omissions during the operational phase (the phase with the highest staffing levels), a summary of project staff was compiled from the individual DETS, with the results shown in Table 2. The majority of staff during this phase are Waste Management Organisation operations and maintenance personnel (OPG04). Running at an average of 415, the OPG04s are supported by approximately 50 Engineers, 84 administration staff and 18 Senior Managers. During this phase Architect Engineers and Purchased Services are relatively small in number and are required for the construction of the later stage emplacement rooms that are carried out on a campaign basis.

Not included in Table 2 are demobilisation, engineering (operations stage), and emplacement room construction Building Contractors all of which are employed during the construction campaigns. In addition, repository performance and seismicity monitoring personnel have also not been included in Table 2 as this activity (employing 9 WMO staff) spans year 30 to year 129.

Table 2: Summary of Staffing Levels Years 30 >> 59

	Waste Management Organisation Summary by Grade				Architect Engineer Summary by Grade			Purchased Services Summary by Grade			
YEAR	OPG01	OPG02	OPG03	OPG04	AE01	AE02	AE03	PS01	PS02	PS03	TOTAL
30	18	84	50	415	0	0	0	0	1	0	568
31	18	84	50	415	0	0	0	0	1	0	568
32	18	84	50	415	0	0	0	0	1	0	568
33	18	99	50	415	5	2	8	0	1	0	598
34	18	99	50	415	5	2	8	0	1	0	598
35	18	99	50	415	7	4	12	0	1	0	606
36	18	84	50	415	0	0	0	0	4	0	571
37	18	84	50	415	0	0	0	0	4	0	571
38	18	84	50	415	0	0	0	0	1	0	568
39	18	84	50	415	0	0	0	0	1	0	568
40	18	84	50	415	0	0	0	0	1	0	568
41	18	84	50	415	0	0	0	0	1	0	568
42	18	99	50	415	5	2	8	0	1	0	598
43	18	99	52	415	5	2	8	0	1	0	600
44	18	99	52	415	7	4	12	0	1	0	608
45	18	84	52	415	0	0	0	0	7	0	576
46	18	84	52	415	0	0	0	0	7	0	576
47	18	84	52	415	0	0	0	0	4	0	573
48	18	84	52	415	0	0	0	0	1	0	570
49	18	84	52	415	0	0	0	0	1	0	570
50	18	99	52	415	5	2	8	0	1	0	600
51	18	99	52	415	5	2	8	0	1	0	600
52	18	99	52	415	7	4	12	0	1	0	608
53	18	84	52	415	0	0	0	0	4	0	573
54	18	84	52	415	0	0	0	0	4	0	573
55	18	84	52	415	0	0	0	0	1	0	570
56	18	84	52	415	0	0	0	0	1	0	570
57	18	84	52	415	0	0	0	0	1	0	570
58	18	84	52	415	0	0	0	0	1	0	570
59	18	84	52	415	0	0	0	0	1	0	570

The staffing levels for the Extended Monitoring Period have been estimated as a total of 67 WMO staff and 8 Architect engineers form Year 65 to 123 with slightly increased levels for the initial and final years. The WMO portion is made up of 19 operators supported by 11 Engineers, 27 administration staff and 10 Senior Management.

To provide a further indication of staffing levels that can be extracted from the estimate DETS, the numbers of WMO Program Management personnel and Architect Engineers for years 1 to 29 have been compiled and presented in Table 3. These show that the numbers for WMO Program Management run at an overall total of 17 for the first 12 years rising to a maximum of 29 for year 20 through to year 29. Architect Engineers commence in year 13 with 17 personnel for 3 years rising to 33 for the next 5 years with a maximum of 57 for the next 7 years reducing over the last 2 years. It should be noted that these are only the management staff during this phase and do not include personnel undertaking activities involved in siting, repository systems development, safety, licensing and approvals, public affairs and facility design and construction.

Many of these personnel are contract labour with their numbers determined by interrogation of individual DETS presented in Annex 3.

Table 3: Summary of Program Management Staffing Levels Year 1 to 29

	Waste Management Organisation - Summary by Grade and Total					Architect Engineer - Summary by Grade and Total			
	OPG01	OPG02	OPG03	OPG04	TOTAL	AE01	AE02	AE03	TOTAL
1	7	6	4	0	17	0	0	0	0
2	7	6	4	0	17	0	0	0	0
3	7	6	4	0	17	0	0	0	0
4	7	6	4	0	17	0	0	0	0
5	7	6	4	0	17	0	0	0	0
6	7	6	4	0	17	0	0	0	0
7	7	6	4	0	17	0	0	0	0
8	7	6	4	0	17	0	0	0	0
9	7	6	4	0	17	0	0	0	0
10	7	6	4	0	17	0	0	0	0
11	7	6	4	0	17	0	0	0	0
12	7	6	4	0	17	0	0	0	0
13	9	6	6	0	21	6	3	8	17
14	9	6	8	0	23	6	3	8	17
15	9	6	8	0	23	6	3	8	17
16	9	6	10	0	25	11	6	16	33
17	9	6	10	0	25	11	6	16	33
18	9	6	10	0	25	11	6	16	33
19	9	6	10	0	25	11	6	16	33
20	9	10	10	0	29	11	6	16	33
21	9	10	10	0	29	20	11	26	57
22	9	10	10	0	29	20	11	26	57
23	9	10	10	0	29	20	1	26	57
24	9	10	10	0	29	20	11	26	57
25	9	10	10	0	29	20	11	26	57
26	9	10	10	0	29	20	11	26	57
27	9	10	10	0	29	20	11	26	57
28	9	10	10	0	29	11	6	16	33
29	9	10	10	0	29	6	3	8	17

5.7 TAXATION AND COMMUNITY PAYMENTS

Taxation, community offsets and benefits are addressed in the Program Management work elements (550 45 05, 550 45 50 05, 550 60 05, 550 60 80 and 550 90) of the estimate.

Provincial Sales Tax (PST) is levied at 8% on such items as office supplies, computers, telecommunication services, labour on services to repair equipment, clean offices, remove snow and travel services. The total cost of these equipment, supplies and services were estimated and multiplied by 8% to obtain an estimate for PST. It has been assumed that PST on materials that would be purchased by a contractor to build property (e.g. buildings, rock caverns, roads and fences) or to install fixtures (e.g. cranes, pumps and processing equipment) is part of the estimated cost and is not shown separately. All equipment and materials used directly in processing, packaging and emplacement of used fuel have been assumed to be is exempt from PST.

The potential cost of Goods and Services Tax (GST) has not been included in the cost estimate. Land transfer tax has been captured under 550-40-10 and is included in the site acquisition costs.

Property Tax is levied at two separate rates, depending on the assumed designation of the buildings, which comprise the DGR facility. The UFPP is considered to be a large industrial manufacturing facility and rated at 4% of the assessed value. The ancillary buildings are considered as commercial industrial buildings, and rated at 3% of their assessed value. These property tax rates were supplied by OPG and are based on tax rates applied to their existing used fuel dry storage facilities. To estimate the property tax it was assumed that the assessed value of structures is 50% of the estimated construction cost.

Allowances for community offsets and benefits have been included in the cost estimate. It recognised that the actual amount of offsets and benefits would ultimately be determined through negotiations between the implementing organisation and the local community. However, for the purposes of this cost estimate it has been assumed that during Y19 to Y29 payment is provided at a rate of $518,000/a. During Y30 to Y129 the payments are assumed to be $68,500/a and during the period Y130 to Y154 the payments are reduced to $52,800/a. These payments would cover the cost of various items including a liaison committee, workforce accommodation and infrastructure improvements, road maintenance and upgrades, emergency service equipment and training, and municipal services and infrastructure improvements.

5.8 INSURANCE

Allowances for insurance are included in the Program Management work elements of the estimate. The following specific insurance has be included in WBS 550 45 5:

Commercial general liability - $65,000/a
Director's & officer's liability - $70,000/a
All risk property insurance - $40,000/a
Vehicular insurance - $600/vechicle
Nuclear liability insurance - $65,000/a

These rates are based on OPG experience and are assumed to be applicable for periods when the fuel is being received and handled at the DGR facility. Lower rates are assumed prior to start of operation, during period of extended monitoring and during decommissioning and closure.

5.9 WASTE ARISINGS

The DGR facility will generate waste streams, particularly during the packaging of fuel, and the dismantling and decommissioning of the surface facilities at the end of their service lives. The waste facilities on the DGR site provide simple waste sorting/segregation/decontamination and interim storage until sufficient waste volumes have been generated, which merit transport off-site. The three principal waste streams are assumed to be low level waste (LLW), intermediate-level waste (ILW) and free release waste.

LLW waste comprises radioactive waste, in which the concentration or quantity of radionuclides is above clearance levels established by the regulatory body (CNSC). This waste does not necessarily require management in a deep geological repository. It contains primarily short-lived radionuclides (half-lives shorter than or equal to the half-life of Cs-137, 30.2 years). It is expected that approximately 31,530 m^3 of LLW will be generated during the 30-year Operation Phase. In addition, approximately 1,125 m^3 of LLW will be generated during the Decommissioning and Closure Phases (see Annex 1, ED033).

The operational LLW will be comprised of empty fuel modules, empty fuel baskets and other solid and liquid LLW produced during the operation of the UFPP. It is assumed, for the purpose of this cost estimate, that the 34,112 empty modules and 4,717 empty fuel baskets will be generated over the 30-year period with a total volume of 28,530 m^3 (see Annex 1, ED039). The empty fuel modules and empty baskets are decontaminated and then held in interim buffer storage. Other solid and liquid LLW will be generated in the UFPP, with the solid LLW being placed in 200-L drums with little to no processing. Liquid LLW will be generated during decontamination of the fuel modules and baskets and during periodic wash downs of active cells and facilities. The liquid wastes will be sent to an on-site treatment facility where it will filtered to reduce its activity levels, sufficient to allow the filtrate to be discharged to a local river course. The spent filter media and residues will be encapsulated to produce approximately 200, 200-L waste drums per year, or 1200 m^3 over 30 years. In total, approximately 15,000, 200-L drums of LLW will be produced over the 30 year operations phase, or about 3,000 m^3. All solid LLW will held in interim buffer storage until sufficient quantities are available for shipment off-site in re-usable full-height ISO freight containers.

ILW comprises radioactive non-fuel waste containing sufficient quantities of long-lived radionuclides (half-lives longer than or equal to the half-life of Cs-137, 30.2 years) that deep geological disposal is a suitable alternative for providing isolation from the environment for the long-term. It is assumed that ILW will be generated as spent resins or filters in the water purification system for the fuel-module buffer-storage pool. The ILW will be packed in 500-L drums or containers, and shipped off-site for processing and disposal as it is generated i.e. no interim storage. It is assumed that 12, 500-L drums of ILW will be generated each year for a total volume of 180 m^3 over 30 years.

Free release waste comprises waste in which the concentration or quantity of radionuclides is below clearance levels established by the regulatory body (CNSC). Most of the free release wastes will be generated during decommissioning of the DGR facilities. The waste will largely comprise bulk materials (concrete, rubble soil etc) and ordinary industrial wastes, such as plastics and scrap metal, including structural frameworks, ventilation ducts and piping produced by facility dismantling activities. Waste materials from facility dismantling activities that are certified to be free of contamination by radioactive or hazardous materials i.e. free release, will be released for conventional disposal. However, it is possible that some of the waste materials could be recycled which would reduce disposal costs, although no credit is taken for recycled waste materials in the cost estimates. It is assumed that 240,000 tonne of free release waste will be generated during decommissioning of the DGR facilities.

The following unit costs have been supplied by OPG and used to calculate allowances for off-site disposal of the aforementioned waste materials (see Annex 1, ED039):

LLW	$1,400/m^3
ILW	$24,000/m^3
Free Release Waste -	$200/tonne (equivalent to $500/m^3 for concrete rubble).

These unit costs include cost of off-site transportation, off-site processing/size-reduction and off-site disposal. They are applicable to the volume or mass of waste loaded and ready for shipment from the DGR facility site (all unit costs include a nominal 30% contingency). The unit costs exclude costs for decontamination and packaging of the waste in preparation for shipment.

5.10 SUMMARY OF COST ESTIMATE

The detailed cost estimates for the siting, development, construction, operation, decommissioning and closure of a DGR is presented in Appendix B of this report. Additional information to support these cost estimates is given in Annexes 1, 2 and 3.

The total life cycle cost for a DGR that can accept 3.6 million fuel bundles over 30 years is approximately $12.675 Billion (2002 constant dollars). Tables 4 and 5 presents the cost estimate for a DGR facility by level two work element and development phase, respectively.

Table 4: DGR Cost Estimate by Level Two Work Element

WBS	Description	Cost (2002k$)
550.15	Siting	396,844
550.20	Repository System Development	411,191
550.25	Safety Assessment	687,190
550.30	Licensing and Approvals	120,421
550.35	Public Affairs (Years 1>>29)	106,945
550.40	Facility Design and Construction	2,381,931
550.45	Facility Operation	7,208,354
550.55	Environmental Assessment and Monitoring	236,142
550.60	Facility Decommissioning and Closure	840,825
550.90	Program Management (Years 1>>29)	285,044
Total Cost		12,674,887

Note: Total does not equal sum of level two work element costs due to rounding.

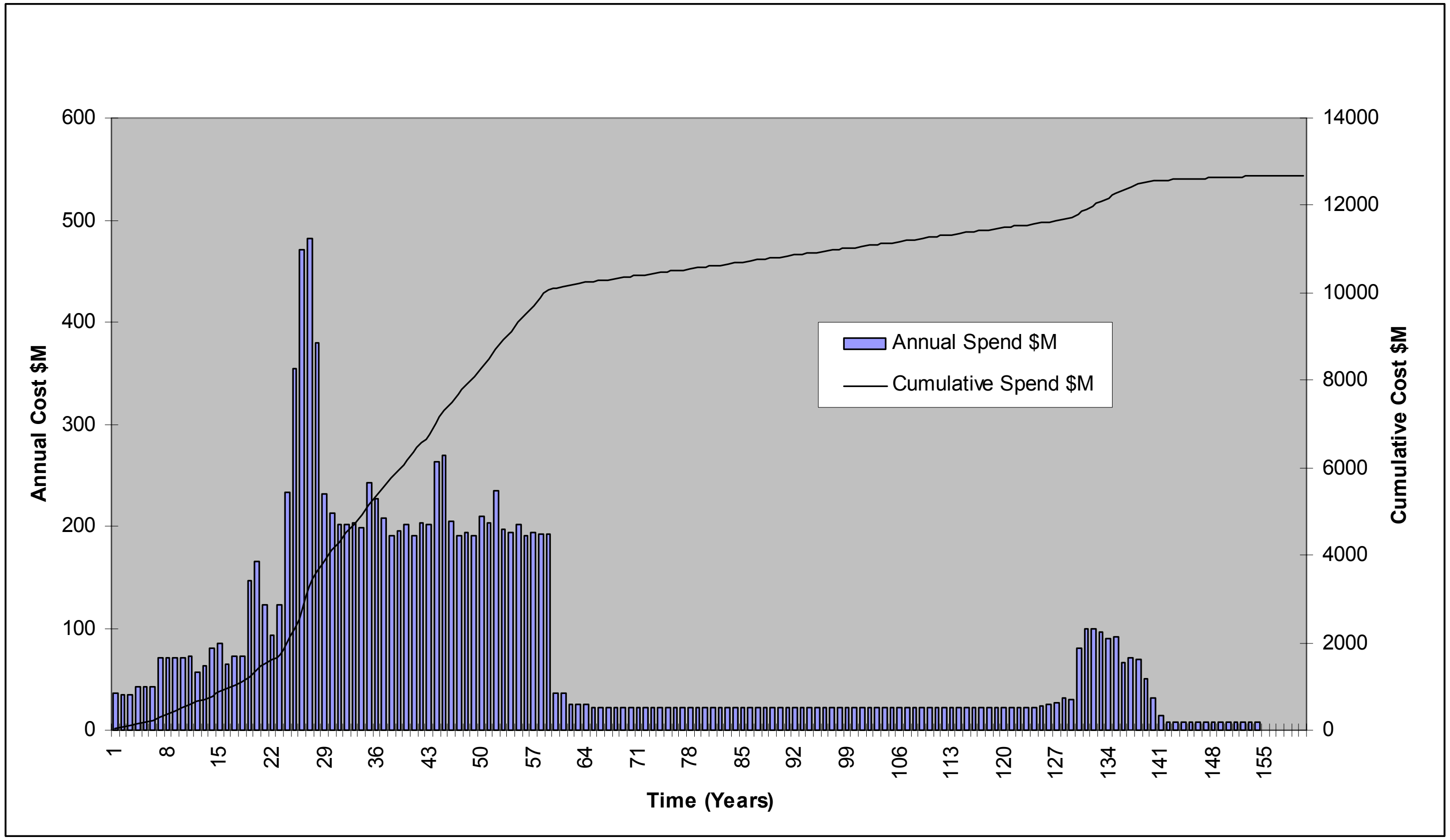
Table 5: DGR Cost Estimate by Development Phase

Development Phase	Cost (2002K$)
Siting (Years 1-18)	1,084,208
Construction (Years 19-29)	2,803,282
Operations (Years 30-129)	7,826,146
Decommissioning (Years 130-141)	881,618
Closure (Years 142-154)	79,610
Total Cost	12,674,887

Note: Total does not equal sum of costs for each phase due to rounding.

Figure 12 presents the cumulative annual cash flow for the program to site, develop, construct, operate, decommission and close the DGR.

Figure 12: DGR Annual Cash Flow Projection and Cumulative Costs



6 References

1 Clegg J B D, Coulthart D R. *'Conceptual Design for a Deep Geologic Repository for Used Nuclear Fuel'*. CTECH Report 1106/MD18085/REP/01. 2002.

2 Nuclear Waste Management Division, OPGI. *'Cost estimating requirements for the Update of the Conceptual Cost estimate for a Deep Geologic Repository for Used Nuclear Fuel'*. OPG Document No 06819-00051.CDGR(UFM) (T5) Revision 3a. 3 June 2002.

3 Nuclear Waste Management Division, OPGI. *'Technical Specification for Updating the Conceptual Design and Cost Estimate for a Deep Geologic Repository for Used Nuclear Fuel'*. OPG Document No 06819-UFM-03789-0001-R00. 9 March 2001.

4 RS Means. *'Square Foot Costs – Residential, Industrial, Commercial and Institutional'*. 23rd Annual Edition. 2002.

APPENDIX A

Glossary of Terms

Activity – a basic element of work or task that must be performed in order to complete a project. An activity occurs over a given period of time.

Allowances – additional resources included in estimates to cover the cost of known but undefined requirements for an individual activity or work item.

Assumption – a statement or hypothesis made concerning unknown factors and data that are required to accomplish the cost analysis. Assumptions should be clearly identified in all cost estimating documents.

Cash Flow – the net flow of dollars into and out of a project. The algebraic sum, in any time period, of all cash receipts, expenses, and investments.

Conceptual cost estimate – an estimate made with conceptual engineering data. This type of estimate should be accurate within +50% or -30% of the most probable final cost.

Constant dollars – current, and future costs that reflect the level of prices of a base year. Constant dollars have the effects of inflation removed.

Contingency – a separately planned amount used to allow for future situations which may be planned for only in part (sometimes referred to as “known unknowns”). Contingencies are intended to reduce the impact of missing cost or schedule objectives. Contingencies are normally included in the project’s cost and schedule baselines. Contingencies usually exclude changes in scope, quality or unforeseeable major events such as strikes, earthquakes, etc.

Cost – the amount measured in money, cash expended, or liability incurred, in consideration of goods and/or services received.

Cost Estimation – the determination of quantity and the prediction or forecasting, within a defined scope, of the costs required to provide services, construct and equip a facility, to manufacture goods, or to furnish a space. Costs are determined utilising experience and calculating and forecasting the future cost of required resources, methods, and management within a scheduled time frame. Included in these costs are an assessment and evaluation of risks and uncertainties.

Deliverable – a report or product of one or more tasks that satisfy one or more objectives and must be delivered to satisfy contractual requirements.

Discounting – a technique for converting various annual cash flows occurring over time to equivalent amounts at a common point in time, considering the time value of money, to facilitate comparison. (This is an alternative definition of present value.)

Direct Cost – (1) in construction, cost of installed equipment, material and labour directly involved in the physical construction of the permanent facility. (2) in operations, services, and other non-construction activities, and the portion operation costs that are generally assignable to a specific product or process area. Usually included are:

1. Input materials – materials appearing as a product
2. Operating and supervision labour
3. Maintenance
4. Utilities
5. Consumables – materials consumed during operations but not appearing as a product.

Equipment cost – is the cost of acquiring permanent equipment such as heavy equipment (trucks, forklifts, cranes) to be used during operations, container fabrication equipment, and laboratory and office equipment. Equipment cost does not include the labour cost for installing the equipment.

Escalation – the provision in the actual or estimated costs for an increase in the cost of labour, equipment and materials over that specified today due to continuing price level changes over time. Used to establish escalated cashflow.

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

High Level Cost Estimating Assumption – are generally those assumptions that impact the scope and timing of more than one Level 2 work element e.g. number of fuel bundles and milestone dates.

Indirect costs – (1) 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. These may include, but are not limited to, field administration, direct supervision, capital tools, start-up costs, contractor's fees, insurance and taxes; (2) 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 cost may include insurance, property taxes or grants in lieu of taxes, maintenance, depreciation, warehousing and loading.

Labour (or payroll) burden – payroll taxes and payroll insurance the employer is required to pay by law based on labour payroll, on behalf of or for the benefit of labour i.e. federal old age benefits, federal unemployment insurance and Workers' Compensation. Labour burden would also include the following employee benefits: statutory holidays, vacation, sick time, hospitalisation and medical insurance, group life insurance, pension plan, plus living and transportation allowances.

Labour cost – the salary plus labour burden. Implementing organisation labour cost does not include overhead costs, which are estimated separately. Purchased services labour cost includes overhead costs where applicable.

Material cost – refers to the cost of permanent materials only, consumables are listed under “other costs”. When the purchase cost includes installation (e.g. of building materials) the cost engineer will be requested to provide a cost breakdown indicating separately the material cost and the installation labour cost.

Milestone – an important or critical event and/or activity that must occur when scheduled in the project cycle in order to achieve the project objective(s).

Other costs – includes items such as consumables (fuel, utilities and non-permanent materials), permits and fees, taxes, duties, licences, royalties, communication costs, furniture, temporary monitoring equipment, and travel and accommodation expenses.

Overhead – a cost or expense inherent in the performing of an operation i.e. engineering, construction, operation or decommissioning, which cannot be charged to or identified with a part of the work, product or asset. Therefore, must be allocated on some arbitrary base believed to be equitable or handled as separate business expense.

Present value dollars – means dollars that have had their annual cash flow occurring over time converted to equivalent amounts at a common point in time in order to account for both inflation and the time value of money. The computation begins with constant dollars.

Program management includes all activities in the implementing organization that cannot be identified with work, products or assets within the organization. Program management activities within the implementing organization would include senior management support and direction, administrative and clerical services, financial and business services, quality engineering services, safety program, human resources and payroll services, records management, and procurement services. Program management would include overheads such as the following: taxes or grants in lieu of taxes, insurance, communication services, office space, office furniture, office supplies and general expenses.

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

- Waste processing, conditioning and packaging facilities
- Waste package handling equipment
- Storage buildings.

Variable Cost – is a cost that is directly proportional to quantity of waste shipped or stored. If the quantity of waste changes, then the operating cost will change in direct proportion to the change in quantity of waste being shipped or stored. Variable operating costs are not sensitive to changes in waste throughput rate and these costs are only incurred during the Operations Phase. Examples of variable costs are the following:

- Labour directly involved in handling the waste, conditioning and packaging waste, constructing storage containers, canisters or vaults, emplacing waste in storage structures, and inspection and monitoring
- Materials – e.g. materials for waste containers and some storage structures
- Maintenance of equipment and facilities
- Utilities

- Consumables – energy and materials consumed during operations but not appearing as a product
- Any indirect costs associated with the above activities.

Work Breakdown Structure (WBS) – a hierarchical grouping of work elements, which organises and defines the total scope of the facility or system. Each descending level represents an increasing detailed definition of the work.

Work Element Definition Sheet (WEDS) – describes a work element in the WBS and includes the following information: WBS number, WBS title, WBS description of work, WBS deliverables, WBS assumptions, WBS schedule, WBS resource and cost estimate and recommended contingency level and its basis. The WEDS includes information on whether the work element is a fixed, step-fixed or variable cost.

APPENDIX B

Work Breakdown Structure for the DGR and Work Element Costs

This comprises the following three Reports from the Access Database:

WBS Summary Report

DGR Cost Estimate – Cost by Phase Report

DGR Cost Estimate – Cost by Category Report

Note:

Total costs in the Cost by Phase Report do not always equal the sum of the costs for individual phases due to rounding.

Deep Geological Repository Cost Estimate

WBS Summary Report

DGR WBS Number	WBS Title
550	**DEEP GEOLOGIC REPOSITORY FACILITY**
550 15	**SITING**
550 15 10	TECHNICAL SITING MANAGEMENT
550 15 20	CANDIDATE AREAS
550 15 20 10	SELECTION OF FEASIBILITY STUDY COMMUNITIES
550 15 20 40	DATABASE & INFORMATION SYSTEM
550 15 20 50	QUALITY ASSURANCE PROGRAM
550 15 20 70	SEISMICITY MONITORING
550 15 20 90	TECHNICAL SITING PLAN
550 15 20 100	GEOSPHERE CHARACTERISATION
550 15 20 105	BIOSPHERE CHARACTERISATION
550 15 50	FEASIBILITY STUDIES (3 SITES)
550 15 50 10	FEASIBILITY STUDIES - SUPPORT & REPORTING
550 15 50 20	CHARACTERISATION & MONITORING PLAN
550 15 50 30	GEOSPHERE CHARACTERISATION & MODELLING
550 15 50 35	BIOSPHERE CHARACTERISATION & MODELLING
550 15 60	CANDIDATE SITES (2 SITES)
550 15 60 10	CANDIDATE SITES - SUPPORT & REPORTING
550 15 60 20	CHARACTERISATION & MONITORING PLAN
550 15 60 30	GEOSPHERE CHARACTERISATION & MODELLING
550 15 60 35	BIOSPHERE CHARACTERISATION & MODELLING
550 15 70	PREFERRED SITE
550 15 70 10	SITE EVALUATION PLAN
550 15 70 30	GEOSPHERE EVALUATION (SURFACE)
550 15 70 35	BIOSPHERE EVALUATION
550 15 70 40	BIOSPHERE MONITORING & TECHNICAL SUPPORT
550 20	**REPOSITORY SYSTEM DEVELOPMENT**
550 20 2	REPOSITORY SYSTEM DEVELOPMENT MANAGEMENT
550 20 5	REPOSITORY SYSTEMS DESIGN INTEGRATION
550 20 10	CONTAINER ENGINEERING
550 20 10 10	PREL CONTAINER DESIGN ENGINEERING
550 20 10 20	FABRICATION, INSPECTION & SEALING TECH DEV
550 20 10 30	MANUFACTURNG, INSPECTION & SEALING DEMONSTRATIONS
550 20 10 40	DETAILED CONTAINER DESIGN & ENGINEERING
550 20 15	REPOSITORY ENGINEERING
550 20 15 10	REPOSITORY DESIGN ALTERNATIVES
550 20 15 20	SITE DEPENDENT REPOSITORY DESIGNS
550 20 15 30	REPOSITORY SEALING SYSTEMS
550 20 15 40	PRELIMINARY REPOSITORY DESIGNS
550 20 15 60	DEMONSTRATIONS
550 20 15 60 10	PLAN REPOSITORY DEV STUDIES
550 20 15 60 20	CONDUCT REPOSITORY DEV STUDIES
550 20 15 60 30	PLAN UCF DEMONSTRATIONS
550 20 15 60 40	CONDUCT UCF DEMONSTRATIONS
550 20 15 60 50	PRODUCE SPECS & INPUT TO FSAR

DGR WBS Number	WBS Title
550 20 15 60 60	DEFEND REPOSITORY & UFPP DESIGNS
550 20 15 60 70	TECH SPECS FOR REPOSITORY & UFPP
550 20 20	USED FUEL PACKAGING SYSTEM PLANT ENG'NG
550 20 20 10	UFPP CONCEPTUAL DESIGN
550 20 20 20	UFPP PRELIMINARY DESIGN
550 20 20 30	DEMONSTRATE UFPP COMPONENTS
550 20 25	SEALING MATERIALS ENGINEERING
550 20 30	EMPLACMENT SYSTEMS ENGINEERING
550 20 35	RETRIEVAL SYSTEMS ENGINEERING
550 20 40	SECURITY & SAFEGUARD ENG'NG
550 20 40 10	SECURITY & SAFEGUARDS SPECIFICATIONS
550 20 40 20	SAFEGUARDS DESIGN & TESTING
550 25	**SAFETY ASSESSMENT**
550 25 10	SAFETY ASSESSMENT MANAGEMENT
550 25 30	SA SITING
550 25 30 10	SA SITING PRECLOSURE
550 25 30 20	SA SITING POSTCLOSURE
550 25 30 30	SA SITING R&D
550 25 40	SA OPERATING LICENSE
550 25 40 10	SA OPERATING LICENCE PRECLOSURE
550 25 40 20	SA OPERATING LICENCE POSTCLOSURE
550 25 40 30	SA OPERATING LICENCE R&D
550 25 50	SA FACILITY OPERATIONS
550 25 60	SA EXTENDED MONITORING
550 25 70	SA DECOMMISSIONING & CLOSURE
550 25 80	GEOSCIENCE MONITORING (Yrs 30 >>154)
550 30	**LICENSING & APPROVALS**
550 30 30	LIASON WITH CNSC
550 30 50	CNSC CONSTRUCTION LICENCE
550 30 60	OTHER GOVERNMENT APPROVALS
550 30 60 10	OTHER GOVERNMENT APPROVALS - REQUIREMENTS
550 30 60 30	OTHER GOVERNMENT APPROVALS - FEDERAL
550 30 60 40	OTHER GOVERNMENT APPROVALS - PROVINCIAL
550 30 60 50	OTHER GOVERNMENT APPROVALS - MUNICIPAL
550 30 65	CNSC OPS LICENCE (INITIAL APPLICATION)
550 30 70	CNSC OPERATING LICENCE (LICENCE MAINTENANCE & RENEWAL)
550 30 70 10	CNSC OPERATING LICENCE (Renewal during operations)
550 30 70 20	CNSC OPERATING LICENCE (Maintenance during preclosure monitoring)
550 30 75	CNSC DECOMMISSIONING LICENCE
550 30 80	CNSC LICENCE TO ABANDON
550 35	**PUBLIC AFFAIRS (Yrs1 >>29)**
550 35 10	PUBLIC AFFAIRS - CANDIDATE AREAS
550 35 30	PUBLIC AFFAIRS - FEASIBILITY STUDIES
550 35 40	PUBLIC AFFAIRS - CANDIDATE SITES
550 35 45	PUBLIC AFFAIRS - PREFERRED SITE
550 35 50	PUBLIC AFFAIRS - PUBLIC REVIEW / EA
550 35 70	PUBLIC AFFAIRS - DESIGN & CONSTRUCTION
550 35 110	PUBLIC AFFAIRS - PROGRAM MANAGEMENT
550 35 120	PUBLIC AFFAIRS - COMMUNITY OFFSETS AND BENEFITS

DGR WBS Number						WBS Title
550	**40**					**FACILITY DESIGN AND CONSTRUCTION**
550	40	5				SITE CONFIRMATION
550	40	5	30			GEOSPHERE BASELINE MONITORING
550	40	5	35			GEOSPHERE EVALUATION (UNDERGROUND)
550	40	5	40			U/G CHARACTERIZATION FACILITY (UCF)
550	40	5	40	10		UCF DESIGN
550	40	5	40	20		UCF CONSTRUCTION
550	40	5	40	20	10	UCF TEMPORARY INFRASTRUCTURE
550	40	5	40	20	20	CONCRETE PLANT
550	40	5	40	20	25	CRUSHING PLANT
550	40	5	40	20	30	CAMPSITE
550	40	5	40	20	40	SERVICE/PRODUCTION SHAFT
550	40	5	40	20	41	MAINTENANCE COMPLEX EXHAUST SHAFT
550	40	5	40	20	50	TUNNEL AND SERVICE AREA EXCAVATION
550	40	5	60			REPORTS
550	40	10				SITE ACQUISITION AND IMPROVEMENTS
550	40	15				CONSTRUCTION INDIRECTS
550	40	20				SURFACE FACILITIES
550	40	20	10			USED FUEL PACKAGING PLANT (UFPP)
550	40	20	10	10		UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION
550	40	20	10	20		UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 1)
550	40	20	10	30		UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 2)
550	40	20	10	40		UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 3)
550	40	20	10	50		BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)
550	40	20	10	60		COMMISSIONING (UFPP)
550	40	20	20			SEALING MATERIALS COMPACTION PLANT (SMCP)
550	40	30				AUXILIARY SURFACE FACILITIES / AREAS
550	40	30	10			ADMIN BUILDING
550	40	30	12			AUXILIARY BUILDING
550	40	30	13			FIREHALL/SECURITY BUILDING
550	40	30	15			ACTIVE LIQUID WASTE TREATMENT (ALWT) BUILDING
550	40	30	16			GARAGE BUILDING / WAREHOUSE
550	40	30	17			SEWAGE TREATMENT PLANT
550	40	30	18			WATER TREATMENT PLANT
550	40	30	19			EMERGENCY POWER GENERATION
550	40	30	20			PUMPHOUSE & INTAKE
550	40	30	21			QC OFFICES & LABS
550	40	30	22			HAZARDOUS MATLS STORAGE BLDG
550	40	30	25			WASTE MANAGEMENT AREA
550	40	30	26			LOW LEVEL LIQUID WASTE STORAGE BUILDING
550	40	30	27			SERVICE SHAFT WATER SETTLING POND
550	40	30	28			ELECTRICAL SWITCHYARD
550	40	30	29			TRANSFORMER AREAS
550	40	30	31			WATER STORAGE TANK AREA
550	40	30	32			PROCESS WATER SETTLING POND
550	40	30	39			TOWNSITE
550	40	30	41			OVERHEAD CORRIDOR
550	40	30	42			LOW LEVEL WASTE STORAGE BUILDING
550	40	30	43			FUEL TANK AREA
550	40	30	44			STORM RUN-OFF POND
550	40	30	45			DUST COLLECTION BAGHOUSE

DGR WBS Number	WBS Title
550 40 40	UNDERGROUND FACILITIES
550 40 40 10	U/G CONSTRUCTION STAGE
550 40 40 15	COMMISSIONING DURING CONST'N
550 40 40 20	WASTE SHAFT
550 40 40 40	UPCAST VENTILATION SHAFT
550 40 40 45	TUNNELS (Panel/Perimeter access)
550 40 40 60	EMPLACEMENT ROOMS (All Panel A & Lower Panel B)
550 40 40 65	ANCILIARY FACILITIES
550 40 40 70	UFC HANDLING SYSTEM EQUIPMENT
550 40 40 75	UNDERGROUND EQUIPMENT
550 40 40 80	SEALING MATERIALS EMPLACEMENT SYSTEM
550 40 50	ELECTRICAL DISTRIBUTION
550 40 60	COMMUNICATION SYSTEM
550 40 70	COMMON PROCESSES & SERVICES
550 40 70 10	COMMON PROCESS SERVICES WATER SYSTEMS
550 40 70 20	SEWAGE, DRAINAGE & TREATMENT
550 40 70 30	COMPRESSED AIR (SURFACE & UNDERGROUND)
550 40 70 35	VENTILATION SYSTEMS
550 40 70 40	SOLID WASTE MGMT (DISPOSAL)
550 45	**FACILITY OPERATION**
550 45 5	OPERATIONS PROGRAM MANAGEMENT
550 45 10	OPERATION MANAGEMENT & ADMINISTRATION
550 45 15	OPERATIONS INDIRECTS
550 45 20	SURFACE WORKS OPERATIONS
550 45 20 5	UFPP OPERATION
550 45 20 10	SUPPLY OF BASKETS AND UFCS
550 45 20 15	SMCP OPERATION
550 45 20 20	AUXILIARY SURFACE FACILITIES
550 45 40	U/G OPERATIONS
550 45 40 1	EMPLACEMENT IN UNDERGROUND ROOMS
550 45 40 2	DEMOBILIZATION
550 45 40 3	U/G EQUIPMENT
550 45 40 4	CAPITAL REPLACEMENT
550 45 40 5	HOIST ROPE REPLACEMENT
550 45 40 6	ENGINEERING (OPS STAGE)
550 45 40 7	CAMP ADDIT'N/OPERAT'G (OPS STAGE)
550 45 40 8	ROOM EXCAVATION (Upper Panel B & Lower Panel D)
550 45 40 9	ROOM EXCAVATION (All Panel C)
550 45 40 10	ROOM EXCAVATION (Upper Panel D)
550 45 40 11	CON LABOUR INDIRECTS (RM EXCV)
550 45 40 12	CON PLANT INDIRECTS (RM EXCV)
550 45 50	EXTENDED MONITORING
550 45 50 5	EXTENDED OPERATIONS MANAGEMENT & ENGINEERING (Direct & Indirect)
550 45 50 10	EXTENDED MONITORING - MAINTENANCE
550 45 60	REPOSITORY PERFORMANCE & SEISMICITY MONITORING
550 55	**EA AND MONITORING**
550 55 10	EA & MONITORING PROGRAM MANAGEMENT
550 55 20	CNSC CONSTRUCTION LIC - EA
550 55 30	CNSC DECOMMISSIONING LIC - EA
550 55 40	GROUNDWATER MONITORING

DGR WBS Number	WBS Title
550 55 50	RADIOLOGICAL BIOSPHERE MONITORING
550 55 60	NON - RAD BIOSPHERE MONITORING
550 55 80	HUMAN HEALTH MONITORING
550 60	**FACILITY DECOMMISSIONING & CLOSURE**
550 60 5	DECOMMISSIONING PROGRAM & OPERATIONS MANAGEMENT
550 60 10	DECOMMISSIONING FACILITIES (CONSTRUCTION & OPERATION)
550 60 20	AUXILIARY SURFACE FACILITIES
550 60 30	U/G FACILITIES
550 60 30 1	ENG'G DESIGN (DECOMMISSIONING)
550 60 30 2	TOWNSITE DECOMMISSIONING
550 60 30 3	CRUSHER PLANT DEMOL (DECOMMISSIONING)
550 60 30 4	PERM VENT FAN REMOVAL (DECOMMISSIONING)
550 60 30 5	SITE CLEANUP (DECOMMISSIONING)
550 60 30 6	ACCESS TUNNELS & DRIFTS
550 60 30 7	SERVICE SHAFT
550 60 30 8	WASTE SHAFT
550 60 30 10	MAINTENANCE AREA VENT SHAFT
550 60 30 11	UPCAST VENTILATION SHAFT
550 60 30 12	CONT'R LAB INDIRECTS (DECOMMISSIONING)
550 60 30 13	CONT'R PLANT INDIRECTS (DECOMMISSIONING)
550 60 50	MAIN SURFACE FACILITIES
550 60 50 1	USED FUEL PACKAGING PLANT (UFPP)
550 60 50 2	SEALING MATERIALS COMPACTION PLANT
550 60 50 3	ANCILLARY ACTIVE AREAS
550 60 50 4	UFC HANDLING SYSTEMS
550 60 60	DECOMMISSIONING WASTE DISPOSAL
550 60 80	CLOSURE
550 90	**PROGRAM MANAGEMENT (Yrs 1 >> 29)**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550			**DEEP GEOLOGIC REPOSITORY FACILITY**						
550	**15**		**SITING**	396,844	346,225	50,593	0	0	0
550	**15**	**10**	**TECHNICAL SITING MANAGEMENT**	**26,645**	**16,539**	**10,109**	**0**	**0**	**0**
550	**15**	**20**	**CANDIDATE AREAS**	**95,438**	**63,908**	**31,508**	**0**	**0**	**0**
			SELECTION OF FEASIBILITY STUDY COMMUNITIES	6,210	6,210	0	0	0	0
			DATABASE & INFORMATION SYSTEM	41,183	26,935	14,249	0	0	0
			QUALITY ASSURANCE PROGRAM	30,240	17,730	12,496	0	0	0
			SEISMICITY MONITORING	12,571	7,800	4,763	0	0	0
			TECHNICAL SITING PLAN	294	294	0	0	0	0
			GEOSPHERE CHARACTERISATION	2,353	2,353	0	0	0	0
			BIOSPHERE CHARACTERISATION	2,588	2,588	0	0	0	0
550	**15**	**50**	**FEASIBILITY STUDIES (3 SITES)**	**34,052**	**34,052**	**0**	**0**	**0**	**0**
			FEASIBILITY STUDIES - SUPPORT & REPORTING	6,075	6,075	0	0	0	0
			CHARACTERISATION & MONITORING PLAN	1,038	1,038	0	0	0	0
			GEOSPHERE CHARACTERISATION & MODELLING	14,750	14,750	0	0	0	0
			BIOSPHERE CHARACTERISATION & MODELLING	12,189	12,189	0	0	0	0
550	**15**	**60**	**CANDIDATE SITES (2 SITES)**	**156,929**	**156,929**	**0**	**0**	**0**	**0**
			CANDIDATE SITES - SUPPORT & REPORTING	8,242	8,242	0	0	0	0
			CHARACTERISATION & MONITORING PLAN	1,581	1,581	0	0	0	0
			GEOSPHERE CHARACTERISATION & MODELLING	127,811	127,811	0	0	0	0
			BIOSPHERE CHARACTERISATION & MODELLING	19,295	19,295	0	0	0	0
550	**15**	**70**	**PREFERRED SITE**	**83,780**	**74,797**	**8,976**	**0**	**0**	**0**
			SITE EVALUATION PLAN	1,265	1,264	0	0	0	0
			GEOSPHERE EVALUATION (SURFACE)	56,370	56,368	0	0	0	0
			BIOSPHERE EVALUATION	14,716	14,716	0	0	0	0

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			BIOSPHERE MONITORING & TECHNICAL SUPPORT	11,429	2,448	8,976	0	0	0
550	**20**		**REPOSITORY SYSTEM DEVELOPMENT**	411,191	241,445	135,222	34,530	0	0
550	**20**	**2**	**REPOSITORY SYSTEM DEVELOPMENT MANAGEMENT**	**30,593**	**18,989**	**11,605**	**0**	**0**	**0**
550	**20**	**5**	**REPOSITORY SYSTEMS DESIGN INTEGRATION**	**3,202**	**3,202**	**0**	**0**	**0**	**0**
550	**20**	**10**	**CONTAINER ENGINEERING**	**42,607**	**42,608**	**0**	**0**	**0**	**0**
			PREL CONTAINER DESIGN ENGINEERING	18,244	18,244	0	0	0	0
			FABRICATION, INSPECTION & SEALING TECH DEV	7,194	7,194	0	0	0	0
			MANUFACTURNG, INSPECTION & SEALING DEMONSTRATIONS	14,387	14,387	0	0	0	0
			DETAILED CONTAINER DESIGN & ENGINEERING	2,782	2,783	0	0	0	0
550	**20**	**15**	**REPOSITORY ENGINEERING**	**192,955**	**76,564**	**81,858**	**34,530**	**0**	**0**
			REPOSITORY DESIGN ALTERNATIVES	3,600	3,600	0	0	0	0
			SITE DEPENDENT REPOSITORY DESIGNS	3,900	3,900	0	0	0	0
			REPOSITORY SEALING SYSTEMS	15,600	15,600	0	0	0	0
			PRELIMINARY REPOSITORY DESIGNS	17,249	17,250	0	0	0	0
			PLAN REPOSITORY DEV STUDIES	832	832	0	0	0	0
			CONDUCT REPOSITORY DEV STUDIES	44,549	31,185	13,365	0	0	0
			PLAN UCF DEMONSTRATIONS	6,025	0	6,020	0	0	0
			CONDUCT UCF DEMONSTRATIONS	92,079	0	57,550	34,530	0	0
			PRODUCE SPECS & INPUT TO FSAR	2,220	2,220	0	0	0	0
			DEFEND REPOSITORY & UFPP DESIGNS	1,335	1,335	0	0	0	0
			TECH SPECS FOR REPOSITORY & UFPP	5,565	642	4,923	0	0	0
550	**20**	**20**	**USED FUEL PACKAGING SYSTEM PLANT ENG'NG**	**28,087**	**15,462**	**12,624**	**0**	**0**	**0**
			UFPP CONCEPTUAL DESIGN	1,912	1,912	0	0	0	0
			UFPP PRELIMINARY DESIGN	4,732	4,734	0	0	0	0

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			DEMONSTRATE UFPP COMPONENTS	21,442	8,816	12,624	0	0	0
550	**20**	**25**	**SEALING MATERIALS ENGINEERING**	**32,607**	**24,455**	**8,151**	**0**	**0**	**0**
550	**20**	**30**	**EMPLACMENT SYSTEMS ENGINEERING**	**49,906**	**37,435**	**12,478**	**0**	**0**	**0**
550	**20**	**35**	**RETRIEVAL SYSTEMS ENGINEERING**	**26,226**	**19,670**	**6,556**	**0**	**0**	**0**
550	**20**	**40**	**SECURITY & SAFEGUARD ENG'NG**	**5,010**	**3,060**	**1,950**	**0**	**0**	**0**
			SECURITY & SAFEGUARDS SPECIFICATIONS	1,110	1,110	0	0	0	0
			SAFEGUARDS DESIGN & TESTING	3,900	1,950	1,950	0	0	0
550	**25**		**SAFETY ASSESSMENT**	687,190	161,779	108,535	350,209	40,080	26,720
550	**25**	**10**	**SAFETY ASSESSMENT MANAGEMENT**	**56,995**	**34,116**	**22,891**	**0**	**0**	**0**
550	**25**	**30**	**SA SITING**	**127,660**	**127,663**	**0**	**0**	**0**	**0**
			SA SITING PRECLOSURE	6,000	6,002	0	0	0	0
			SA SITING POSTCLOSURE	25,713	25,715	0	0	0	0
			SA SITING R&D	95,946	95,946	0	0	0	0
550	**25**	**40**	**SA OPERATING LICENSE**	**85,642**	**0**	**85,644**	**0**	**0**	**0**
			SA OPERATING LICENCE PRECLOSURE	4,644	0	4,640	0	0	0
			SA OPERATING LICENCE POSTCLOSURE	23,113	0	23,122	0	0	0
			SA OPERATING LICENCE R&D	57,886	0	57,882	0	0	0
550	**25**	**50**	**SA FACILITY OPERATIONS**	**86,187**	**0**	**0**	**86,190**	**0**	**0**
550	**25**	**60**	**SA EXTENDED MONITORING**	**94,773**	**0**	**0**	**94,780**	**0**	**0**
550	**25**	**70**	**SA DECOMMISSIONING & CLOSURE**	**27,160**	**0**	**0**	**0**	**16,305**	**10,870**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**25**	**80**	**GEOSCIENCE MONITORING (Yrs 30 >>154)**	**208,773**	**0**	**0**	**169,239**	**23,775**	**15,850**
550	**30**		**LICENSING & APPROVALS**	120,421	20,954	13,657	73,656	7,245	4,892
550	**30**	**30**	**LIASON WITH CNSC**	**4,315**	**4,315**	**0**	**0**	**0**	**0**
550	**30**	**50**	**CNSC CONSTRUCTION LICENCE**	**26,820**	**15,299**	**11,517**	**0**	**0**	**0**
550	**30**	**60**	**OTHER GOVERNMENT APPROVALS**	**1,765**	**1,340**	**429**	**0**	**0**	**0**
			OTHER GOVERNMENT APPROVALS - REQUIREMENTS	1,067	1,067	0	0	0	0
			OTHER GOVERNMENT APPROVALS - FEDERAL	238	91	143	0	0	0
			OTHER GOVERNMENT APPROVALS - PROVINCIAL	222	90	143	0	0	0
			OTHER GOVERNMENT APPROVALS - MUNICIPAL	238	91	143	0	0	0
550	**30**	**65**	**CNSC OPS LICENCE (INITIAL APPLICATION)**	**1,710**	**0**	**1,711**	**0**	**0**	**0**
550	**30**	**70**	**CNSC OPERATING LICENCE (LICENCE MAINTENANCE & RENEWAL)**	**70,127**	**0**	**0**	**70,110**	**0**	**0**
			CNSC OPERATING LICENCE (Renewal during operations)	42,998	0	0	43,020	0	0
			CNSC OPERATING LICENCE (Maintenance during preclosure monitoring)	27,130	0	0	27,090	0	0
550	**30**	**75**	**CNSC DECOMMISSIONING LICENCE**	**15,139**	**0**	**0**	**3,546**	**7,245**	**4,347**
550	**30**	**80**	**CNSC LICENCE TO ABANDON**	**544**	**0**	**0**	**0**	**0**	**545**
550	**35**		**PUBLIC AFFAIRS (Yrs1 >>29)**	106,945	77,700	29,238	0	0	0
550	**35**	**10**	**PUBLIC AFFAIRS - CANDIDATE AREAS**	**11,999**	**11,999**	**0**	**0**	**0**	**0**
550	**35**	**30**	**PUBLIC AFFAIRS - FEASIBILITY STUDIES**	**15,002**	**15,002**	**0**	**0**	**0**	**0**
550	**35**	**40**	**PUBLIC AFFAIRS - CANDIDATE SITES**	**23,504**	**23,504**	**0**	**0**	**0**	**0**

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**35**	**45**	**PUBLIC AFFAIRS - PREFERRED SITE**	**11,839**	**11,840**	**0**	**0**	**0**	**0**
550	**35**	**50**	**PUBLIC AFFAIRS - PUBLIC REVIEW / EA**	**10,042**	**10,041**	**0**	**0**	**0**	**0**
550	**35**	**70**	**PUBLIC AFFAIRS - DESIGN & CONSTRUCTION**	**17,444**	**0**	**17,446**	**0**	**0**	**0**
550	**35**	**110**	**PUBLIC AFFAIRS - PROGRAM MANAGEMENT**	**8,565**	**5,314**	**3,245**	**0**	**0**	**0**
550	**35**	**120**	**PUBLIC AFFAIRS - COMMUNITY OFFSETS AND BENEFITS**	**8,550**	**0**	**8,547**	**0**	**0**	**0**
550	**40**		**FACILITY DESIGN AND CONSTRUCTION**	2,381,931	44,166	2,337,748	0	0	0
550	**40**	**5**	**SITE CONFIRMATION**	**398,959**	**44,166**	**354,793**	**0**	**0**	**0**
			GEOSPHERE BASELINE MONITORING	19,401	19,401	0	0	0	0
			GEOSPHERE EVALUATION (UNDERGROUND)	127,761	0	127,759	0	0	0
			UCF DESIGN	38,099	24,765	13,335	0	0	0
			UCF TEMPORARY INFRASTRUCTURE	2,706	0	2,706	0	0	0
			CONCRETE PLANT	6,563	0	6,562	0	0	0
			CRUSHING PLANT	8,303	0	8,303	0	0	0
			CAMPSITE	76,349	0	76,350	0	0	0
			SERVICE/PRODUCTION SHAFT	52,058	0	52,058	0	0	0
			MAINTENANCE COMPLEX EXHAUST SHAFT	18,385	0	18,384	0	0	0
			TUNNEL AND SERVICE AREA EXCAVATION	47,544	0	47,542	0	0	0
			REPORTS	1,792	0	1,794	0	0	0
550	**40**	**10**	**SITE ACQUISITION AND IMPROVEMENTS**	**72,987**	**0**	**72,988**	**0**	**0**	**0**
550	**40**	**15**	**CONSTRUCTION INDIRECTS**	**133,820**	**0**	**133,818**	**0**	**0**	**0**

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**40**	**20**	**SURFACE FACILITIES**	**855,206**	**0**	**855,209**	**0**	**0**	**0**
			UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION	98,915	0	98,914	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 1)	113,019	0	113,021	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 2)	82,609	0	82,610	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 3)	128,278	0	128,279	0	0	0
			BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)	28,047	0	28,048	0	0	0
			COMMISSIONING (UFPP)	64,837	0	64,836	0	0	0
			SEALING MATERIALS COMPACTION PLANT (SMCP)	339,500	0	339,501	0	0	0
550	**40**	**30**	**AUXILIARY SURFACE FACILITIES / AREAS**	**522,273**	**0**	**522,270**	**0**	**0**	**0**
			ADMIN BUILDING	22,674	0	22,674	0	0	0
			AUXILIARY BUILDING	4,761	0	4,762	0	0	0
			FIREHALL/SECURITY BUILDING	1,204	0	1,204	0	0	0
			ACTIVE LIQUID WASTE TREATMENT (ALWT) BUILDING	34,552	0	34,552	0	0	0
			GARAGE BUILDING / WAREHOUSE	13,838	0	13,838	0	0	0
			SEWAGE TREATMENT PLANT	538	0	538	0	0	0
			WATER TREATMENT PLANT	4,064	0	4,064	0	0	0
			EMERGENCY POWER GENERATION	5,153	0	5,153	0	0	0
			PUMPHOUSE & INTAKE	2,039	0	2,038	0	0	0
			QC OFFICES & LABS	15,811	0	15,810	0	0	0
			HAZARDOUS MATLS STORAGE BLDG	8,876	0	8,876	0	0	0
			WASTE MANAGEMENT AREA	4,739	0	4,740	0	0	0
			LOW LEVEL LIQUID WASTE STORAGE BUILDING	3,724	0	3,723	0	0	0
			SERVICE SHAFT WATER SETTLING POND	1,901	0	1,900	0	0	0
			ELECTRICAL SWITCHYARD	1,017	0	1,017	0	0	0
			TRANSFORMER AREAS	1,017	0	1,017	0	0	0
			WATER STORAGE TANK AREA	1,423	0	1,422	0	0	0

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			PROCESS WATER SETTLING POND	5,029	0	5,028	0	0	0
			TOWNSITE	374,079	0	374,079	0	0	0
			OVERHEAD CORRIDOR	4,577	0	4,576	0	0	0
			LOW LEVEL WASTE STORAGE BUILDING	5,580	0	5,580	0	0	0
			FUEL TANK AREA	173	0	173	0	0	0
			STORM RUN-OFF POND	2,427	0	2,428	0	0	0
			DUST COLLECTION BAGHOUSE	3,078	0	3,078	0	0	0
550	**40**	**40**	**UNDERGROUND FACILITIES**	**335,339**	**0**	**335,333**	**0**	**0**	**0**
			U/G CONSTRUCTION STAGE	25,878	0	25,872	0	0	0
			COMMISSIONING DURING CONST'N	10,643	0	10,641	0	0	0
			WASTE SHAFT	48,439	0	48,438	0	0	0
			UPCAST VENTILATION SHAFT	15,803	0	15,802	0	0	0
			TUNNELS (Panel/Perimeter access)	86,024	0	86,024	0	0	0
			EMPLACEMENT ROOMS (All Panel A & Lower Panel B)	94,981	0	94,984	0	0	0
			ANCILIARY FACILITIES	1,962	0	1,965	0	0	0
			UFC HANDLING SYSTEM EQUIPMENT	26,375	0	26,372	0	0	0
			UNDERGROUND EQUIPMENT	13,908	0	13,908	0	0	0
			SEALING MATERIALS EMPLACEMENT SYSTEM	11,327	0	11,327	0	0	0
550	**40**	**50**	**ELECTRICAL DISTRIBUTION**	**44,426**	**0**	**44,424**	**0**	**0**	**0**
550	**40**	**60**	**COMMUNICATION SYSTEM**	**2,600**	**0**	**2,600**	**0**	**0**	**0**
550	**40**	**70**	**COMMON PROCESSES & SERVICES**	**16,319**	**0**	**16,313**	**0**	**0**	**0**
			COMMON PROCESS SERVICES WATER SYSTEMS	1,402	0	1,402	0	0	0
			SEWAGE, DRAINAGE & TREATMENT	3,170	0	3,168	0	0	0
			COMPRESSED AIR (SURFACE & UNDERGROUND)	924	0	923	0	0	0
			VENTILATION SYSTEMS	9,404	0	9,400	0	0	0

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			SOLID WASTE MGMT (DISPOSAL)	1,419	0	1,420	0	0	0
550	**45**		**FACILITY OPERATION**	7,208,354	0	0	7,208,357	0	0
550	**45**	**5**	**OPERATIONS PROGRAM MANAGEMENT**	257,367	0	0	257,370	0	0
550	**45**	**10**	**OPERATION MANAGEMENT & ADMINISTRATION**	323,362	0	0	323,340	0	0
550	**45**	**15**	**OPERATIONS INDIRECTS**	789,594	0	0	789,595	0	0
550	**45**	**20**	**SURFACE WORKS OPERATIONS**	3,835,731	0	0	3,835,754	0	0
			UFPP OPERATION	626,749	0	0	626,764	0	0
			SUPPLY OF BASKETS AND UFCS	2,264,782	0	0	2,264,770	0	0
			SMCP OPERATION	542,069	0	0	542,070	0	0
			AUXILIARY SURFACE FACILITIES	402,131	0	0	402,150	0	0
550	**45**	**40**	**U/G OPERATIONS**	636,189	0	0	636,187	0	0
			EMPLACEMENT IN UNDERGROUND ROOMS	320,979	0	0	320,980	0	0
			DEMOBILIZATION	8,366	0	0	8,368	0	0
			U/G EQUIPMENT	4,854	0	0	4,854	0	0
			CAPITAL REPLACEMENT	56,250	0	0	56,250	0	0
			HOIST ROPE REPLACEMENT	44,407	0	0	44,410	0	0
			ENGINEERING (OPS STAGE)	22,854	0	0	22,853	0	0
			CAMP ADDIT'N/OPERAT'G (OPS STAGE)	14,414	0	0	14,412	0	0
			ROOM EXCAVATION (Upper Panel B & Lower Panel D)	56,195	0	0	56,193	0	0
			ROOM EXCAVATION (All Panel C)	56,195	0	0	56,193	0	0
			ROOM EXCAVATION (Upper Panel D)	28,338	0	0	28,339	0	0
			CON LABOUR INDIRECTS (RM EXCV)	11,034	0	0	11,035	0	0
			CON PLANT INDIRECTS (RM EXCV)	12,303	0	0	12,300	0	0
550	**45**	**50**	**EXTENDED MONITORING**	1,107,342	0	0	1,107,311	0	0

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			EXTENDED OPERATIONS MANAGEMENT & ENGINEERING (Direct & Indirect)	880,116	0	0	880,091	0	0
			EXTENDED MONITORING - MAINTENANCE	227,226	0	0	227,220	0	0
550	**45**	**60**	**REPOSITORY PERFORMANCE & SEISMICITY MONITORING**	**258,768**	**0**	**0**	**258,800**	**0**	**0**
550	**55**		**EA AND MONITORING**	236,142	16,637	18,542	159,394	24,821	16,626
550	**55**	**10**	**EA & MONITORING PROGRAM MANAGEMENT**	**45,513**	**4,917**	**4,512**	**26,454**	**5,775**	**3,850**
550	**55**	**20**	**CNSC CONSTRUCTION LIC - EA**	**7,840**	**7,840**	**0**	**0**	**0**	**0**
550	**55**	**30**	**CNSC DECOMMISSIONING LIC - EA**	**5,180**	**0**	**0**	**5,180**	**0**	**0**
550	**55**	**40**	**GROUNDWATER MONITORING**	**25,104**	**543**	**1,991**	**18,100**	**2,715**	**1,810**
550	**55**	**50**	**RADIOLOGICAL BIOSPHERE MONITORING**	**118,678**	**2,559**	**9,383**	**85,300**	**12,795**	**8,530**
550	**55**	**60**	**NON - RAD BIOSPHERE MONITORING**	**30,649**	**660**	**2,420**	**22,000**	**3,300**	**2,200**
550	**55**	**80**	**HUMAN HEALTH MONITORING**	**3,179**	**118**	**236**	**2,360**	**236**	**236**
550	**60**		**FACILITY DECOMMISSIONING & CLOSURE**	840,825	0	0	0	809,472	31,372
550	**60**	**5**	**DECOMMISSIONING PROGRAM & OPERATIONS MANAGEMENT**	**128,427**	**0**	**0**	**0**	**128,430**	**0**
550	**60**	**10**	**DECOMMISSIONING FACILITIES (CONSTRUCTION & OPERATION)**	**329,727**	**0**	**0**	**0**	**329,731**	**0**
550	**60**	**20**	**AUXILIARY SURFACE FACILITIES**	**7,995**	**0**	**0**	**0**	**8,000**	**0**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**60**	**30**	**U/G FACILITIES**	**249,269**	**0**	**0**	**0**	**249,272**	**0**
			ENG'G DESIGN (DECOMMISSIONING)	14,984	0	0	0	14,982	0
			TOWNSITE DECOMMISSIONING	2,350	0	0	0	2,350	0
			CRUSHER PLANT DEMOL (DECOMMISSIONING)	1,356	0	0	0	1,356	0
			PERM VENT FAN REMOVAL (DECOMMISSIONING)	432	0	0	0	432	0
			SITE CLEANUP (DECOMMISSIONING)	850	0	0	0	850	0
			ACCESS TUNNELS & DRIFTS	132,378	0	0	0	132,378	0
			SERVICE SHAFT	17,967	0	0	0	17,967	0
			WASTE SHAFT	16,921	0	0	0	16,923	0
			MAINTENANCE AREA VENT SHAFT	13,623	0	0	0	13,623	0
			UPCAST VENTILATION SHAFT	13,611	0	0	0	13,611	0
			CONT'R LAB INDIRECTS (DECOMMISSIONING)	21,269	0	0	0	21,264	0
			CONT'R PLANT INDIRECTS (DECOMMISSIONING)	13,529	0	0	0	13,536	0
550	**60**	**50**	**MAIN SURFACE FACILITIES**	**21,105**	**0**	**0**	**0**	**21,104**	**0**
			USED FUEL PACKAGING PLANT (UFPP)	13,071	0	0	0	13,072	0
			SEALING MATERIALS COMPACTION PLANT	3,206	0	0	0	3,204	0
			ANCILLARY ACTIVE AREAS	2,782	0	0	0	2,782	0
			UFC HANDLING SYSTEMS	2,046	0	0	0	2,046	0
550	**60**	**60**	**DECOMMISSIONING WASTE DISPOSAL**	**64,403**	**0**	**0**	**0**	**64,403**	**0**
550	**60**	**80**	**CLOSURE**	39,901	0	0	0	8,532	31,372
550	**90**		**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	285,044	175,302	109,747	0	0	0
550	**90**	**0**	**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	285,044	175,302	109,747	0	0	0
			TOTAL	**12,674,887**	**1,084,208**	**2,803,282**	**7,826,146**	**881,618**	**79,610**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS	WBS Title	Total	Siting	Construction	Operation	Decommission	Closure

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550			**DEEP GEOLOGIC REPOSITORY FACILITY**						
550	**15**		**SITING**	396,844	346,225	50,593	0	0	0
550	**15**	**10**	**TECHNICAL SITING MANAGEMENT**	**26,645**	**16,539**	**10,109**	**0**	**0**	**0**
550	**15**	**20**	**CANDIDATE AREAS**	**95,438**	**63,908**	**31,508**	**0**	**0**	**0**
			SELECTION OF FEASIBILITY STUDY COMMUNITIES	6,210	6,210	0	0	0	0
			DATABASE & INFORMATION SYSTEM	41,183	26,935	14,249	0	0	0
			QUALITY ASSURANCE PROGRAM	30,240	17,730	12,496	0	0	0
			SEISMICITY MONITORING	12,571	7,800	4,763	0	0	0
			TECHNICAL SITING PLAN	294	294	0	0	0	0
			GEOSPHERE CHARACTERISATION	2,353	2,353	0	0	0	0
			BIOSPHERE CHARACTERISATION	2,588	2,588	0	0	0	0
550	**15**	**50**	**FEASIBILITY STUDIES (3 SITES)**	**34,052**	**34,052**	**0**	**0**	**0**	**0**
			FEASIBILITY STUDIES - SUPPORT & REPORTING	6,075	6,075	0	0	0	0
			CHARACTERISATION & MONITORING PLAN	1,038	1,038	0	0	0	0
			GEOSPHERE CHARACTERISATION & MODELLING	14,750	14,750	0	0	0	0
			BIOSPHERE CHARACTERISATION & MODELLING	12,189	12,189	0	0	0	0
550	**15**	**60**	**CANDIDATE SITES (2 SITES)**	**156,929**	**156,929**	**0**	**0**	**0**	**0**
			CANDIDATE SITES - SUPPORT & REPORTING	8,242	8,242	0	0	0	0
			CHARACTERISATION & MONITORING PLAN	1,581	1,581	0	0	0	0
			GEOSPHERE CHARACTERISATION & MODELLING	127,811	127,811	0	0	0	0
			BIOSPHERE CHARACTERISATION & MODELLING	19,295	19,295	0	0	0	0
550	**15**	**70**	**PREFERRED SITE**	**83,780**	**74,797**	**8,976**	**0**	**0**	**0**
			SITE EVALUATION PLAN	1,265	1,264	0	0	0	0
			GEOSPHERE EVALUATION (SURFACE)	56,370	56,368	0	0	0	0
			BIOSPHERE EVALUATION	14,716	14,716	0	0	0	0

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			BIOSPHERE MONITORING & TECHNICAL SUPPORT	11,429	2,448	8,976	0	0	0
550	**20**		**REPOSITORY SYSTEM DEVELOPMENT**	411,191	241,445	135,222	34,530	0	0
550	**20**	**2**	**REPOSITORY SYSTEM DEVELOPMENT MANAGEMENT**	**30,593**	**18,989**	**11,605**	**0**	**0**	**0**
550	**20**	**5**	**REPOSITORY SYSTEMS DESIGN INTEGRATION**	**3,202**	**3,202**	**0**	**0**	**0**	**0**
550	**20**	**10**	**CONTAINER ENGINEERING**	**42,607**	**42,608**	**0**	**0**	**0**	**0**
			PREL CONTAINER DESIGN ENGINEERING	18,244	18,244	0	0	0	0
			FABRICATION, INSPECTION & SEALING TECH DEV	7,194	7,194	0	0	0	0
			MANUFACTURNG, INSPECTION & SEALING DEMONSTRATIONS	14,387	14,387	0	0	0	0
			DETAILED CONTAINER DESIGN & ENGINEERING	2,782	2,783	0	0	0	0
550	**20**	**15**	**REPOSITORY ENGINEERING**	**192,955**	**76,564**	**81,858**	**34,530**	**0**	**0**
			REPOSITORY DESIGN ALTERNATIVES	3,600	3,600	0	0	0	0
			SITE DEPENDENT REPOSITORY DESIGNS	3,900	3,900	0	0	0	0
			REPOSITORY SEALING SYSTEMS	15,600	15,600	0	0	0	0
			PRELIMINARY REPOSITORY DESIGNS	17,249	17,250	0	0	0	0
			PLAN REPOSITORY DEV STUDIES	832	832	0	0	0	0
			CONDUCT REPOSITORY DEV STUDIES	44,549	31,185	13,365	0	0	0
			PLAN UCF DEMONSTRATIONS	6,025	0	6,020	0	0	0
			CONDUCT UCF DEMONSTRATIONS	92,079	0	57,550	34,530	0	0
			PRODUCE SPECS & INPUT TO FSAR	2,220	2,220	0	0	0	0
			DEFEND REPOSITORY & UFPP DESIGNS	1,335	1,335	0	0	0	0
			TECH SPECS FOR REPOSITORY & UFPP	5,565	642	4,923	0	0	0
550	**20**	**20**	**USED FUEL PACKAGING SYSTEM PLANT ENG'NG**	**28,087**	**15,462**	**12,624**	**0**	**0**	**0**
			UFPP CONCEPTUAL DESIGN	1,912	1,912	0	0	0	0
			UFPP PRELIMINARY DESIGN	4,732	4,734	0	0	0	0

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			DEMONSTRATE UFPP COMPONENTS	21,442	8,816	12,624	0	0	0
550	**20**	**25**	**SEALING MATERIALS ENGINEERING**	**32,607**	**24,455**	**8,151**	**0**	**0**	**0**
550	**20**	**30**	**EMPLACMENT SYSTEMS ENGINEERING**	**49,906**	**37,435**	**12,478**	**0**	**0**	**0**
550	**20**	**35**	**RETRIEVAL SYSTEMS ENGINEERING**	**26,226**	**19,670**	**6,556**	**0**	**0**	**0**
550	**20**	**40**	**SECURITY & SAFEGUARD ENG'NG**	**5,010**	**3,060**	**1,950**	**0**	**0**	**0**
			SECURITY & SAFEGUARDS SPECIFICATIONS	1,110	1,110	0	0	0	0
			SAFEGUARDS DESIGN & TESTING	3,900	1,950	1,950	0	0	0
550	**25**		**SAFETY ASSESSMENT**	687,190	161,779	108,535	350,209	40,080	26,720
550	**25**	**10**	**SAFETY ASSESSMENT MANAGEMENT**	**56,995**	**34,116**	**22,891**	**0**	**0**	**0**
550	**25**	**30**	**SA SITING**	**127,660**	**127,663**	**0**	**0**	**0**	**0**
			SA SITING PRECLOSURE	6,000	6,002	0	0	0	0
			SA SITING POSTCLOSURE	25,713	25,715	0	0	0	0
			SA SITING R&D	95,946	95,946	0	0	0	0
550	**25**	**40**	**SA OPERATING LICENSE**	**85,642**	**0**	**85,644**	**0**	**0**	**0**
			SA OPERATING LICENCE PRECLOSURE	4,644	0	4,640	0	0	0
			SA OPERATING LICENCE POSTCLOSURE	23,113	0	23,122	0	0	0
			SA OPERATING LICENCE R&D	57,886	0	57,882	0	0	0
550	**25**	**50**	**SA FACILITY OPERATIONS**	**86,187**	**0**	**0**	**86,190**	**0**	**0**
550	**25**	**60**	**SA EXTENDED MONITORING**	**94,773**	**0**	**0**	**94,780**	**0**	**0**
550	**25**	**70**	**SA DECOMMISSIONING & CLOSURE**	**27,160**	**0**	**0**	**0**	**16,305**	**10,870**

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**25**	**80**	**GEOSCIENCE MONITORING (Yrs 30 >>154)**	**208,773**	**0**	**0**	**169,239**	**23,775**	**15,850**
550	**30**		**LICENSING & APPROVALS**	120,421	20,954	13,657	73,656	7,245	4,892
550	**30**	**30**	**LIASON WITH CNSC**	**4,315**	**4,315**	**0**	**0**	**0**	**0**
550	**30**	**50**	**CNSC CONSTRUCTION LICENCE**	**26,820**	**15,299**	**11,517**	**0**	**0**	**0**
550	**30**	**60**	**OTHER GOVERNMENT APPROVALS**	**1,765**	**1,340**	**429**	**0**	**0**	**0**
			OTHER GOVERNMENT APPROVALS - REQUIREMENTS	1,067	1,067	0	0	0	0
			OTHER GOVERNMENT APPROVALS - FEDERAL	238	91	143	0	0	0
			OTHER GOVERNMENT APPROVALS - PROVINCIAL	222	90	143	0	0	0
			OTHER GOVERNMENT APPROVALS - MUNICIPAL	238	91	143	0	0	0
550	**30**	**65**	**CNSC OPS LICENCE (INITIAL APPLICATION)**	**1,710**	**0**	**1,711**	**0**	**0**	**0**
550	**30**	**70**	**CNSC OPERATING LICENCE (LICENCE MAINTENANCE & RENEWAL)**	**70,127**	**0**	**0**	**70,110**	**0**	**0**
			CNSC OPERATING LICENCE (Renewal during operations)	42,998	0	0	43,020	0	0
			CNSC OPERATING LICENCE (Maintenance during preclosure monitoring)	27,130	0	0	27,090	0	0
550	**30**	**75**	**CNSC DECOMMISSIONING LICENCE**	**15,139**	**0**	**0**	**3,546**	**7,245**	**4,347**
550	**30**	**80**	**CNSC LICENCE TO ABANDON**	**544**	**0**	**0**	**0**	**0**	**545**
550	**35**		**PUBLIC AFFAIRS (Yrs1 >>29)**	106,945	77,700	29,238	0	0	0
550	**35**	**10**	**PUBLIC AFFAIRS - CANDIDATE AREAS**	**11,999**	**11,999**	**0**	**0**	**0**	**0**
550	**35**	**30**	**PUBLIC AFFAIRS - FEASIBILITY STUDIES**	**15,002**	**15,002**	**0**	**0**	**0**	**0**
550	**35**	**40**	**PUBLIC AFFAIRS - CANDIDATE SITES**	**23,504**	**23,504**	**0**	**0**	**0**	**0**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**35**	**45**	**PUBLIC AFFAIRS - PREFERRED SITE**	**11,839**	**11,840**	**0**	**0**	**0**	**0**
550	**35**	**50**	**PUBLIC AFFAIRS - PUBLIC REVIEW / EA**	**10,042**	**10,041**	**0**	**0**	**0**	**0**
550	**35**	**70**	**PUBLIC AFFAIRS - DESIGN & CONSTRUCTION**	**17,444**	**0**	**17,446**	**0**	**0**	**0**
550	**35**	**110**	**PUBLIC AFFAIRS - PROGRAM MANAGEMENT**	**8,565**	**5,314**	**3,245**	**0**	**0**	**0**
550	**35**	**120**	**PUBLIC AFFAIRS - COMMUNITY OFFSETS AND BENEFITS**	**8,550**	**0**	**8,547**	**0**	**0**	**0**
550	**40**		**FACILITY DESIGN AND CONSTRUCTION**	2,381,931	44,166	2,337,748	0	0	0
550	**40**	**5**	**SITE CONFIRMATION**	**398,959**	**44,166**	**354,793**	**0**	**0**	**0**
			GEOSPHERE BASELINE MONITORING	19,401	19,401	0	0	0	0
			GEOSPHERE EVALUATION (UNDERGROUND)	127,761	0	127,759	0	0	0
			UCF DESIGN	38,099	24,765	13,335	0	0	0
			UCF TEMPORARY INFRASTRUCTURE	2,706	0	2,706	0	0	0
			CONCRETE PLANT	6,563	0	6,562	0	0	0
			CRUSHING PLANT	8,303	0	8,303	0	0	0
			CAMPSITE	76,349	0	76,350	0	0	0
			SERVICE/PRODUCTION SHAFT	52,058	0	52,058	0	0	0
			MAINTENANCE COMPLEX EXHAUST SHAFT	18,385	0	18,384	0	0	0
			TUNNEL AND SERVICE AREA EXCAVATION	47,544	0	47,542	0	0	0
			REPORTS	1,792	0	1,794	0	0	0
550	**40**	**10**	**SITE ACQUISITION AND IMPROVEMENTS**	**72,987**	**0**	**72,988**	**0**	**0**	**0**
550	**40**	**15**	**CONSTRUCTION INDIRECTS**	**133,820**	**0**	**133,818**	**0**	**0**	**0**

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**40**	**20**	**SURFACE FACILITIES**	**855,206**	**0**	**855,209**	**0**	**0**	**0**
			UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION	98,915	0	98,914	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 1)	113,019	0	113,021	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 2)	82,609	0	82,610	0	0	0
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 3)	128,278	0	128,279	0	0	0
			BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)	28,047	0	28,048	0	0	0
			COMMISSIONING (UFPP)	64,837	0	64,836	0	0	0
			SEALING MATERIALS COMPACTION PLANT (SMCP)	339,500	0	339,501	0	0	0
550	**40**	**30**	**AUXILIARY SURFACE FACILITIES / AREAS**	**522,273**	**0**	**522,270**	**0**	**0**	**0**
			ADMIN BUILDING	22,674	0	22,674	0	0	0
			AUXILIARY BUILDING	4,761	0	4,762	0	0	0
			FIREHALL/SECURITY BUILDING	1,204	0	1,204	0	0	0
			ACTIVE LIQUID WASTE TREATMENT (ALWT) BUILDING	34,552	0	34,552	0	0	0
			GARAGE BUILDING / WAREHOUSE	13,838	0	13,838	0	0	0
			SEWAGE TREATMENT PLANT	538	0	538	0	0	0
			WATER TREATMENT PLANT	4,064	0	4,064	0	0	0
			EMERGENCY POWER GENERATION	5,153	0	5,153	0	0	0
			PUMPHOUSE & INTAKE	2,039	0	2,038	0	0	0
			QC OFFICES & LABS	15,811	0	15,810	0	0	0
			HAZARDOUS MATLS STORAGE BLDG	8,876	0	8,876	0	0	0
			WASTE MANAGEMENT AREA	4,739	0	4,740	0	0	0
			LOW LEVEL LIQUID WASTE STORAGE BUILDING	3,724	0	3,723	0	0	0
			SERVICE SHAFT WATER SETTLING POND	1,901	0	1,900	0	0	0
			ELECTRICAL SWITCHYARD	1,017	0	1,017	0	0	0
			TRANSFORMER AREAS	1,017	0	1,017	0	0	0
			WATER STORAGE TANK AREA	1,423	0	1,422	0	0	0

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Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			PROCESS WATER SETTLING POND	5,029	0	5,028	0	0	0
			TOWNSITE	374,079	0	374,079	0	0	0
			OVERHEAD CORRIDOR	4,577	0	4,576	0	0	0
			LOW LEVEL WASTE STORAGE BUILDING	5,580	0	5,580	0	0	0
			FUEL TANK AREA	173	0	173	0	0	0
			STORM RUN-OFF POND	2,427	0	2,428	0	0	0
			DUST COLLECTION BAGHOUSE	3,078	0	3,078	0	0	0
550	**40**	**40**	**UNDERGROUND FACILITIES**	**335,339**	**0**	**335,333**	**0**	**0**	**0**
			U/G CONSTRUCTION STAGE	25,878	0	25,872	0	0	0
			COMMISSIONING DURING CONST'N	10,643	0	10,641	0	0	0
			WASTE SHAFT	48,439	0	48,438	0	0	0
			UPCAST VENTILATION SHAFT	15,803	0	15,802	0	0	0
			TUNNELS (Panel/Perimeter access)	86,024	0	86,024	0	0	0
			EMPLACEMENT ROOMS (All Panel A & Lower Panel B)	94,981	0	94,984	0	0	0
			ANCILIARY FACILITIES	1,962	0	1,965	0	0	0
			UFC HANDLING SYSTEM EQUIPMENT	26,375	0	26,372	0	0	0
			UNDERGROUND EQUIPMENT	13,908	0	13,908	0	0	0
			SEALING MATERIALS EMPLACEMENT SYSTEM	11,327	0	11,327	0	0	0
550	**40**	**50**	**ELECTRICAL DISTRIBUTION**	**44,426**	**0**	**44,424**	**0**	**0**	**0**
550	**40**	**60**	**COMMUNICATION SYSTEM**	**2,600**	**0**	**2,600**	**0**	**0**	**0**
550	**40**	**70**	**COMMON PROCESSES & SERVICES**	**16,319**	**0**	**16,313**	**0**	**0**	**0**
			COMMON PROCESS SERVICES WATER SYSTEMS	1,402	0	1,402	0	0	0
			SEWAGE, DRAINAGE & TREATMENT	3,170	0	3,168	0	0	0
			COMPRESSED AIR (SURFACE & UNDERGROUND)	924	0	923	0	0	0
			VENTILATION SYSTEMS	9,404	0	9,400	0	0	0

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			SOLID WASTE MGMT (DISPOSAL)	1,419	0	1,420	0	0	0
550	**45**		**FACILITY OPERATION**	7,208,354	0	0	7,208,357	0	0
550	**45**	**5**	**OPERATIONS PROGRAM MANAGEMENT**	257,367	0	0	257,370	0	0
550	**45**	**10**	**OPERATION MANAGEMENT & ADMINISTRATION**	323,362	0	0	323,340	0	0
550	**45**	**15**	**OPERATIONS INDIRECTS**	789,594	0	0	789,595	0	0
550	**45**	**20**	**SURFACE WORKS OPERATIONS**	3,835,731	0	0	3,835,754	0	0
			UFPP OPERATION	626,749	0	0	626,764	0	0
			SUPPLY OF BASKETS AND UFCS	2,264,782	0	0	2,264,770	0	0
			SMCP OPERATION	542,069	0	0	542,070	0	0
			AUXILIARY SURFACE FACILITIES	402,131	0	0	402,150	0	0
550	**45**	**40**	**U/G OPERATIONS**	636,189	0	0	636,187	0	0
			EMPLACEMENT IN UNDERGROUND ROOMS	320,979	0	0	320,980	0	0
			DEMOBILIZATION	8,366	0	0	8,368	0	0
			U/G EQUIPMENT	4,854	0	0	4,854	0	0
			CAPITAL REPLACEMENT	56,250	0	0	56,250	0	0
			HOIST ROPE REPLACEMENT	44,407	0	0	44,410	0	0
			ENGINEERING (OPS STAGE)	22,854	0	0	22,853	0	0
			CAMP ADDIT'N/OPERAT'G (OPS STAGE)	14,414	0	0	14,412	0	0
			ROOM EXCAVATION (Upper Panel B & Lower Panel D)	56,195	0	0	56,193	0	0
			ROOM EXCAVATION (All Panel C)	56,195	0	0	56,193	0	0
			ROOM EXCAVATION (Upper Panel D)	28,338	0	0	28,339	0	0
			CON LABOUR INDIRECTS (RM EXCV)	11,034	0	0	11,035	0	0
			CON PLANT INDIRECTS (RM EXCV)	12,303	0	0	12,300	0	0
550	**45**	**50**	**EXTENDED MONITORING**	1,107,342	0	0	1,107,311	0	0

Deep Geological Repository Cost Estimate

Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
			EXTENDED OPERATIONS MANAGEMENT & ENGINEERING (Direct & Indirect)	880,116	0	0	880,091	0	0
			EXTENDED MONITORING - MAINTENANCE	227,226	0	0	227,220	0	0
550	**45**	**60**	**REPOSITORY PERFORMANCE & SEISMICITY MONITORING**	**258,768**	**0**	**0**	**258,800**	**0**	**0**
550	**55**		**EA AND MONITORING**	236,142	16,637	18,542	159,394	24,821	16,626
550	**55**	**10**	**EA & MONITORING PROGRAM MANAGEMENT**	**45,513**	**4,917**	**4,512**	**26,454**	**5,775**	**3,850**
550	**55**	**20**	**CNSC CONSTRUCTION LIC - EA**	**7,840**	**7,840**	**0**	**0**	**0**	**0**
550	**55**	**30**	**CNSC DECOMMISSIONING LIC - EA**	**5,180**	**0**	**0**	**5,180**	**0**	**0**
550	**55**	**40**	**GROUNDWATER MONITORING**	**25,104**	**543**	**1,991**	**18,100**	**2,715**	**1,810**
550	**55**	**50**	**RADIOLOGICAL BIOSPHERE MONITORING**	**118,678**	**2,559**	**9,383**	**85,300**	**12,795**	**8,530**
550	**55**	**60**	**NON - RAD BIOSPHERE MONITORING**	**30,649**	**660**	**2,420**	**22,000**	**3,300**	**2,200**
550	**55**	**80**	**HUMAN HEALTH MONITORING**	**3,179**	**118**	**236**	**2,360**	**236**	**236**
550	**60**		**FACILITY DECOMMISSIONING & CLOSURE**	840,825	0	0	0	809,472	31,372
550	**60**	**5**	**DECOMMISSIONING PROGRAM & OPERATIONS MANAGEMENT**	**128,427**	**0**	**0**	**0**	**128,430**	**0**
550	**60**	**10**	**DECOMMISSIONING FACILITIES (CONSTRUCTION & OPERATION)**	**329,727**	**0**	**0**	**0**	**329,731**	**0**
550	**60**	**20**	**AUXILIARY SURFACE FACILITIES**	**7,995**	**0**	**0**	**0**	**8,000**	**0**

Deep Geological Repository Cost Estimate
Cost by Phase K$

WBS			WBS Title	Total	Siting	Construction	Operation	Decommission	Closure
550	**60**	**30**	**U/G FACILITIES**	**249,269**	**0**	**0**	**0**	**249,272**	**0**
			ENG'G DESIGN (DECOMMISSIONING)	14,984	0	0	0	14,982	0
			TOWNSITE DECOMMISSIONING	2,350	0	0	0	2,350	0
			CRUSHER PLANT DEMOL (DECOMMISSIONING)	1,356	0	0	0	1,356	0
			PERM VENT FAN REMOVAL (DECOMMISSIONING)	432	0	0	0	432	0
			SITE CLEANUP (DECOMMISSIONING)	850	0	0	0	850	0
			ACCESS TUNNELS & DRIFTS	132,378	0	0	0	132,378	0
			SERVICE SHAFT	17,967	0	0	0	17,967	0
			WASTE SHAFT	16,921	0	0	0	16,923	0
			MAINTENANCE AREA VENT SHAFT	13,623	0	0	0	13,623	0
			UPCAST VENTILATION SHAFT	13,611	0	0	0	13,611	0
			CONT'R LAB INDIRECTS (DECOMMISSIONING)	21,269	0	0	0	21,264	0
			CONT'R PLANT INDIRECTS (DECOMMISSIONING)	13,529	0	0	0	13,536	0
550	**60**	**50**	**MAIN SURFACE FACILITIES**	**21,105**	**0**	**0**	**0**	**21,104**	**0**
			USED FUEL PACKAGING PLANT (UFPP)	13,071	0	0	0	13,072	0
			SEALING MATERIALS COMPACTION PLANT	3,206	0	0	0	3,204	0
			ANCILLARY ACTIVE AREAS	2,782	0	0	0	2,782	0
			UFC HANDLING SYSTEMS	2,046	0	0	0	2,046	0
550	**60**	**60**	**DECOMMISSIONING WASTE DISPOSAL**	**64,403**	**0**	**0**	**0**	**64,403**	**0**
550	**60**	**80**	**CLOSURE**	**39,901**	**0**	**0**	**0**	**8,532**	**31,372**
550	**90**		**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	285,044	175,302	109,747	0	0	0
550	**90**	**0**	**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	**285,044**	**175,302**	**109,747**	**0**	**0**	**0**
			TOTAL	**12,674,887**	**1,084,208**	**2,803,282**	**7,826,146**	**881,618**	**79,610**

WBS	WBS Title	Total	Siting	Construction	Operation	Decommission	Closure

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550			**DEEP GEOLOGIC REPOSITORY FACILITY**					
550	**15**		**SITING**	**396,844**	**171,681**	**0**	**120,998**	**104,166**
550	**15**	**10**	**TECHNICAL SITING MANAGEMENT**	**26,645**	**12,634**	**0**	**9,570**	**4,441**
550	**15**	**20**	**CANDIDATE AREAS**	**95,438**	**44,809**	**0**	**33,688**	**16,941**
			SELECTION OF FEASIBILITY STUDY COMMUNITIES	6,210	3,555	0	585	2,070
			DATABASE & INFORMATION SYSTEM	41,183	18,569	0	15,750	6,864
			QUALITY ASSURANCE PROGRAM	30,240	17,400	0	7,800	5,040
			SEISMICITY MONITORING	12,571	2,476	0	8,000	2,095
			TECHNICAL SITING PLAN	294	192	0	53	49
			GEOSPHERE CHARACTERISATION	2,353	960	0	1,000	392
			BIOSPHERE CHARACTERISATION	2,588	1,656	0	500	431
550	**15**	**50**	**FEASIBILITY STUDIES (3 SITES)**	**34,052**	**23,113**	**0**	**2,525**	**8,415**
			FEASIBILITY STUDIES - SUPPORT & REPORTING	6,075	3,555	0	495	2,025
			CHARACTERISATION & MONITORING PLAN	1,038	640	0	225	173
			GEOSPHERE CHARACTERISATION & MODELLING	14,750	10,746	0	600	3,404
			BIOSPHERE CHARACTERISATION & MODELLING	12,189	8,171	0	1,205	2,813
550	**15**	**60**	**CANDIDATE SITES (2 SITES)**	**156,929**	**53,207**	**0**	**53,655**	**50,067**
			CANDIDATE SITES - SUPPORT & REPORTING	8,242	5,090	0	405	2,747
			CHARACTERISATION & MONITORING PLAN	1,581	1,067	0	250	263
			GEOSPHERE CHARACTERISATION & MODELLING	127,811	34,707	0	50,500	42,604
			BIOSPHERE CHARACTERISATION & MODELLING	19,295	12,342	0	2,500	4,453
550	**15**	**70**	**PREFERRED SITE**	**83,780**	**37,918**	**0**	**21,560**	**24,302**
			SITE EVALUATION PLAN	1,265	854	0	200	211
			GEOSPHERE EVALUATION (SURFACE)	56,370	19,080	0	18,500	18,790
			BIOSPHERE EVALUATION	14,716	9,020	0	2,300	3,396

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
			BIOSPHERE MONITORING & TECHNICAL SUPPORT	11,429	8,964	0	560	1,905
550	**20**		**REPOSITORY SYSTEM DEVELOPMENT**	**411,191**	**240,285**	**24,000**	**51,000**	**95,906**
550	**20**	**2**	**REPOSITORY SYSTEM DEVELOPMENT MANAGEMENT**	**30,593**	**18,824**	**0**	**6,670**	**5,099**
550	**20**	**5**	**REPOSITORY SYSTEMS DESIGN INTEGRATION**	**3,202**	**3,202**	**0**	**0**	**0**
550	**20**	**10**	**CONTAINER ENGINEERING**	**42,607**	**24,599**	**0**	**8,176**	**9,832**
			PREL CONTAINER DESIGN ENGINEERING	18,244	10,245	0	3,789	4,210
			FABRICATION, INSPECTION & SEALING TECH DEV	7,194	4,055	0	1,478	1,660
			MANUFACTURNG, INSPECTION & SEALING DEMONSTRATIONS	14,387	8,538	0	2,530	3,320
			DETAILED CONTAINER DESIGN & ENGINEERING	2,782	1,761	0	379	642
550	**20**	**15**	**REPOSITORY ENGINEERING**	**192,955**	**117,367**	**0**	**31,290**	**44,297**
			REPOSITORY DESIGN ALTERNATIVES	3,600	2,305	0	695	600
			SITE DEPENDENT REPOSITORY DESIGNS	3,900	2,305	0	695	900
			REPOSITORY SEALING SYSTEMS	15,600	10,245	0	1,755	3,600
			PRELIMINARY REPOSITORY DESIGNS	17,249	11,889	0	1,380	3,981
			PLAN REPOSITORY DEV STUDIES	832	640	0	0	192
			CONDUCT REPOSITORY DEV STUDIES	44,549	26,893	0	7,375	10,281
			PLAN UCF DEMONSTRATIONS	6,025	3,842	0	793	1,390
			CONDUCT UCF DEMONSTRATIONS	92,079	53,527	0	17,303	21,249
			PRODUCE SPECS & INPUT TO FSAR	2,220	1,708	0	0	512
			DEFEND REPOSITORY & UFPP DESIGNS	1,335	427	0	600	308
			TECH SPECS FOR REPOSITORY & UFPP	5,565	3,586	0	695	1,284
550	**20**	**20**	**USED FUEL PACKAGING SYSTEM PLANT ENG'NG**	**28,087**	**17,673**	**0**	**4,169**	**6,245**
			UFPP CONCEPTUAL DESIGN	1,912	1,708	0	0	205
			UFPP PRELIMINARY DESIGN	4,732	2,945	0	695	1,092

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
			DEMONSTRATE UFPP COMPONENTS	21,442	13,020	0	3,474	4,948
550	**20**	**25**	**SEALING MATERIALS ENGINEERING**	**32,607**	**12,732**	**12,350**	**0**	**7,525**
550	**20**	**30**	**EMPLACMENT SYSTEMS ENGINEERING**	**49,906**	**28,397**	**7,250**	**0**	**14,259**
550	**20**	**35**	**RETRIEVAL SYSTEMS ENGINEERING**	**26,226**	**14,333**	**4,400**	**0**	**7,493**
550	**20**	**40**	**SECURITY & SAFEGUARD ENG'NG**	**5,010**	**3,159**	**0**	**695**	**1,156**
			SECURITY & SAFEGUARDS SPECIFICATIONS	1,110	854	0	0	256
			SAFEGUARDS DESIGN & TESTING	3,900	2,305	0	695	900
550	**25**		**SAFETY ASSESSMENT**	**687,190**	**290,351**	**97,200**	**99,322**	**200,317**
550	**25**	**10**	**SAFETY ASSESSMENT MANAGEMENT**	**56,995**	**27,522**	**0**	**16,320**	**13,153**
550	**25**	**30**	**SA SITING**	**127,660**	**54,971**	**31,200**	**3,612**	**37,876**
			SA SITING PRECLOSURE	6,000	4,212	0	403	1,385
			SA SITING POSTCLOSURE	25,713	18,103	0	1,709	5,902
			SA SITING R&D	95,946	32,656	31,200	1,500	30,590
550	**25**	**40**	**SA OPERATING LICENSE**	**85,642**	**36,677**	**16,500**	**6,765**	**25,701**
			SA OPERATING LICENCE PRECLOSURE	4,644	3,394	0	179	1,072
			SA OPERATING LICENCE POSTCLOSURE	23,113	16,001	0	1,778	5,334
			SA OPERATING LICENCE R&D	57,886	17,282	16,500	4,809	19,295
550	**25**	**50**	**SA FACILITY OPERATIONS**	**86,187**	**47,858**	**7,500**	**2,100**	**28,729**
550	**25**	**60**	**SA EXTENDED MONITORING**	**94,773**	**53,382**	**7,000**	**2,800**	**31,591**
550	**25**	**70**	**SA DECOMMISSIONING & CLOSURE**	**27,160**	**11,446**	**0**	**625**	**15,089**

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550	**25**	**80**	**GEOSCIENCE MONITORING (Yrs 30 >>154)**	**208,773**	**58,494**	**35,000**	**67,100**	**48,178**
550	**30**		**LICENSING & APPROVALS**	**120,421**	**23,491**	**0**	**70,983**	**25,948**
550	**30**	**30**	**LIASON WITH CNSC**	**4,315**	**764**	**0**	**2,555**	**996**
550	**30**	**50**	**CNSC CONSTRUCTION LICENCE**	**26,820**	**5,163**	**0**	**15,468**	**6,189**
550	**30**	**60**	**OTHER GOVERNMENT APPROVALS**	**1,765**	**1,187**	**0**	**0**	**578**
			OTHER GOVERNMENT APPROVALS - REQUIREMENTS	1,067	711	0	0	356
			OTHER GOVERNMENT APPROVALS - FEDERAL	238	159	0	0	79
			OTHER GOVERNMENT APPROVALS - PROVINCIAL	222	159	0	0	63
			OTHER GOVERNMENT APPROVALS - MUNICIPAL	238	159	0	0	79
550	**30**	**65**	**CNSC OPS LICENCE (INITIAL APPLICATION)**	**1,710**	**514**	**0**	**920**	**276**
550	**30**	**70**	**CNSC OPERATING LICENCE (LICENCE MAINTENANCE & RENEWAL)**	**70,127**	**12,754**	**0**	**41,190**	**16,183**
			CNSC OPERATING LICENCE (Renewal during operations)	42,998	5,955	0	27,120	9,923
			CNSC OPERATING LICENCE (Maintenance during preclosure monitoring)	27,130	6,799	0	14,070	6,261
550	**30**	**75**	**CNSC DECOMMISSIONING LICENCE**	**15,139**	**2,999**	**0**	**10,540**	**1,600**
550	**30**	**80**	**CNSC LICENCE TO ABANDON**	**544**	**109**	**0**	**310**	**126**
550	**35**		**PUBLIC AFFAIRS (Yrs1 >>29)**	**106,945**	**49,311**	**0**	**21,986**	**35,648**
550	**35**	**10**	**PUBLIC AFFAIRS - CANDIDATE AREAS**	**11,999**	**6,824**	**0**	**1,175**	**4,000**
550	**35**	**30**	**PUBLIC AFFAIRS - FEASIBILITY STUDIES**	**15,002**	**7,827**	**0**	**2,175**	**5,001**

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550	**35**	**40**	**PUBLIC AFFAIRS - CANDIDATE SITES**	**23,504**	**13,044**	**0**	**2,625**	**7,835**
550	**35**	**45**	**PUBLIC AFFAIRS - PREFERRED SITE**	**11,839**	**6,092**	**0**	**1,800**	**3,946**
550	**35**	**50**	**PUBLIC AFFAIRS - PUBLIC REVIEW / EA**	**10,042**	**4,569**	**0**	**2,125**	**3,347**
550	**35**	**70**	**PUBLIC AFFAIRS - DESIGN & CONSTRUCTION**	**17,444**	**6,955**	**0**	**4,675**	**5,815**
550	**35**	**110**	**PUBLIC AFFAIRS - PROGRAM MANAGEMENT**	**8,565**	**3,999**	**0**	**1,711**	**2,855**
550	**35**	**120**	**PUBLIC AFFAIRS - COMMUNITY OFFSETS AND BENEFITS**	**8,550**	**0**	**0**	**5,700**	**2,850**
550	**40**		**FACILITY DESIGN AND CONSTRUCTION**	**2,381,931**	**748,418**	**829,116**	**288,394**	**516,003**
550	**40**	**5**	**SITE CONFIRMATION**	**398,959**	**136,083**	**48,038**	**112,535**	**102,303**
			GEOSPHERE BASELINE MONITORING	19,401	12,167	0	4,000	3,233
			GEOSPHERE EVALUATION (UNDERGROUND)	127,761	56,174	0	29,000	42,587
			UCF DESIGN	38,099	25,399	2,540	2,540	7,620
			UCF TEMPORARY INFRASTRUCTURE	2,706	1,336	546	200	624
			CONCRETE PLANT	6,563	0	5,250	0	1,313
			CRUSHING PLANT	8,303	2,881	3,506	0	1,916
			CAMPSITE	76,349	16,510	2,800	39,420	17,619
			SERVICE/PRODUCTION SHAFT	52,058	8,572	15,513	15,959	12,013
			MAINTENANCE COMPLEX EXHAUST SHAFT	18,385	1,600	3,009	9,533	4,243
			TUNNEL AND SERVICE AREA EXCAVATION	47,544	9,815	14,874	11,883	10,972
			REPORTS	1,792	1,629	0	0	163
550	**40**	**10**	**SITE ACQUISITION AND IMPROVEMENTS**	**72,987**	**20,160**	**16,768**	**23,895**	**12,165**

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550	**40**	**15**	**CONSTRUCTION INDIRECTS**	**133,820**	**82,046**	**0**	**25,010**	**26,764**
550	**40**	**20**	**SURFACE FACILITIES**	**855,206**	**210,662**	**414,126**	**51,083**	**179,336**
			UFPP PROJ MAN / BUILDING DESIGN & CONSTRUCTION	98,915	41,634	29,530	7,968	19,783
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 1)	113,019	22,999	62,455	5,312	22,254
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 2)	82,609	17,095	44,988	4,004	16,522
			UFPP EQUIPMENT DESIGN SUPPLY AND INSTALL (AREA 3)	128,278	20,280	76,527	5,816	25,656
			BUILDING SERVICES DESIGN SUPPLY & INSTALLATION (UFPP)	28,047	7,734	13,211	1,493	5,610
			COMMISSIONING (UFPP)	64,837	34,354	2,000	6,871	21,612
			SEALING MATERIALS COMPACTION PLANT (SMCP)	339,500	66,566	185,414	19,620	67,900
550	**40**	**30**	**AUXILIARY SURFACE FACILITIES / AREAS**	**522,273**	**204,739**	**198,126**	**2,443**	**116,965**
			ADMIN BUILDING	22,674	9,099	7,534	0	6,042
			AUXILIARY BUILDING	4,761	2,175	1,362	0	1,225
			FIREHALL/SECURITY BUILDING	1,204	329	634	0	241
			ACTIVE LIQUID WASTE TREATMENT (ALWT) BUILDING	34,552	7,305	19,350	1,611	6,286
			GARAGE BUILDING / WAREHOUSE	13,838	4,386	6,684	0	2,768
			SEWAGE TREATMENT PLANT	538	187	244	0	108
			WATER TREATMENT PLANT	4,064	720	2,406	0	938
			EMERGENCY POWER GENERATION	5,153	1,977	2,145	0	1,031
			PUMPHOUSE & INTAKE	2,039	851	718	0	471
			QC OFFICES & LABS	15,811	5,976	6,672	0	3,162
			HAZARDOUS MATLS STORAGE BLDG	8,876	3,765	3,336	0	1,775
			WASTE MANAGEMENT AREA	4,739	1,496	2,229	224	790
			LOW LEVEL LIQUID WASTE STORAGE BUILDING	3,724	1,215	1,680	208	621
			SERVICE SHAFT WATER SETTLING POND	1,901	1,381	81	0	439
			ELECTRICAL SWITCHYARD	1,017	517	297	0	203

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
			TRANSFORMER AREAS	1,017	517	297	0	203
			WATER STORAGE TANK AREA	1,423	754	340	0	328
			PROCESS WATER SETTLING POND	5,029	3,741	128	0	1,161
			TOWNSITE	374,079	151,553	136,200	0	86,326
			OVERHEAD CORRIDOR	4,577	1,845	1,817	0	915
			LOW LEVEL WASTE STORAGE BUILDING	5,580	2,171	2,384	400	625
			FUEL TANK AREA	173	52	81	0	40
			STORM RUN-OFF POND	2,427	1,709	158	0	560
			DUST COLLECTION BAGHOUSE	3,078	1,018	1,350	0	710
550	**40**	**40**	**UNDERGROUND FACILITIES**	**335,339**	**68,598**	**128,541**	**73,427**	**64,773**
			U/G CONSTRUCTION STAGE	25,878	6,035	1,760	12,112	5,972
			COMMISSIONING DURING CONST'N	10,643	6,720	375	0	3,548
			WASTE SHAFT	48,439	3,261	16,578	20,542	8,058
			UPCAST VENTILATION SHAFT	15,803	1,273	2,774	9,122	2,634
			TUNNELS (Panel/Perimeter access)	86,024	19,285	28,928	20,607	17,205
			EMPLACEMENT ROOMS (All Panel A & Lower Panel B)	94,981	30,076	38,304	10,771	15,830
			ANCILIARY FACILITIES	1,962	581	872	0	509
			UFC HANDLING SYSTEM EQUIPMENT	26,375	957	19,140	191	6,087
			UNDERGROUND EQUIPMENT	13,908	0	11,590	0	2,318
			SEALING MATERIALS EMPLACEMENT SYSTEM	11,327	411	8,220	82	2,614
550	**40**	**50**	**ELECTRICAL DISTRIBUTION**	**44,426**	**18,281**	**15,893**	**0**	**10,252**
550	**40**	**60**	**COMMUNICATION SYSTEM**	**2,600**	**800**	**1,200**	**0**	**600**
550	**40**	**70**	**COMMON PROCESSES & SERVICES**	**16,319**	**7,050**	**6,425**	**0**	**2,845**
			COMMON PROCESS SERVICES WATER SYSTEMS	1,402	819	303	0	280
			SEWAGE, DRAINAGE & TREATMENT	3,170	925	1,717	0	528
			COMPRESSED AIR (SURFACE & UNDERGROUND)	924	221	518	0	185

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
			VENTILATION SYSTEMS	9,404	4,170	3,667	0	1,567
			SOLID WASTE MGMT (DISPOSAL)	1,419	915	220	0	284
550	**45**		**FACILITY OPERATION**	**7,208,354**	**2,502,530**	**2,698,279**	**750,522**	**1,257,022**
550	**45**	**5**	**OPERATIONS PROGRAM MANAGEMENT**	**257,367**	**127,294**	**0**	**87,178**	**42,894**
550	**45**	**10**	**OPERATION MANAGEMENT & ADMINISTRATION**	**323,362**	**269,468**	**0**	**0**	**53,894**
550	**45**	**15**	**OPERATIONS INDIRECTS**	**789,594**	**233,605**	**0**	**398,070**	**157,919**
550	**45**	**20**	**SURFACE WORKS OPERATIONS**	**3,835,731**	**831,026**	**2,335,631**	**61,130**	**607,944**
			UFPP OPERATION	626,749	310,087	142,850	48,462	125,350
			SUPPLY OF BASKETS AND UFCS	2,264,782	0	1,958,360	12,668	293,754
			SMCP OPERATION	542,069	289,234	144,421	0	108,414
			AUXILIARY SURFACE FACILITIES	402,131	231,705	90,000	0	80,426
550	**45**	**40**	**U/G OPERATIONS**	**636,189**	**298,677**	**187,858**	**31,459**	**118,196**
			EMPLACEMENT IN UNDERGROUND ROOMS	320,979	224,199	32,584	0	64,196
			DEMOBILIZATION	8,366	6,640	332	0	1,394
			U/G EQUIPMENT	4,854	0	4,045	0	809
			CAPITAL REPLACEMENT	56,250	0	46,875	0	9,375
			HOIST ROPE REPLACEMENT	44,407	0	37,006	0	7,401
			ENGINEERING (OPS STAGE)	22,854	17,580	0	0	5,274
			CAMP ADDIT'N/OPERAT'G (OPS STAGE)	14,414	0	0	12,012	2,402
			ROOM EXCAVATION (Upper Panel B & Lower Panel D)	56,195	20,068	26,761	0	9,366
			ROOM EXCAVATION (All Panel C)	56,195	20,068	26,761	0	9,366
			ROOM EXCAVATION (Upper Panel D)	28,338	10,122	13,493	0	4,723
			CON LABOUR INDIRECTS (RM EXCV)	11,034	0	0	9,195	1,839
			CON PLANT INDIRECTS (RM EXCV)	12,303	0	0	10,252	2,050

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550	**45**	**50**	**EXTENDED MONITORING**	**1,107,342**	**584,578**	**174,790**	**131,515**	**216,460**
			EXTENDED OPERATIONS MANAGEMENT & ENGINEERING (Direct & Indirect)	880,116	584,578	0	131,515	164,023
			EXTENDED MONITORING - MAINTENANCE	227,226	0	174,790	0	52,437
550	**45**	**60**	**REPOSITORY PERFORMANCE & SEISMICITY MONITORING**	**258,768**	**157,883**	**0**	**41,170**	**59,716**
550	**55**		**EA AND MONITORING**	**236,142**	**170,838**	**11,454**	**6,826**	**47,024**
550	**55**	**10**	**EA & MONITORING PROGRAM MANAGEMENT**	**45,513**	**33,470**	**0**	**1,540**	**10,503**
550	**55**	**20**	**CNSC CONSTRUCTION LIC - EA**	**7,840**	**3,076**	**0**	**2,150**	**2,613**
550	**55**	**30**	**CNSC DECOMMISSIONING LIC - EA**	**5,180**	**2,153**	**0**	**1,300**	**1,727**
550	**55**	**40**	**GROUNDWATER MONITORING**	**25,104**	**15,652**	**2,131**	**1,529**	**5,793**
550	**55**	**50**	**RADIOLOGICAL BIOSPHERE MONITORING**	**118,678**	**91,521**	**7,377**	**0**	**19,780**
550	**55**	**60**	**NON - RAD BIOSPHERE MONITORING**	**30,649**	**22,573**	**1,946**	**0**	**6,130**
550	**55**	**80**	**HUMAN HEALTH MONITORING**	**3,179**	**2,393**	**0**	**307**	**479**
550	**60**		**FACILITY DECOMMISSIONING & CLOSURE**	**840,825**	**362,099**	**203,952**	**90,401**	**184,373**
550	**60**	**5**	**DECOMMISSIONING PROGRAM & OPERATIONS MANAGEMENT**	**128,427**	**91,457**	**3,500**	**12,065**	**21,404**
550	**60**	**10**	**DECOMMISSIONING FACILITIES (CONSTRUCTION & OPERATION)**	**329,727**	**119,830**	**109,839**	**23,966**	**76,091**

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS			WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
550	**60**	**20**	**AUXILIARY SURFACE FACILITIES**	**7,995**	**6,396**	**0**	**0**	**1,599**
550	**60**	**30**	**U/G FACILITIES**	**249,269**	**112,570**	**77,802**	**0**	**58,896**
			ENG'G DESIGN (DECOMMISSIONING)	14,984	11,526	0	0	3,458
			TOWNSITE DECOMMISSIONING	2,350	1,280	600	0	470
			CRUSHER PLANT DEMOL (DECOMMISSIONING)	1,356	960	125	0	271
			PERM VENT FAN REMOVAL (DECOMMISSIONING)	432	320	40	0	72
			SITE CLEANUP (DECOMMISSIONING)	850	480	200	0	170
			ACCESS TUNNELS & DRIFTS	132,378	39,728	58,330	0	34,320
			SERVICE SHAFT	17,967	10,397	3,424	0	4,146
			WASTE SHAFT	16,921	11,417	1,598	0	3,905
			MAINTENANCE AREA VENT SHAFT	13,623	9,591	888	0	3,144
			UPCAST VENTILATION SHAFT	13,611	9,447	1,023	0	3,141
			CONT'R LAB INDIRECTS (DECOMMISSIONING)	21,269	17,424	300	0	3,545
			CONT'R PLANT INDIRECTS (DECOMMISSIONING)	13,529	0	11,274	0	2,255
550	**60**	**50**	**MAIN SURFACE FACILITIES**	**21,105**	**12,612**	**1,100**	**2,522**	**4,870**
			USED FUEL PACKAGING PLANT (UFPP)	13,071	7,879	600	1,576	3,016
			SEALING MATERIALS COMPACTION PLANT	3,206	1,888	200	378	740
			ANCILLARY ACTIVE AREAS	2,782	1,617	200	323	642
			UFC HANDLING SYSTEMS	2,046	1,228	100	246	472
550	**60**	**60**	**DECOMMISSIONING WASTE DISPOSAL**	**64,403**	**0**	**290**	**49,250**	**14,862**
550	**60**	**80**	**CLOSURE**	**39,901**	**19,233**	**11,420**	**2,597**	**6,650**
550	**90**		**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	**285,044**	**203,115**	**0**	**34,421**	**47,507**
550	**90**	**0**	**PROGRAM MANAGEMENT (Yrs 1 >> 29)**	**285,044**	**203,115**	**0**	**34,421**	**47,507**

Deep Geological Repository Cost Estimate

Cost by Category K$

WBS	WBS Title	Total	Labour	Materials and Equipment	Other	Cont'y
	TOTAL	**12,674,887**	**4,762,119**	**3,864,000**	**1,534,854**	**2,513,915**

APPENDIX C

DGR Cost Estimate Access Database (CD included)

APPENDIX D

Used Fuel Container Cost Estimate Detail

Contents

Used Fuel Container Capital Costs

1 Introduction

The current used fuel container (UFC) design has a fuel capacity of 324 fuel bundles per container. The dimensions of the deep geologic repository (DGR) UFC are shown in Table 1. This UFC design consists of a number of components:

- an outer 25-mm-thick corrosion-barrier vessel
- an inner load-bearing steel vessel
- three fuel baskets.

In the present study, the cost of fabricating the current UFC was based on a UFC production plan as shown in Figure 1. This production plan was derived from the UFC production plan of SKB that was designed for serial production of copper containers with cast inserts [1]. Key container components, including the copper tubes, copper lids and bottoms, the inner steel vessels and fuel baskets, will be fabricated by various suppliers and shipped to the Container Factory. UFCs will be fabricated, machined, inspected and assembled at the Container Factory. From the Container Factory, finished UFCs i.e. copper vessel/steel vessel assembly, the copper and steel lids, and the fuel baskets, will be shipped to the DGR used fuel packaging plant (UFPP). The cost of a UFC is broken down as follow:

- production cost of container components from suppliers
- transportation cost of container components from suppliers to the Container Factory
- cost of container fabrication, machining and inspection and assembly at the Container factory
- transportation costs of UFCs from the Container Factory to the DGR.

The transportation costs of UFCs from the Container Factory to the DGR are not included in the present cost estimate for UFCs. This has been developed separately.

2 Estimated Cost of Used Fuel Containers

2.1 COPPER VESSEL COST

Table 1 shows the canister dimensions, the material requirements, and the production costs for the fabrication of the copper tube, lid and bottom for a 30-mm-thick copper vessel for a ‘BWR’ canister, provided by SKB. Based on the cost information provided by SKB, the production costs of the copper tube, lid and bottom for the current UFC design were estimated to be $42,369 (2000 $). With an assumed escalation factor of 2.5% per year, the production cost of the copper tube, lid and bottom of the current UFC design was estimated at $45,000 (2002 $). The production cost of the copper tube was based on the extrusion method. SKB has demonstrated that the high quality copper tubes can be fabricated by the roll forming/electron beam welding, extrusion and pierce/draw methods [1]. For the purpose of this cost estimate, it is assumed that extruded copper tubes are fabricated and shipped to the Container Factory without machining. The copper lids and bottoms are fabricated by forging and rough machining will be carried out by the suppliers prior to being shipped to the Container Factory for final machining.

2.2 COSTS OF THE INNER STEEL VESSEL AND THE FUEL BASKET

2.2.1 Cost Based on Conventional Forming and Welding Method

Poon et al. [2] of Ontario Power Generation (OPG) developed a preliminary technical specification for the fabrication of inner vessels and associated fuel baskets for four specific container designs. The inner vessels were assumed to be fabricated and inspected to the intent the ASME Boiler & Pressure Vessel Code, Section III, Subsection NC. Based on this preliminary specification, a pressure vessel manufacturer, Babcock & Wilcox (B&W) of Cambridge, Ontario, prepared and provided OPG with estimated costs of the inner vessels and associated baskets [3]. The costs were based on a batch of 100 vessels and baskets. The estimated costs included for labour, quality assurance, inspection, tooling, technical support and material. Based on these estimated costs, a cost formula was developed by OPG that can be used to estimate the costs of the inner vessels and fuel baskets of container designs with other fuel capacities and sizes [3]. The formula can be represented in a logarithmic plot with following equation:

Estimated cost (2000 $) = 28852Ln(fuel capacity) – 46881

By using this formula, the estimated cost of the steel vessel and fuel basket of the current UFC design with 324 fuel bundles was estimated at $119,905 (2000 $). With the use of an escalation factor of 2.5% per year, the estimated costs of the inner vessel and basket for the current UFC design was estimated at approximately $126,000 (2002 $).

According to estimated costs provided by B&W, the cost of the inner vessel and basket was about 74% and 26% of the combined vessel/basket cost, respectively Maak [3]. This would imply that the costs of the inner vessel and basket of the current UFC design would be about $93,000 and $33,000 (2002 $), respectively.

In the B&W cost estimate [3], conventional fabrication techniques were assumed to estimate the fabrication of the inner vessel that required a substantial level of manual labour. The total cost of labour, QA/inspection and technical support represented about 64% i.e. $60,000, of the overall fabrication cost of the inner vessel i.e. $93,000. For serial production of over 11,000 inner vessels, it is anticipated that cost savings of about $18,000 per container i.e. 30% of the $60,000, could be conservatively realised by the use of automated/mechanised forming, welding and inspection equipment and procedures. In this case, the fabrication cost of the inner vessel can be conservatively reduced to $75,000. The total cost of the inner vessel and the fuel basket cost would become $108,000 (2002 $) i.e. sum of $75,000 and $33,000.

2.2.2 Cost Based on Other Fabrication Methods

For serial production of the inner vessel, other fabrication methods that involve less manual labour should be considered in the future. These include casting and pierce and draw techniques.

Estimated fabrication costs of fabricating cast iron inserts of a number of UFC geometric alternatives were obtained by Maak [3] from a number of manufacturers. The unit manufacturing costs ranged from $6.2 /kg to $8.1/kg (2000 $). These cast iron inserts are large castings with a large number of channels, which weighed from about 13000 to 18000 kg. In comparison with these cast insert designs, the inner vessel of the current design is approximately 11500 kg and has a less complex geometry. It is anticipated that high quality inner vessels can be fabricated using existing casting technology. Furthermore, it is expected that the unit manufacturing cost of a cast iron or cast steel inner vessel would be lower than those of the cast iron insert. With a conservative assumed unit manufacturing cost of $6.2/kg, the estimated cost of an inner vessel fabricated by the casting technique would be about $71,300 (2000 $). Based on an assumed escalation factor of 2.5%, the estimated cost of an inner vessel fabricated by the casting technique would be about $75,000 (2002 $).

Based on a preliminary assessment, Vallourec and Mannesmann Tubes of Germany has indicated that it is possible to use the pierce and draw technique for fabricating an inner steel vessel. This vessel could be manufactured with an integral bottom for the current UFC design i.e. a steel vessel with an outside diameter of 1116 mm and a wall thickness of 96 mm, at an estimated cost of about $28,700, including material. Vallourec and Mannesmann Tubes had previously produced tubes for the German 'Pollux' container that had finished dimensions of 1012 mm outside diameter, 690 mm inside diameter and 5086 mm long and weighing about 17.2 tons. Although Vallourec and Mannesmann Tubes did not provide costs for machining the steel vessel and fabrication of the inner-vessel lid, it is likely that the total cost of the inner vessel together with the lid would be less than $75,000 (2002$).

2.2.3 Recommended Estimated Cost of Inner Vessel and Fuel Baskets

In view of the above discussion in Sections 2.2.1 and 2.2.2, it is envisaged that the estimated cost of $93,000 for the inner vessel can be conservatively reduced by about $18,000. This can be achieved through the improvement of the conventional forming/welding method, or the use of other fabrication techniques such as casting, or pierce and draw techniques. The revised estimated cost of the inner vessel would then be $75,000. The total cost of the inner vessel ($75,000) and the basket ($33,000) would be $108,000.

2.3 TRANSPORTATION COST OF CONTAINER COMPONENTS FROM SUB-SUPPLIERS TO THE CONTAINER FACTORY

An allowance of $3,000 (2002 $) per container is included as an estimate for the transport cost of container components from the suppliers to the Container factory. The container components include copper tube, lids and bottom of the copper vessel, the inner vessel and the fuel basket. The transportation cost will depend mainly on the distance between the supplier and the Container Factory. The current cost estimate of $3,000 was based on the assumption that suppliers are located in regions within 100-200 km of the Container Factory.

2.4 UFC PRODUCTION COST AT CONTAINER FACTORY

According to Andersson [1], the SKB canister factory would be capable to produce 210 canisters per year. The factory would have floor space of 5,800 m^2 and would cost 78 million SEK (2001 SEK) to build. The total investment cost for machines and other equipment has been estimated at 99 million SEK (2001 SEK) and the personnel requirement at 21 persons. Based on these SKB data, the cost of a Container Factory that would produce 370 UFCs per year over an assumed 30 year operational period were developed and shown in Table 2. As shown in Table 2, the cost for producing each UFC at the Container Factory has been estimated at about $20,000 (2002 $).

3 Potential Means for Reducing UFC Production Costs

It is expected that the estimated fabrication cost of UFCs may be reduced in future because:

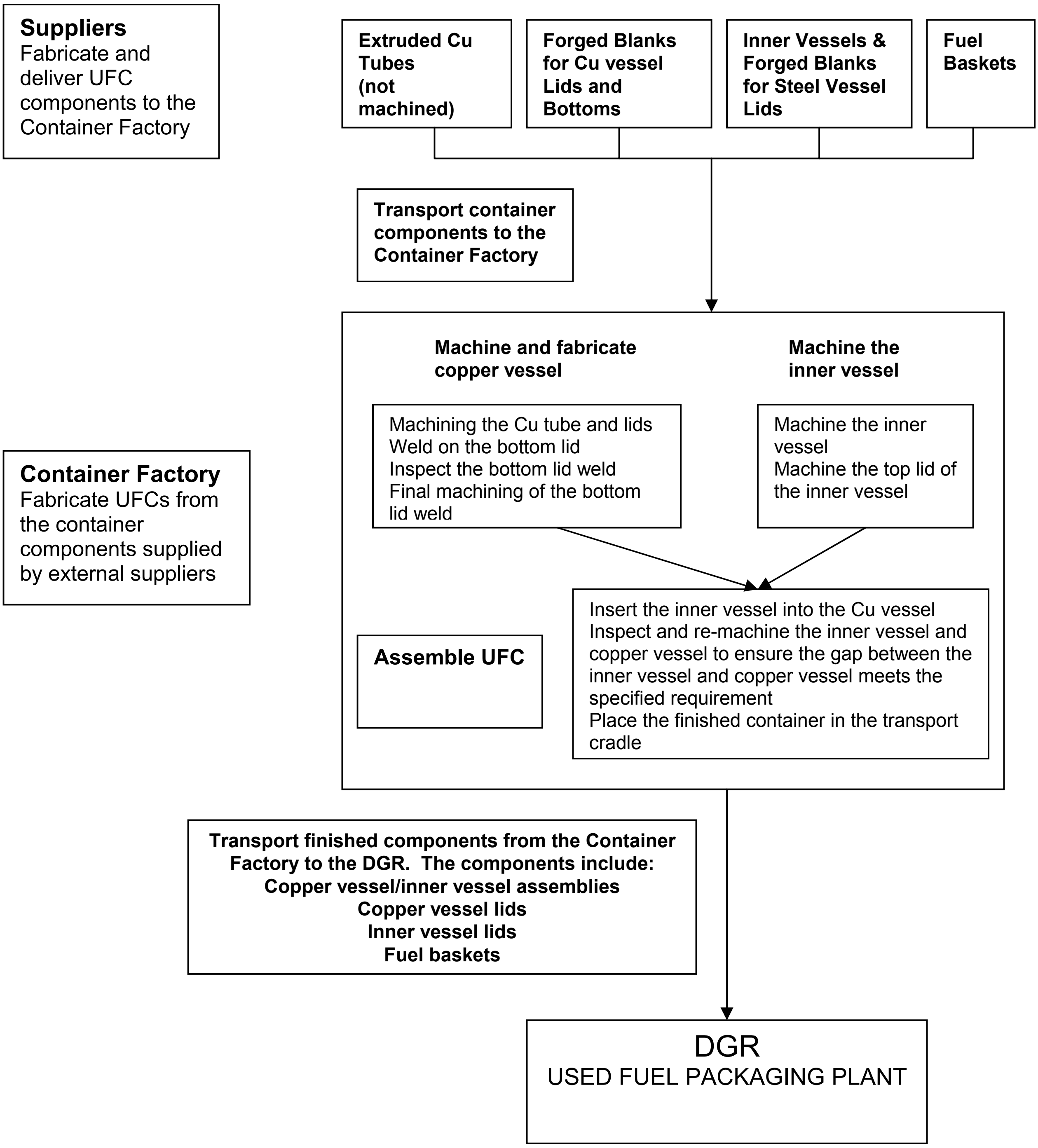
a) It has been shown in the POSIVA study [4] that although the price of copper has increased during the past 40 years, the real price in general has decreased during the last 25 years. The real price of copper will likely decrease in the future because of technical development of the manufacturing processes. This suggests that there will be a decrease in the material cost of the copper vessel.
b) The cost of machining, welding and inspection of the copper vessel will likely decrease in future due to technical advances in these technologies for serial production of copper vessels.
c) The cost of fabrication the inner steel vessel can be further reduced by:
   - Development and the use of fabrication methods suitable for serial production of the steel vessels, including automated/mechanised forming/welding methods, casting and pierce and draw methods
   - Improvement in the current inner vessel design.
d) The cost of the fuel basket may be further reduced by reducing the complexity of the current design.

4 Summary

The total UFC fabrication cost, including transportation cost of container components from suppliers to the Container Factory, has been estimated to be approximately $176,000 (2002 $) as shown in Table 3. This value is considered to be a conservative estimate. The estimated UFC cost does not include the transportation cost of the finished UFC from the Container Factory to the DGR.

5 Figures

Figure 1.



6 Tables

Table 1
Estimated Cost of the Copper Vessel of a Used Fuel Container

	SKB Canister for BWR Used Fuel (provided by Lars Werme of SKB, 16/9/02		**DGR Container**		
Container Diameter (mm)	1,050		1,168		
Container Length (mm)	4,800		3,708		
Copper Vessel Thickness (mm)	30		25		
Mass of Finished Copper Vessel (kg)	4,050		3,770		
Mass of Raw Copper Material (kg)	8,600		7,992		
Ratio Raw/Finished	2		2		
Mass of Copper-vessel Lid and Bottom (kg)	560		739		
Recoverable Scrap Copper Material (kg)	4,550		4,222		
	Estimated Production Cost (2000 SEK)	**Estimated Production Cost (2000 $)[1]**	**Estimated Production Cost (2000 $)[1]**	**SKB Cost Data provided by Lars Werme of SKB, 16/9/02**	**Cost Data in $ derived from SKB Data**
Raw Copper Material Cost	135,880	20,790	19,342	15.8 SEK/kg (LME+0.8 SEK); Assumed LME at 15 SEK	2.42 $/kg
Recoverable Scrap metal	-47,775	-7,310	-6,798	10.50 SEK/kg	1.61 $/kg
Net Copper Material Cost for the Copper Vessel	88,105	13,480	12,271		
Ingot Casting	29,670	4,540	4,236	3.45 SEK/kg	0.53 $/kg
Ingot Machining	22,500	3,443	3,443	22500 SEK/ingot	3443 $/ingot
Forged Lid and Bottom of the Copper Vessel	15,568	2,382	3,141	27.8 SEK/kg	4.25 $/kg
Extrusion	126,000	19,278	19,278	126000 SEK/tube	19278 $/tube
Transport	11,000	1,683	N/A		
Estimated Copper Vessel Cost (2000 $)	292,843	43,926	42,369		
Estimated Copper Vessel Cost (2002 $)[2,3]			**45,000**		

1 Assumed 1 SEK = 0.153$
2 An escalation factor of 2.5% per year was used to convert 2000 $ to 2002 $
3 The estimated copper vessel cost does not include any transportation cost

Table 2
Used Fuel Container Cost at the Container Factory

	SKB's Canister Factory (Andersson 2002)		DGR Container Factory	Assumption for the DGR Container Factory Design and Costs
Annual Container Production Capacity (Containers/per year)	210		370	production of 11,111 UFCs over an assumed operational period of 30 years
Personnel Requirement (no. of persons)	21		37	proprotional to the annual container production capacity
Total Cost for the Factory, Building and Equipment				
	Estimated Cost (2001 SEK)	**Estimated Cost (2001 $)[1]**	**Estimated Cost in 2002 $[1,2]**	
Building Cost for the Factory	78,000,000	11,934,000	24,464,700	assumed the building cost, machine and equipment cost of the CTECH's Container Factory are twice those of the SKB's Container Factory
Machine and Equipment Cost	99,000,000	15,147,000	31,051,350	
Combined Building, Machine and Equipment Costs	177,000,000	27,081,000	55,516,050	
Total annual labour cost				
Total Annual Labour Cost			5,550,000	assumed the annual labour cost per year is 150,000 $/year
Unit UFC Cost for Building, Machine, Equipment and Labour				
Unit Cost of building, machine and equipment (per container)			4,996	assumed a total of 11,111 UFCs
Unit labour Cost per Container			15,000	assumed annual container production rate of 370 containers per year
Total UFC Container Cost at a Container Factory			**20,000**	This cost includes the labour cost and associated costs for the building, machine and equipment

1 Assumed 1 SEK = 0.153 Canadian $

2 An escalation factor of 2.5% per year was used to convert the 2001 $ to 2002 $

Table 3
Estimated Capital Cost for the Used Fuel Container
(2002 $)

	Estimated Capital Cost per UFC (2002 $)
Copper Vessel	45,000
Inner Vessel	108,000
Transport cost of container components from suppliers to the Container Factory	3,000
UFC cost at the Container Factory	20,000
Total UFC Capital Cost	**176,000**

7 References

1 Andersson, C.G. 2002. Development of fabrication technology for copper canisters with cast inserts, status report in August 2001. Swedish Nuclear Fuel and Waste Management Company Technical Report TR-02-07, Stockholm, Sweden.

2 Poon, G., M. Saiedfar, and P. Maak. 2001. Selection of a primary load-bearing component conceptual design for used-fuel containers. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10051-R00. Toronto, Ontario.

3 Maak, P. 2001. Preliminary estimated costs of used-fuel containers in deep geologic repository. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01300-10021-R01. Toronto, Ontario.

4 Aalto, H., H. Rajainmaki and L. Laakso. 1996. Production methods and costs of oxygen free copper canisters for nuclear waste disposal. POSIVA Report POSIVA-96-08, Posiva Oy, Helsinki, Finland.

APPENDIX E

DGR Labour Rates for the Conceptual Cost Estimate

1 Background and Purpose

The purpose of this document is to describe the labour resources to be used within the DGR conceptual estimate and the basis for the calculation of the labour rates.
It is the intention, for estimating purposes, to simplify the number of different resources to be attributed to the project, and a selection of composite resources have been identified for each of the organisations to be involved in the project.

A composite resource is a term used to describe a rate that accommodates a range of grades and job descriptions and takes account of the likely % composition of the range to reflect the hierarchy within the range. For example a composite administration rate may account for, say; 1 administration manager, 10 senior clerical grades and 10 junior clerical grades. In this case, the gross hourly rate is then divided by 21 persons to obtain an average composite rate.

2 OPG / WMO Labour Rates

Table 1 below provides the basic composite labour rates to be used when estimating the work performed by Waste Management Organisation (WMO) staff. These rates include the base pay, payroll burdens, SAVH and an allowance for training.

The activity hours used for the denominator in calculating the hourly rate assumes staff are paid for 260 days per year. Available days of work are 210 after factoring in SAVH (40 days) and training (10 days). Category OPG01, OPG02 and OPG03 staff work 35 hours a week. Therefore theses grades are paid for 1,820 hours per year, and available to work 1,470 hours per year.

Category OPG04 staff work 40 hours a week. Therefore, this grade is paid for 2,080 hours per year and is available to work 1,680 hours per year.

Overhead costs are not included in the rates quoted above. A regime has been adopted were WMO staff based on site are provided with free housing and community subsidies. Therefore no further compensation is considered necessary. Also, as all site accommodation, utilities, management, support staff and consumables have been costed elsewhere in the estimate, a further overhead charge is not appropriate. However, an overhead rate $45K per annum per employee has been applied to WMO staff working at home offices or off-site to cover management and clerical support, home office accommodation, insurance, IT and telephones, service costs and vehicle leases. This rate is included in the estimate where applicable as a separate item under the category of ‘other’ costs.

Table 1: OPG/WMO Composite Labour Rates (January 2002)

Labour Category		Examples of Resource Types in each Category	Rate ($/hr)	Annual Rate ($/year)
OPG01	Management/ Executive	Department Manager Section Manager Vice President/Director	93.81	137,900
OPG02	Administration	Clerk Administrative Assistant Managerial Services Cost & Schedule Technician	47.48	69,800
OPG03	Engineering/ Technical/ Specialists	Cost & Schedule Analyst Business Officer Design Engineer Technical Engineer Technical Specialist Health Physicist	67.52	99,250
OPG04	Operations & Maintenance	First Line Manager Civil Maintainer Mechanical Maintainer Control Technician Operator Radiation & Safety Technician	58.94	99,000

3 Purchased Service Labour Rates

Table 2 indicates the composite rates applicable to Purchased Services engineers (PS). The composite labour rates have been developed by SNC Lavalin and reflect rates applicable to design and project management in the mining and construction industries for medium and long-term contracts.

The annual hours available for PS contractors is 1,856, which is calculated as follows:

Total hours (52 weeks @ 40 hours)	2080 hours per year
Vacation (3 weeks @ 40 hours)	120hours
Statutory holidays (11 days @ 8 hours)	88 hours
Average sick day allowance (2 days @ 8 hours)	16 hours
Available hours	1856 hours per year

The assumed utilisation for Purchased Service contractors is 100%, and the rates given in Table 2 are inclusive of contractor overheads and profit.

Table 2: Purchased Service Labour Rates (January 2002)

Labour Category		**Description of Work Responsibilities**	**Rate ($/hr)**	**Annual Rate ($/year)**
PS01	Manager or Project Manager	Make responsible decisions not usually subject to technical review. Takes courses of action necessary to expedite the successful accomplishment of assigned projects	125	232,000
PS02	Senior Technical Specialist	Recommendations reviewed for soundness of judgement but usually accepted as technically accurate and feasible	115	213,440
PS03	Intermediate Technical Specialist	Makes independent studies, analyses, interpretations and conclusions. Difficult, complex or unusual matters or decisions are usually referred to more senior authority	105	194,880
PS04	Junior Technical Specialist or Senior Technician	Few technical decisions called for and these will be of a routine nature with ample precedent or clearly defined procedures guidance	90	167,040

4 Architect Engineer Labour Rates

Table 3 indicates the composite rates applicable to Architect Engineer (AE). The composite labour rates are the same as those developed by SNC Lavalin in Table 2, based on AE responsibilities being similar to PS contractors. These rates are also applicable to design and project management in the mining and construction industries for medium and long-term contracts.

The available hours for AEs are the same as those for PS contractors i.e.1856 with a 100% utilisation. The rates given in Table 3 are inclusive of contractor overheads and profit.

Table 3: Architect Engineer Labour Rates (January 2002)

Labour Category		Description of Work Responsibilities	Rate ($/hr)	Annual Rate ($/year)
AE01	Executive/ Management/ Senior Engineer	As job title	125	232,000
AE02	Administration	As job title	90	167,040
AE03	Engineering/ Technical/ Specialist	As job title	105	194,880

5 Design and Build Contractor Labour Rates

SNC have developed the following composite rates appropriate for site construction engineers and labour. The rates for home / site office Design and Build Contractors (BC) are shown in Table 4. An average availability of 2000 hours per annum has been used for construction workers.

Table 4 also present Site Engineering and administration composite rates and are based on 1856 available hours as derived above.

In addition to the labour rates given Table 4, an additional allowance has been included within the estimate to cover accommodation, travel expenses, and messing.

Table 4 Design/ Build Contractor (January 2002)

Labour Category		Description of Work Responsibilities	Rate ($/hour)	Annual Rate ($/year)
BC01	Executive/ management/ Senior Engineer	As job title	110	204,160
BC02	Administration	As job title	80	139,200
BC03	Engineering/ Technical/ Specialist/ Design	As job title	90	167,040
BC04	Site Administration	As job title	80	139,200
BC05	Site management/ Senior Engineers	As job title	110	204,160
BC06	Site Engineering/ Technical/ Specialist	As job title	90	167,040
BC07	Site Construction workers (Surface)	As job title	80	160,000
BC08	Site Construction workers (Underground)	As job title	100	200,000

APPENDIX F

DGR Cost Estimate Contingency

1 Introduction and Background

The DGR program is still in the early stages of planning, and thus the facility design and other elements of the program are not well defined. Therefore, the DGR conceptual design cost estimate is based on incomplete design information, technology that is in the early stages of development and assumptions about the program and how it will executed. As a result there is uncertainty associated with various elements of the estimate. However, as the DGR program develops so the uncertainty in future estimates will be reduced and the accuracy of the estimates will increase [1].

The inclusion of contingency improves the accuracy of the cost estimate by compensating for inherent inaccuracies due to uncertainties in the DGR program. The contingency shall be large enough to compensate for the maximum range of inaccuracy associated with the estimate. The resulting DGR total cost estimate equates to the sum of all work element estimates and their associated contingencies.

Contingency is assigned to the estimate by work element at the lowest level of the Work Breakdown Structure (WBS). This approach highlights activities in the estimate subject to significant risk or estimating error and will enable future work to be better focused.

The DGR estimate has been compiled by a number of estimators and therefore guidance has been set to ensure that levels of contingency applied are consistent. This appendix presents that guidance and the methodology used in its application.

2 Guidance

CTECH has reviewed a variety of published information concerning the estimation of project contingency [1, 2]. Common themes within the publications are the use of subjective criteria and design status as a means to gauge the quality of the base estimate and thereby the level of contingency to be applied. A similar approach has been adopted for the DGR cost estimate presented and has been applied over the range of project phases involved.

For a project at the conceptual stage of design and development the reference documents suggest a minimum level of contingency in the range of 25% to 50%. However, because the DGR cost estimate contingency is assigned to activities with varying degrees of design input and in certain cases use assumptions to mitigate specific risks and uncertainties, it is considered justified employing a lower limit of 15%.

Therefore, the range of contingency applied to the various activities that make up the DGR cost estimate, together with the category assigned to each level of contingency are given below:

- LOW 15% (Minimum for conceptual estimate)
- MEDIUM LOW 20%
- MEDIUM 25%
- MEDIUM HIGH 30%
- HIGH 40%
- EXTRA HIGH 50%+

Based on this range of contingency, the following guidance is given for the selection of the appropriate level for the activity under consideration:

15%	Off the shelf item - no further work necessary Previous identical / similar contract, cost data available High degree of confidence in design status and procurement specification Accurate measurement of quantities Contractors fixed / firm quotations Risk areas identified and mitigated by assumptions
20%	Previous similar contract, benchmarking data available Confidence in methods of measurement - quantities High degree of confidence in design status and procurement specification. Off the shelf item - Identifiable modifications required Contractors firm or budget quotation Risk areas identified and mitigated by assumptions
25%	Design reviewed and assessed (CDR - Critical Design Review) Suppliers budget quotation against provisional specification Previous similar contract, benchmarking data available. Conventional construction / manufacture Quantities / methods of measurement reasonably reliable
30%	Design reviewed and assessed (PDR - Preliminary Design Review) Estimating data from similar contracts available Quantities / methods of measurement unreliable Unconventional construction / manufacture Labour intensive activity (includes operations)
40%	Labour intensive activity liable to overrun Suppliers budget price - outline design Little previous experience, unconventional manufacture / construction Requires development
50%	SOTA (State of the art) Requires significant development Never been done before - Innovative design - complex features Labour intensive activity liable to overrun (includes commissioning)

A percentage higher than 50% may be applied where justified. However, it may be more appropriate to include such a contingency as an 'allowance' within the estimate (see below).

To ensure a consistent level of contingency is applied across the project a common set of subjective criteria have been used. The level of contingency chosen will be that required to mitigate against uncertainties due to the following criteria:

- Level and quality of design or activity definition
- Accuracy of quantities and specifications
- Definition of scope and deliverables
- Quality and reliability of the cost data
- Previous experience through benchmarking
- Mitigation of risk and uncertainty through generic / specific project assumptions
- Complexity of activity, conventional >>>State of the Art (SOTA)
- Probability of schedule overrun (Particularly effect on activity labour element)
- Traditional accuracy/uncertainty of type of activity
- Estimating method
- Others to be specified by the estimator

The above criteria are not applicable to all DGR work elements but are addressed as an aid in deciding on and justifying the level of contingency suitable for a particular work element. The criteria, and any other factors applicable in choosing the level of contingency, are included on the relevant work element data sheets (WEDS) under the heading ‘Contingency Basis’.

Generally a single level of contingency is applied covering all activities included in a single work element. However, alternative contingency levels may be applied to individual activities within a work element should those activities be considered to contain a significantly greater degree of uncertainty than the remaining activities within the work element.

Allowances may be included within the body of work element estimates to accommodate unquantifiable items, special risks and uncertainties. In such circumstances the reasons for the allowance will be identified. In addition and to remain consistent, contingency will normally be added to the allowance, a factor that needs to be recognised when setting the allowance.

3 References

1. Professional Practice Guide to Contingency, Association for the Advancement of Cost Engineering International (AACE).
2. Waste Management Project Contingency Analysis, EL Parsons, DOE/FETC-99/1100

APPENDIX G

DGR Cost Estimate Database User Manual

1 Introduction

These instructions describe the operation of the Deep Geological Repository Cost Estimate Database. Microsoft Access 97 or later version must be used to view the database. The application does not require previous database knowledge.

2 Installation

All files supplied with the database should be installed to the local hard disk – e.g. C:\Program Files\DGR Database.

In order to ensure integrity of the data held on the cost estimate database, the file "Secure DGR Database.mdb" has been protected using the workgroup security feature in MS Access. It is therefore necessary to join the database workgroup DGR-SYSTEM.mdw before using the database. This can be done through the Workgroup Administrator program supplied with MS Access, or, more simply, through the use of a modified shortcut.

3 Creating a Shortcut

In MS Explorer locate the file MSAccess.exe. Right click on the file name and select "Create Shortcut". This will create a shortcut in explore, which can be dragged to the desktop. This now requires editing. Right click on the shortcut icon and select "Properties". In the "Target" field add the following to the end of the existing data */wrkgrp "path\DGR-SYSTEM.mdw*" In the "Startup" field enter the path for the DGR database files. The icon can be changed to that supplied with the database.

4 Start-up

To start the DGR Database either click on the shortcut and when requested enter the location of the file "Secure DGR Database.mdb". Otherwise use the Workgroup administrator program as described below.

To start the Workgroup Administrator use the **MS Access Workgroup Administrator** shortcut in the \Program Files\Microsoft Office\Office folder. In the **Workgroup Administrator** dialog box, click **Join**. Type the path and name of the workgroup information file DGR-System.mdw, and then click **OK**, or click **Browse** and then use the **Select Workgroup Information File** dialog box to locate the workgroup information file DGR-SYSTEM.mdw.

Start Access as normal, and select the DGR database file "Secure DGR Database.mdb". On entering the database, the **Logon** box is displayed, requiring the user to enter a valid user account name and associated password. Passwords are case sensitive. The appropriate account name and password will have been supplied with the database disk.

The database ***Main Menu*** screen will then come up (see figure 1). This is the gateway to all the forms and reports. A detailed description of the various options follows.

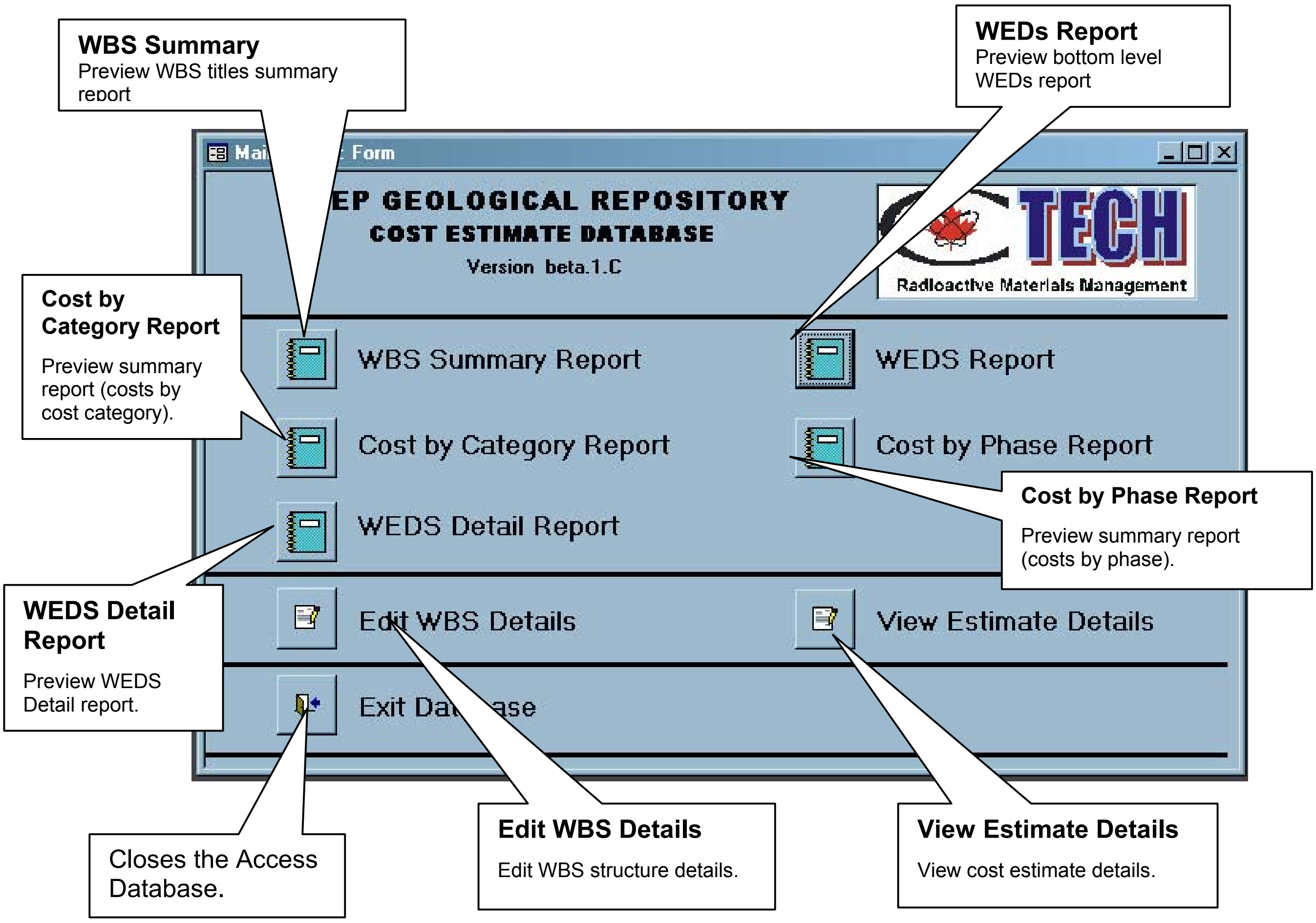


Figure 1: Main Menu

5 Database Maintenance

5.1 EDIT WBS DETAILS

The database maintenance facility is only available to higher level users in order to maintain the database integrity. This form (Figure 2) allows the details associated with each element of the Work Breakdown Structure (WBS) to be edited. The Work Element Description sheet (WEDS) contains the description of work, deliverables and assumptions. The form can be used to search for a particular WED sheet using the search engine. Available options for each level of WBS number will be displayed in a pull down menu box. The navigation buttons at the foot of the form can be used to scroll through records satisfying the search parameter, or a further level can be filtered.

5.2 ADD WBS ELEMENT

The WBS Description Editing form (Figure 3) allows WBS titles to be edited and new elements added. A similar search engine is provided to that used on the WBS Detail editing form described previously.

To edit an existing WBS element title, select the relevant record using the search engine or the navigation buttons, then type in the required title.

To add a new WBS element press the Add record button at the foot of the form, then type in the new WBS reference number and title.

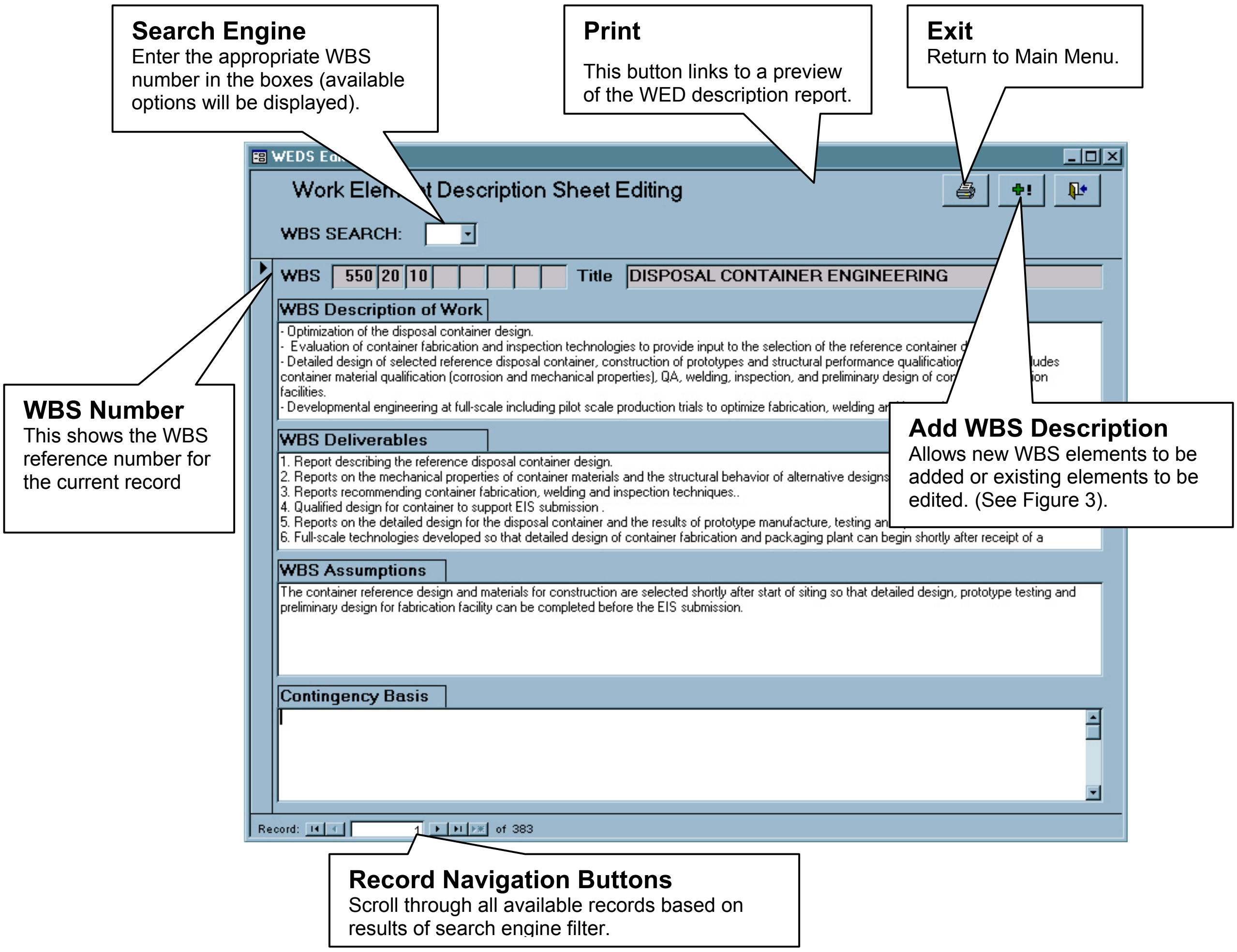


Figure 2: Work Element Description Sheet Editing Form

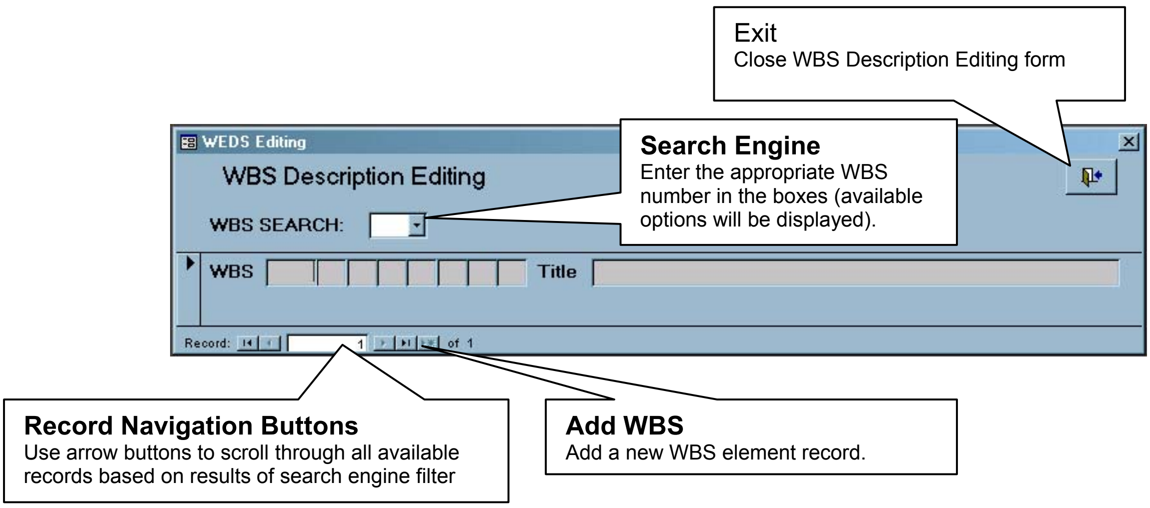


Figure 3: WBS Description Editing Form

5.3 VIEW COST ESTIMATE DETAIL FORM

This form allows the cost details associated with each element of the Work Breakdown Structure (WBS) to be viewed. The Cost Estimate Details sheet contains details of the cost category (Labour, Equipment and Materials, Other and Contingency), WBS Type (Fixed, Step-fixed and Variable), Start year and Finish year, total cost and cost breakdown information on a yearly basis. Also recorded is the author of the information.

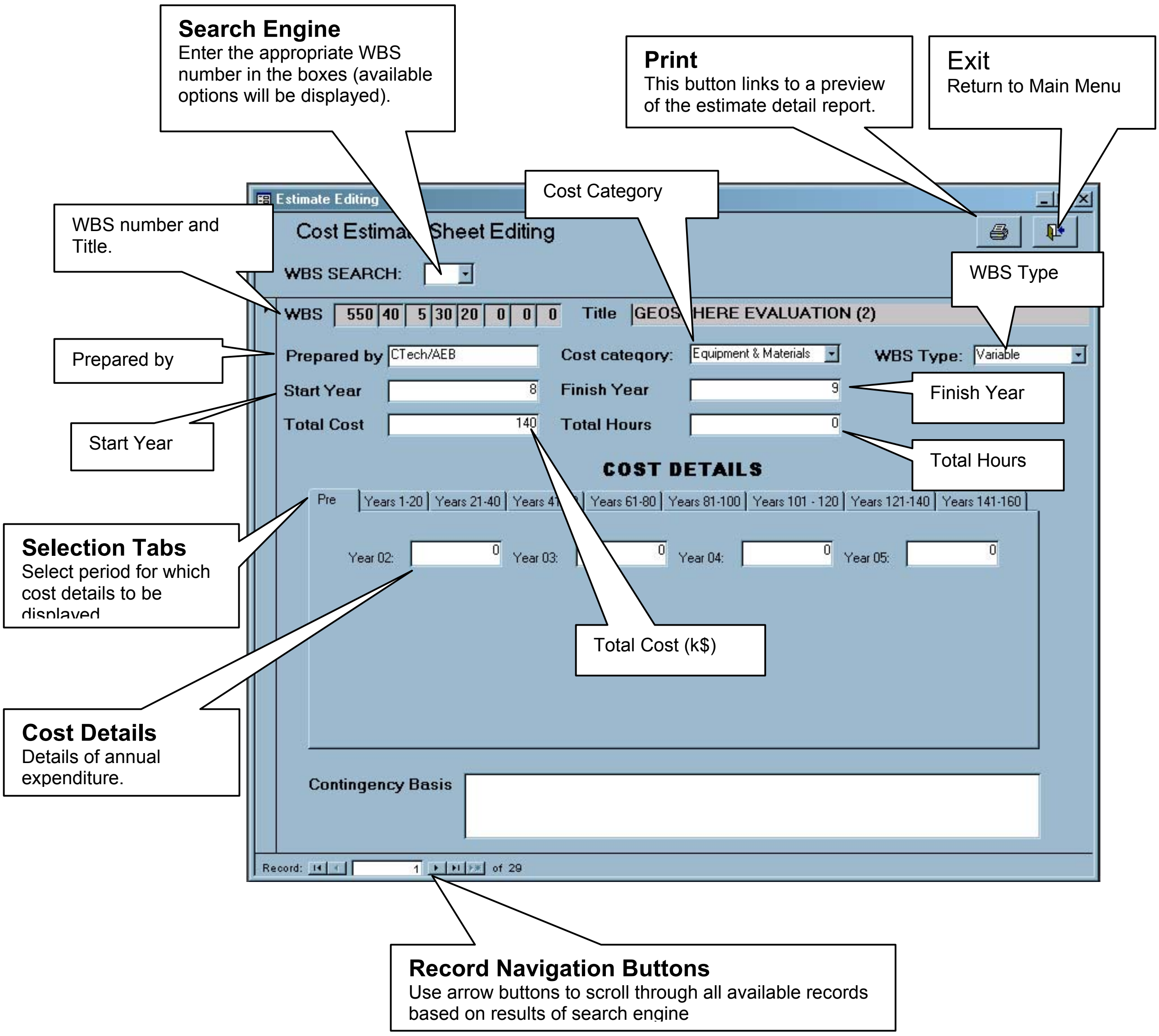


Figure 4: Cost Estimate Editing Form

The form can be used to search for a particular cost estimate detail sheet using the search engine. A description of the search engine operation is given in section 3 of the operating instructions. The navigation buttons at the foot of the form can be used to scroll through records.

Cost details can be viewed for each year (1 – 160). The Tabs at the top of the Cost Details section of the form are used to display the required group of years.

6 Reporting

6.1 GENERAL

All of the report preview buttons bring up a preview of the relevant report, along with a common print preview toolbar. This allows the report to be viewed as required or exported to a printer or word document. The principal controls provided on the preview toolbar are briefly described in Figure 5.

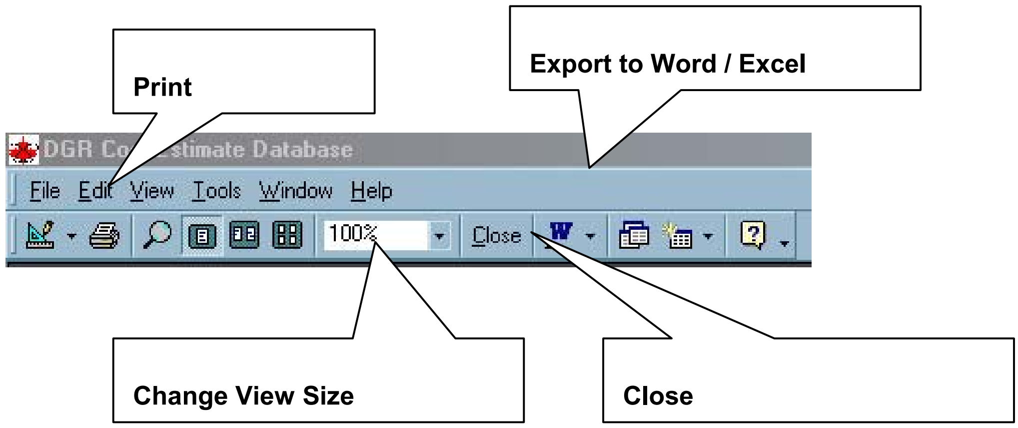


Figure 5: Print Preview Toolbar

To print part only of the report, use the navigation keys to identify the required page number. Then select File / Print to bring up the standard Microsoft printer control menu (Figure 6)

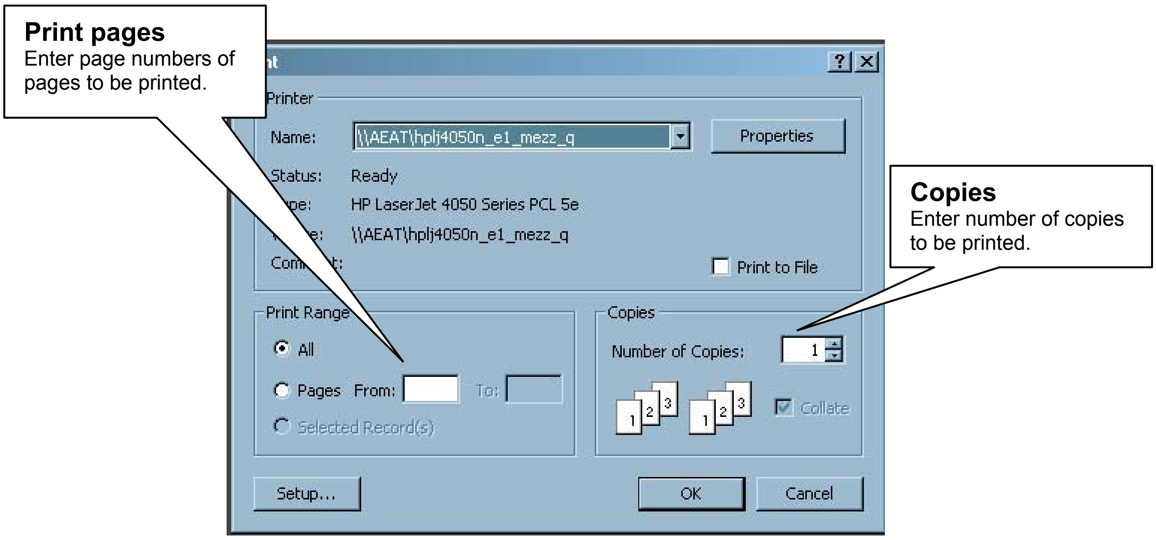


Figure 6: Printer Control Menu

6.2 WBS SUMMARY REPORT

This report shows the work breakdown structure in numerical order. The report also shows the previously allocated reference number where appropriate.

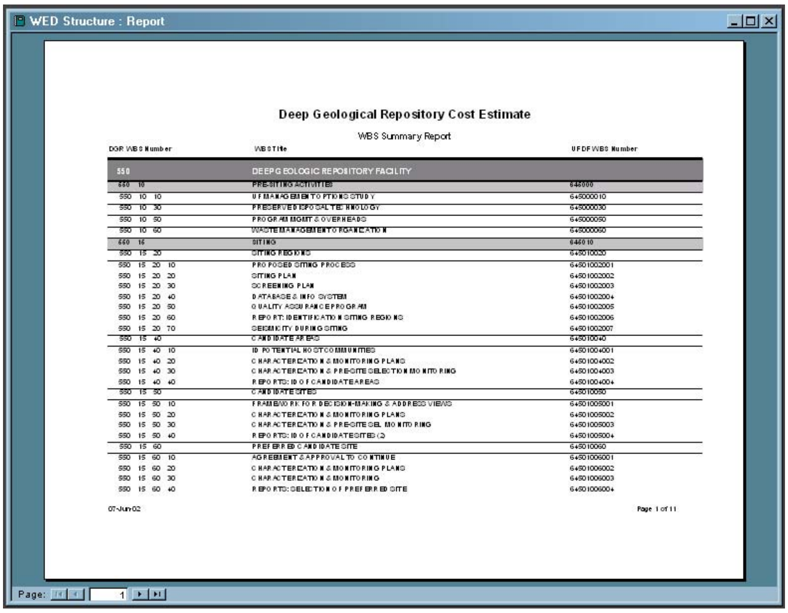


Figure 7: WBS Summary Report

6.3 WEDS REPORT

This report summarises all WED at the bottom level of information.

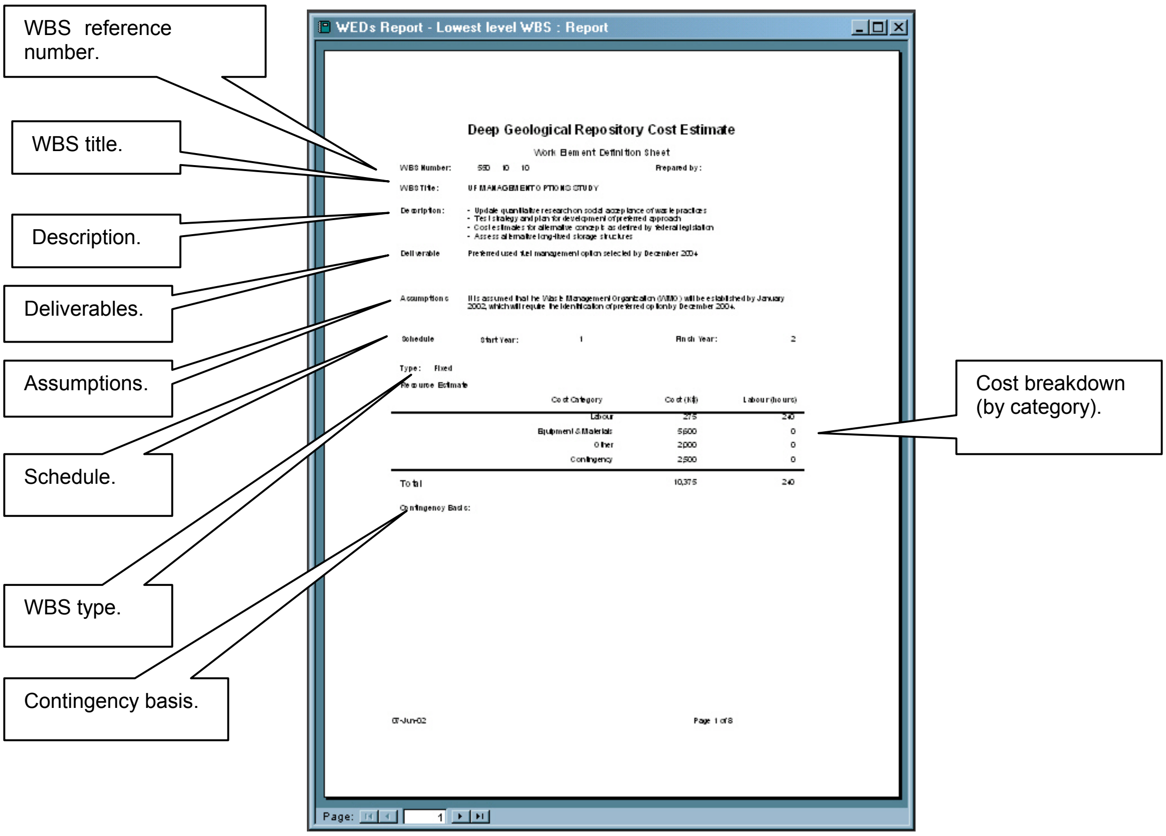
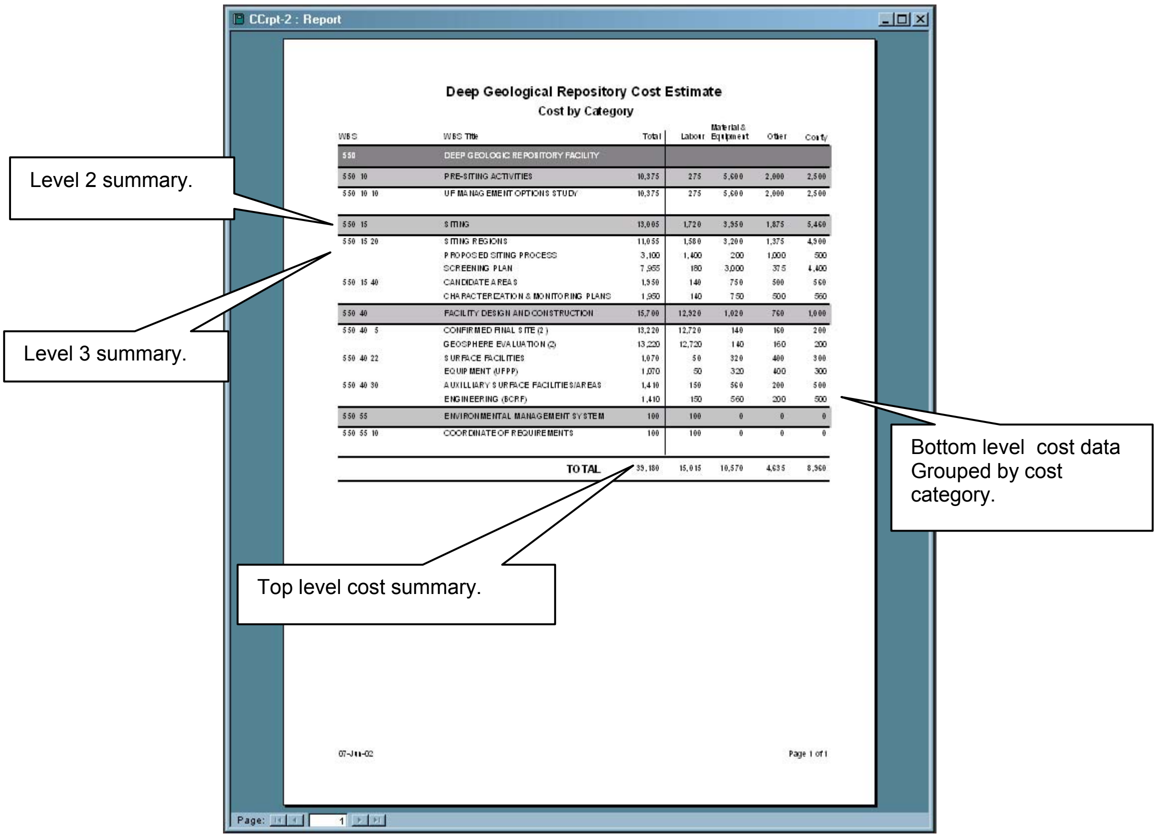


Figure 8: WEDS Report

6.4 COST BY CATEGORY REPORT

This report summarises the cost estimate information at level 3, with the data grouped according to labour category as shown in Figure 9



Deep Geological Repository Cost Estimate

Cost by Category

WBS	WBS Title	Total	Labour	Material & Equipment	Other	Conty
550	DEEP GEOLOGIC REPOSITORY FACILITY					
550 10	PRE-SITING ACTIVITIES	10,375	275	5,600	2,000	2,500
550 10 10	UF MANAGEMENT OPTIONS STUDY	10,375	275	5,600	2,000	2,500
550 15	SITING	13,005	1,720	3,950	1,875	5,460
550 15 20	SITING REGIONS	11,055	1,580	3,200	1,375	4,900
	PROPOSED SITING PROCESS	3,100	1,400	200	1,000	500
	SCREENING PLAN	7,955	180	3,000	375	4,400
550 15 40	CANDIDATE AREAS	1,950	140	750	500	560
	CHARACTERIZATION & MONITORING PLANS	1,950	140	750	500	560
550 40	FACILITY DESIGN AND CONSTRUCTION	15,700	12,920	1,020	760	1,000
550 40 5	CONFIRMED FINAL SITE (2)	13,220	12,720	140	160	200
	GEOSPHERE EVALUATION (2)	13,220	12,720	140	160	200
550 40 22	SURFACE FACILITIES	1,070	50	320	400	300
	EQUIPMENT (UFPP)	1,070	50	320	400	300
550 40 30	AUXILLIARY SURFACE FACILITIES/AREAS	1,410	150	560	200	500
	ENGINEERING (BCRF)	1,410	150	560	200	500
550 55	ENVIRONMENTAL MANAGEMENT SYSTEM	100	100	0	0	0
550 55 10	COORDINATE OF REQUIREMENTS	100	100	0	0	0
	TOTAL	39,180	15,015	10,570	4,635	8,960

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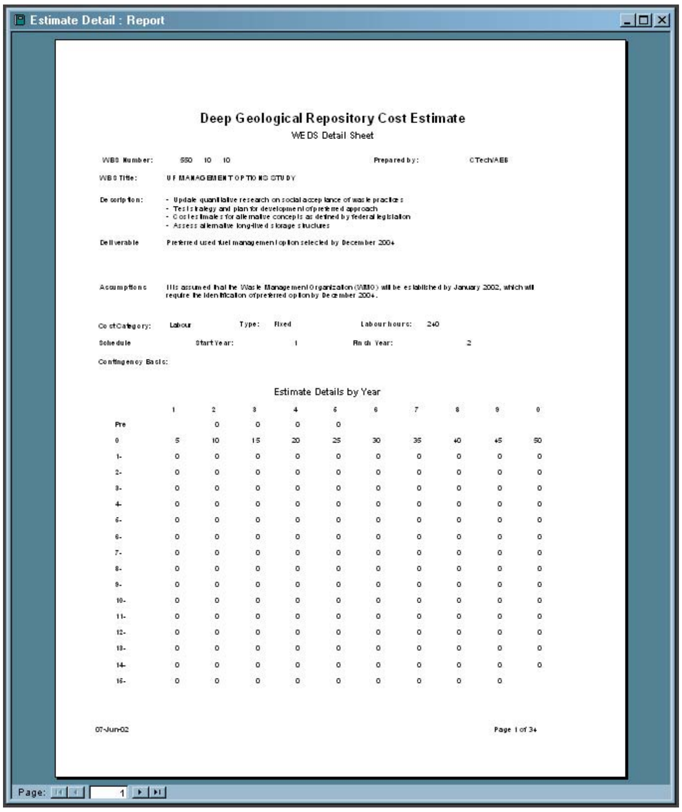
Figure 9: Summary Report

6.5 COST BY PHASE REPORT

Similar report to that above, but data grouping by phase.

6.6 WEDS DETAIL REPORT

This report shows the cost breakdown by year for each bottom level cost estimate sheet. The basic report format is similar to the WED reports, with the addition of cost information by year.



Estimate Detail : Report

Deep Geological Repository Cost Estimate

WEDS Detail Sheet

WBS Number: 550 10 10 Prepared by: CTech/AEB

WBS Title: UF MANAGEMENT OPTIONS STUDY

Description:
- Update quantitative research on social acceptance of waste practices
- Test strategy and plan for development of preferred approach
- Cost estimates for alternative concepts as defined by federal legislation
- Assess alternative long-lived storage structures

Deliverable Preferred used fuel management option selected by December 2004

Assumptions It is assumed that the Waste Management Organization (WMO) will be established by January 2002, which will require the identification of preferred option by December 2004.

Cost Category: Labour Type: Fixed Labour hours: 240

Schedule Start Year: 1 Finish Year: 2

Contingency Basis:

Estimate Details by Year

	1	2	3	4	5	6	7	8	9	0
Pre		0	0	0	0					
0	5	10	15	20	25	30	35	40	45	50
1-	0	0	0	0	0	0	0	0	0	0
2-	0	0	0	0	0	0	0	0	0	0
3-	0	0	0	0	0	0	0	0	0	0
4-	0	0	0	0	0	0	0	0	0	0
5-	0	0	0	0	0	0	0	0	0	0
6-	0	0	0	0	0	0	0	0	0	0
7-	0	0	0	0	0	0	0	0	0	0
8-	0	0	0	0	0	0	0	0	0	0
9-	0	0	0	0	0	0	0	0	0	0
10-	0	0	0	0	0	0	0	0	0	0
11-	0	0	0	0	0	0	0	0	0	0
12-	0	0	0	0	0	0	0	0	0	0
13-	0	0	0	0	0	0	0	0	0	0
14-	0	0	0	0	0	0	0	0	0	0
15-	0	0	0	0	0	0	0	0	0	

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Page: 1

Figure 10: WEDS Detail Report

7 Cost Estimate Data Entry

The cost estimate data included in the database is supported by an underlying spreadsheet for each bottom level work element. A common format for these spreadsheets has been developed in order to facilitate initial data entry (Figure 11).

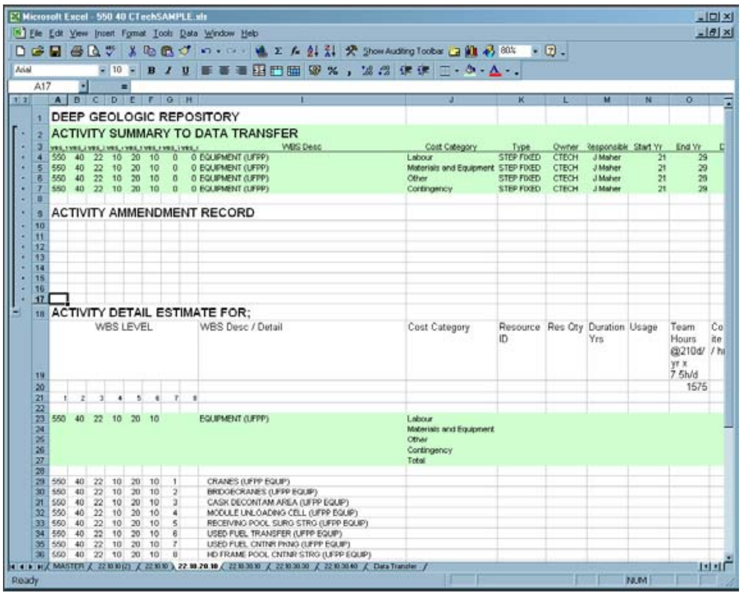

Figure 11: Cost Estimate Spreadsheet

It is possible to extract data directly from the spreadsheet by means of the "Data Transfer" sheet, which collates the information in the "Calculation" sheet in the format required by the database. Open both the DGR Cost Estimate database, and the required spreadsheet. In the spreadsheet select the "Data Transfer" tab, and then use the mouse to select and copy all rows containing data to the clipboard (Click on the numbers at the left hand side of the screen, and then press the copy button, or use Ctrl + C – See Figure 12). Now select the database, and open the "Estimate Details" table (Located under the "Tables" tab of the database window). Select the new data row (Designated by a * -Figure 13) and then paste in the clipboard contents (Ctrl + V).

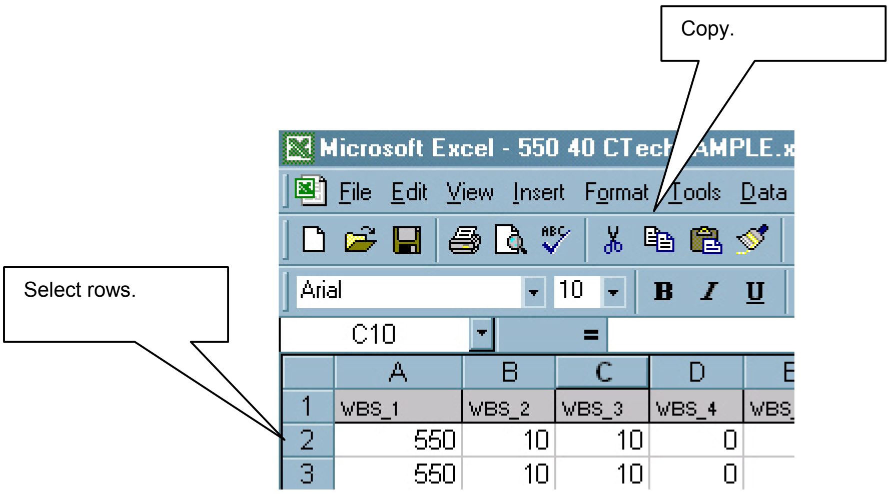

Figure 12: Copy Data to Clipboard

Estimate Detail : Table

WBS_	WB	WB	WB	WE	WB	WB	WB	Prepared by	Cost Category	WBS Type	Start Year	End Year	Contingency	Total K$	Total hou
550	55	10	0	0	0	0	0	CTech/AEB	Labour	Step-fixed	1	5		100	
550	10	10	0	0	0	0	0	CTech/AEB	Labour	Fixed	1	2		275	
550	10	10	0	0	0	0	0	CTech/AEB	Equipment & Materials	Fixed	5	10		5600	
550	10	10	0	0	0	0	0	CTech/AEB	Other	Step-fixed	5	10		2000	
550	10	10	0	0	0	0	0	CTech/AEB	Contingency	Variable	5	10		2500	
550	15	20	10	0	0	0	0	CTech/AEB	Contingency	Step-fixed	9	10		500	
550	15	20	30	0	0	0	0	CTech/AEB	Equipment & Materials	Step-fixed	8	9		3000	
550	15	20	30	0	0	0	0	CTech/AEB	Other	Variable	9	10		375	
550	15	20	30	0	0	0	0	CTech/AEB	Contingency	Fixed	9	10		4400	
550	15	20	10	0	0	0	0	CTech/AEB	Labour	Variable	7	10		1400	
550	15	20	10	0	0	0	0	CTech/AEB	Equipment & Materials	Step-fixed	7	10		200	
550	15	20	10	0	0	0	0	CTech/AEB	Other	Fixed	7	10		1000	
550	15	20	30	0	0	0	0	CTech/AEB	Labour	Fixed	8	9		180	
550	40	22	10	20	10	0	0	CTech/AEB	Labour	Fixed	2	6		50	
550	40	22	10	20	10	0	0	CTech/AEB	Equipment & Materials	Step-fixed	1	5		320	
550	40	22	10	20	10	0	0	CTech/AEB	Other	Variable	1	5		400	
550	40	22	10	20	10	0	0	CTech/AEB	Contingency	Step-fixed	1	5		300	
550	40	30	50	10	0	0	0	CTech/AEB	Labour	Variable	9	10		150	
550	40	30	50	10	0	0	0	CTech/AEB	Equipment & Materials	Variable	2	6		560	
550	40	30	50	10	0	0	0	CTech/AEB	Other	Step-fixed	2	6		200	
550	40	30	50	10	0	0	0	CTech/AEB	Contingency	Variable	2	6		500	
550	15	40	20	0	0	0	0	CTech/AEB	Labour	Fixed	7	10		140	
550	15	40	20	0	0	0	0	CTech/AEB	Equipment & Materials	Fixed	9	10		750	
550	15	40	20	0	0	0	0	CTech/AEB	Other	Variable	9	10		500	
550	15	40	20	0	0	0	0	CTech/AEB	Contingency	Fixed	1	3		560	
0	0	0	0	0	0	0	0				0	0		0	

Record: 30 of 30

Add data.

Figure 13: Paste Data to Database

APPENDIX H

Basis for Cost Estimate for the Construction of DGR Surface Facilities and Underground Repository

1 Estimation of Construction Costs of Surface Facilities

1.1 General

The cost estimate was based on the assumption that the DGR is a stand-alone facility located in the Ontario portion of the Canadian Shield.

The estimate has been prepared in first quarter 2002 Canadian dollars and includes all design and construction work, WBS 550 40 and any ongoing costs during the operations phase, WBS 550 45.

The estimate includes all direct costs except for the exceptions noted below.

Indirect costs such as design engineering, construction management and commissioning are included in the estimate as line items.

1.2 Estimating Methodology

1.2.1 Determination of Direct Cost:

On the basis of the scope information prepared for each designated level of WBS and the drawings prepared as part of the design process by CTECH, material quantity take-offs were prepared.

The cost of bulk construction materials, such as steel, concrete, architectural cladding and finishes, piping materials were based on SNC-Lavalin data for recent construction projects in Northern Ontario.

The cost of the purchase of mobile and stationary equipment including pumps was based on the SNC-Lavalin historical data, except for main mine ventilation and secondary fans and HEPA filtration systems that were based on recent quotations.

1.2.2 Labour Rates and Productivity Factor:

The composite labour rate for site construction workers has been established to be $80 per hour.

A composite crew cost has been estimated, as detailed in the DETS Resource Data Sheets (reference ID #BC 07), Site Construction Workers. The crew composition is as follows;

- Foreman 10%
- Skilled tradesmen/operators 60%
- Semi-skilled workers 30%

The construction labour rate is all inclusive and includes:

- Basic wage
- Payroll burden
- Insurance and taxes
- Benefits
- Tools and consumables
- Overhead and profit

Standard North American productivity factors for construction activity have been assumed.

1.2.3 Indirect Costs

Indirect labour costs include the following:

- Field supervision and administration
- Mobilization and demobilization
- Temporary facilities and utilities
- Miscellaneous indirect costs
- Snow removal
- Safety protection and safety training
- Spark watch and welders' certificates.

Construction equipment, including cranes up to 25 tonnes, has been included in the direct labour rate.

The following construction indirect costs are estimated separately:

- Field supervision
- Mobilization and demobilization
- Temporary facilities
- Construction equipment including heavy crane rentals greater than 25 tonne capacity
- Scaffolding
- Miscellaneous indirect costs.

1.2.4 Contingency Determination

The contingency applied was established based on the work complexity and the defined scope of work for each WBS element as described in Appendix F.

2 Estimation of Construction Costs of Underground Repository

2.1 Shaft Capital Cost Estimates

Shaft capital costs include all components required for the sinking and operation of the shafts. These include collar construction, headframe (temporary sinking headframe or permanent headframe), sinking hoist arrangements, hoists, ropes and conveyances, contingency and costs directly associated with shaft excavation. The costs of all these components were separately estimated for each shaft. A summary of the total construction costs for the shafts is provided in Table 2.1.

Table 2.1 Total Construction Costs for the DGR Shafts

Item	**Service Shaft**	**Maintenance Complex Exhaust Shaft**	**Waste Shaft**	**Upcast Ventilation Shaft**
Length	1060 m	1030 m	1030 m	1000 m
Total Cost ($)	52,058,300	18,384,600	48,438,600	15,802,700

Costs for the Service Shaft and Waste Shaft are considerably greater than those for the Maintenance Complex Exhaust Shaft and Upcast Ventilation Shaft. This is because the latter two shafts are smaller in diameter and have no permanent headframe or hoisting facilities.

Excavation costs for each of the shafts were independently estimated. These costs are representative of the excavation cycle and comprise plant set-up for shaft sinking, direct costs, indirect labour, indirect plant and a contingency allowance for these areas. A comparison of these shaft unit costs are given in Table 2.2.

Table 2.2 Shaft Excavation Unit Cost Comparison

Item	**Service Shaft** **Cost/m**	**Maintenance Complex Exhaust Shaft** **Cost/m**	**Waste Shaft** **Cost/m**	**Upcast Ventilation Shaft** **Cost/m**
WBS Number	550 40 05 40 20 40	550 40 05 40 20 41	550 40 40 20	550 40 40 40
Plant Set-Up	$ 2,774	$ 2,569	$ 2,855	$ 2,646
Direct Cost	$ 7,629	$ 4,374	$6,705	$ 4,220
Indirect Labour	$ 2,697	$ 1,396	$2,169	$ 1,302
Indirect Plant	$ 1,815	$ 850	$ 1,419	$ 778
Contingency	$ 4,475	$ 2,757	$ 2,630	$ 1,789
Total Shaft Excavation Cost/m	$ 19,390	$ 11,946	$ 15,778	$ 10,735
Total Shaft Excavation Cost/m^3	$ 395	$ 838	$ 440	$ 871

Plant set-up charges exclude costs associated with sinking hoists and headframes, while direct costs include for direct labour and shaft-related equipment operating and materials. Contractor profit and overheads, estimated to be 15%, have been applied. All labour costs utilize current competitive rates for mine contractor personnel and cover basic hourly rate, overtime allowance, bonus, burdens, small tools, clothing and travel allowances.

Material consumption during shaft sinking was estimated and unit prices for supplies were based on experience and historical data. Direct costs were included for items such as drill steel, drill bits, hose and fittings, pipe, electric cables, ventilation fans, ground support items, and explosives. Other supplies to be amortized by the contractor over the life of the contract were also estimated. These items included cutting torches, ventilation tubing, ropes, doors, dump, chutes, crosshead and chairs. Also, shaft furnishings such as sets, guides and hanging rods were estimated.

Equipment costs for the sinking equipment were estimated. Items included Galloway stage, shaft drill jumbo, stage winches Cryderman shaft mucker, station loader, cement forms and curb rings together with other equipment such as pumps, blocks and winches.

The daily cost of maintaining equipment for shaft sinking was also included.

Indirect Plant Costs included:

- Office costs
- Engineering and survey supplies
- Fire protection
- Safety supplies
- Mine rescue equipment
- Training
- Mine air heating (where applicable)
- Equipment operating and maintenance charges
- Workshop consumables

A shaft advance cycle was estimated assuming only two 8-hour shifts were available for shaft excavation activity with the third shift being reserved for geological and geotechnical investigation by DGR staff. The daily advance per shaft varied, as indicated below:

- Service Shaft : average advance of 2.2 m per day
- Maintenance Complex Exhaust Shaft: average advance of 4.3 m per day
- Waste Shaft: average advance of 2.8 m per day
- Upcast Ventilation Shaft: average advance of 4.6 m per day.

Costs vary as a function of shaft diameter, shaft length and productivity.

2.2 Repository Excavation Cost Estimates

Repository excavation costs include all components required for the construction of the tunnels and emplacement rooms and include items such as exploratory drilling, diamond drilling, excavation costs, surface disposal of waste rock, concrete work, electrical power, track installation and contingency depending on the specific area of the repository. The costs of all these components were separately estimated for each area. A summary of the total construction costs for the repository is provided in Table 2.3.

Table 2.3 Comparison of Repository Construction Costs

Item	Tunnel and Service Area	Perimeter Tunnel and Drifts	Emplacement Rooms
Total Cost ($)	47,543,500	85,220,800	226,675,800

The total for the emplacement rooms is the sum of the four mining campaigns comprising all Panel A and Lower Panel B, Upper Panel B and Lower Panel D, all Panel C and Upper Panel D.

As in the case of the shaft estimates, Table 2.4 highlights the respective Contractor's direct mining, indirect labour, indirect plant and contingency costs for the excavation cycle component of the construction costs.

The costs, in Table 2.4, are presented in terms of cost per meter, cost per cubic meter and cost per day. These costs are summarized on a basis of Contractor Direct Mining (labour, burdens, supplies, equipment and maintenance) and Contractor Indirect Labour (labour, burdens and benefits) and Contractor Indirect Plant (materials and supplies) costs. Contractor equipment amortization was also estimated. Contractor profit and overhead was estimated to be 15% and applied to these costs. All labour costs utilize current competitive rates for mine contractor personnel and cover basic hourly rate, overtime allowance, bonus, burdens, small tools, clothing and travel allowances.

Direct costs comprised the costs of consumables for ground support, explosives, pipe, electric cable and ventilation equipment. Equipment operating costs for drill jumbos, rock bolters, trucks and load-haul-dump (LHD) units were estimated on a per hour basis.

Indirect costs covered electrical power for fans.

Indirect labour costs were estimated on the same basis as direct labour costs. Persons included in the indirect labour category were Superintendent, supervisors, clerk, hoistmen, deckman, mechanic, surface and underground nippers and rockbreaker operators. The numbers of these workers varied with activity, with additional persons being required for level development work as opposed to shaft sinking.

Mine air heating was estimated on a basis of the energy required to heat the required volume of ventilating air from the average monthly minimum temperature to 4 degree centigrade. Heating was assumed to be by propane. Weather data from Pinawa and Kenora in northern Ontario was used in the analysis. Propane requirements were estimated for the various phases of the underground construction and for the operating phase during emplacement.

Equipment and operating costs of surface equipment generally comprising a forklift, pick-ups and service truck were estimated on a basis of historical information. Historical hourly costs for fuel, tires and maintenance parts formed the basis of the estimate for the equipment operating costs.

Costs vary as a function of tunnel dimensions, length and productivity. This is confirmed by past studies undertaken by CTECH. For example, it was estimated that total excavation costs for the expansion of the Sudbury Neutrino Observatory (2002 data) would be approximately $\$320/m^3$. This project was to be conducted at a depth of approximately 2000 m underground, whilst production mining from INCO and science experiments at the observatory were ongoing.

Table 2.4 Excavation Unit Cost Comparisons

Item	Tunnel and Service Area Excavation Cost/m	Perimeter Tunnel and Drifts Cost/m	Room Excavation (All Panel A and Lower Panel B) Cost/m	Room Excavation (Upper Panel B – Lower Panel D) Cost/m	Room Excavation (All Panel C) Cost/m	Room Excavation (Upper Panel D) Cost/m	Contractor Labour Indirects Cost/m			Contractor Plant Indirects Cost/m		
DETS Number	550 40 05 40 20 50	550 40 40 45	550 40 40 60	550 45 40 08	550 45 40 09	550 45 40 10	550 45 40 11			550 45 40 12		
							2nd	3rd	4th	2nd	3rd	4th
Direct Mining[1]	$ 5,816	$ 3,325	$ 4,039	$ 4,039	$ 4,039	$ 4,039	-	-	-	-	-	-
Additional Work[4]	$ 856	$ 831	$ 1,671	$ 1,679	$ 1,679	$ 1,728						
Indirect Labour	$ 2,181	$ 315	$ 484	See 550 45 40 11	See 550 45 40 11	See 550 45 40 11	$ 459	$ 459	$ 424	-	-	-
Indirect Plant	$1,030	$ 275	$ 249	See 550 45 40 12	See 550 45 40 12	See 550 45 40 12	-	-	-	$ 424	$ 424	$ 391
Contingency	$ 2,965	$ 1,187	$ 1,289	$ 1,144	$ 1,144	$ 1,153						
Total Cost/m	**$ 12,848**	**$ 5,933**	**$ 7,732**	**$ 6,862**	**$ 6,862**	**$ 6,920**	**$ 459**	**$ 459**	**$ 424**	**$ 424**	**$ 424**	**$ 391**
Mining Length	3700 m	14,500 m	12,285 m	8,190 m	8,190 m	4,095 m						
Total Cost/m^3 [5, 6]	**$ 481**	**$ 222**	**$ 328**	**$ 329**	**$329**	**$329**						

Item	Tunnel and Service Area Excavation Cost/day	Perimeter Tunnel and Drifts Cost/day	Room Excavation (Lower Panel A – All Panel B) Cost/day	Room Excavation (Upper Panel A – Lower Panel D) Cost/day	Room Excavation (All Panel C) Cost/day	Room Excavation (Upper Panel D) Cost/day	Contractor Labour Indirects Cost/day			Contractor Plant Indirects Cost/day		
DETS Number	550 40 05 40 20 50	550 40 40 45	550 40 40 60	550 45 40 08	550 45 40 09	550 45 40 10	550 45 40 11			550 45 40 12		
							2nd	3rd	4th	2nd	3rd	4th
Direct Mining[1, 3]	$ 29,478	$ 44,151	$ 34,857	$ 34,857	$ 34,857	$ 37,762	-	-	-	-	-	-
Additional Work[4]	$ 4,339	$ 11,034	$ 14,420	$ 14,490	$ 14,490	$ 16,156						
Indirect Labour[3]	$ 11,054	$ 4,183	$ 4,177	See 550 45 40 11	See 550 45 40 11	See 550 45 40 11	$ 3,961	$ 3,961	$ 3,964	-	-	-
Indirect Plant[3]	$ 5,220	$ 3,652	$ 2,149	See 550 45 40 12	See 550 45 40 12	See 550 45 40 12	-	-	-	$ 3,659	$ 3,659	$ 3,656
Contingency	$ 15,028	$ 15,761	$ 11,124	$ 9,873	$ 9,873	$ 10,780						
Total Cost/day	**$65,119**	**$78,781**	**$ 66,727**	**$ 59,220**	**$ 59,220**	**$ 64,698**	**$ 3,961**	**$ 3,961**	**$ 3,964**	**$ 3,659**	**$ 3,659**	**$ 3,656**
Time Duration	2 years[2]	3 years	3.9 years	2.6 years	2.6 years	1.2 years	2.6 yrs	2.6 yrs	1.2 yrs	2.6 yrs	2.6 yrs	1.2 yrs

Note:

1 “Direct Mining” refers to the total direct mining cost (labour, equipment and materials) to excavate.
2 Mining of the Tunnel and Service Area Excavation as part of the UCF construction (WBS# 550 40 05 40 20) will be intermittent due to diamond drilling and component testing, which will define and dictate the DGR’s orientation and configuration.
3 The Contractor Indirect Labour and Contractor Indirect Plant charges have only been applied over the duration required to complete the excavation only, which is approximately 2 years.
4 “Additional Work” refers to mining related activities outside “Direct Mining”, which are included in the DETS. Examples of such type of work would be laying of track, exploratory diamond drilling, and placing the concrete floor in the emplacement rooms.
5 In calculating the “Total Cost/m^3” for DETS # 550 40 05 40 20 40 and DETS # 550 40 40 45 utilized a cross-sectional area of 26.7 m^2, reflecting the arched roof of the Drift and tunnel. For the emplacement room excavations, a cross-sectional area of 23.5 m^2 was utilized to calculate the cost. With respect to DETS # 550 45 40 08 through to DETS # 550 45 40 10 the Contractor Indirect Labour and Plant costs (DETS # 550 45 40 11/12) were included.

2.3 Contractor Indirect Labour Costs

Indirect labour costs were estimated on the same basis as direct labour costs. Persons included in the indirect labour category were Superintendent, supervisors, clerk, hoistmen, deckman, mechanic, surface and underground nippers and rockbreaker operators. The numbers of these workers varied with activity, with additional persons being required for level development work as opposed to shaft sinking.

2.4 Contractor Indirect Plant Costs

Contractor indirect plant costs were estimated on a daily basis. Allowances were provided for office costs, engineering and survey supplies, fire protection, safety supplies, mine rescue equipment, training, temporary building heating and workshop consumables.

2.5 Description of Shafts

2.5.1 Service Shaft

This shaft will be 7300 mm finished diameter, concrete lined. It will accommodate balanced skips, a large cage with counterweight, auxiliary cage, and principal mine service lines.

This will be the first shaft sunk on the project. A double drum hoist is provided for sinking. As this hoist is more than adequate for long term skipping of repository lateral development muck, it will be retained permanently. Particulars of this and the other two hoists are provided below.

Hoist for Sinking and Skipping
Double drum, 3050 mm diameter, 8500 kg payload, speed of 7.5 m/s power at 1000 kW and one (1) 38.1 mm diameter rope.

Counterweighted Main Cage
Koepe hoist, 3180 mm diameter, 12,500 kg payload, 7.5 m/s speed, 500 kW power and four (4) ropes at 31.7 mm diameter.

Auxiliary Cage
Single drum, 1800 mm diameter, 1000 kg payload, 7.5 m/s hoisting speed, 200 kW power and one (1) 19 mm diameter rope.

The headframe will be a concrete tower, founded on bedrock approximately 6 m below surface grade to allow for subgrade ventilation intake. The headframe will be erected before sinking, after excavation of the collar to a depth of 30 m, to eliminate the need for a temporary headframe. The footprint of the tower will be approximately 13.5 m x 15.6 m. The top floor of the headframe accommodates the main cage hoist. An overhead crane is installed above the hoist, capable of lifting the heaviest hoist components from ground level. Below this floor are mounted the cage deflection sheaves, the auxiliary cage hoist, and the skip hoist sheaves. The skip hoist sheaves are partitioned from the rest of the headframe to minimize inflow of cold air from the ropeway openings.

Electrical equipment is mounted on the sheave floor and a floor below. An access floor is installed at the elevation of the skip dump.

A muck bin is formed into one corner of the headframe, with capacity for one days projected hoisting tonnage. Discharge from the bin will be via a truck chute through the wall of the headframe.

An Alimak elevator and a stairwell provide access to the upper part of the headframe. Three major doors are provided at collar level; main cage access into collarhouse; skip access door; and auxiliary cage and main cage counterweight access. Roll-up rubber doors are proposed.

A collarhouse with a length of 15 m and a height of 10 m is attached to the side of the tower facing the main cage entrance. A 10 tonne capacity overhead crane is included for materials handling.

HVAC for the headframe and collarhouse will be based on the mine ventilation supply, which will continuously supply heated fresh air to the headframe subcollar. Electrical infrared spot heat will be provided in assembly and maintenance areas. Duty cycles on the cage hoists will be light, and cooling ventilation needs will be small. Hoist motors will be cooled by direct-mounted fans. One roof vent will be provided for summer use.

2.5.2 Maintenance Complex Exhaust Shaft

For the purposes of this study it is assumed that construction will be by shaft sinking from surface, although the raise and slash method is an option, with this shaft and the Service shaft being so close together. The Maintenance Complex Exhaust Shaft will be 3960 mm diameter, concrete lined. No permanent utility lines will be installed.
This shaft will provide direct exhaust of maintenance shops and other facilities that present a fire or dust hazard. It will also exhaust development headings at least until the Upcast Ventilation Shaft is completed and connected to the existing openings. This facility may be employed indefinitely for part or all of development exhaust.

This shaft will serve as the second exit from the repository level for a period of years while underground exploration and characterization is being carried out. As no muck hoisting is needed in this shaft, it is proposed to install a small single drum hoist to service the shaft lining installation and to retain this hoist for a semi-permanent escape hoist. For estimating purposes this hoist is assumed to be the same as the auxiliary cage hoist in the Service Shaft. Rope guides will be installed for the escape cage.

The escape cage will be of conventional design with a capacity of five persons. No safety dogs will be used on this application, the cage being equipped with slippers to run on the guide ropes.

A permanent steel headframe will be used, designed to provide an airlock for the temporary escape cage. Air exhaust plenum will be above surface. The headframe foundations will be a flat slab at collar level.

2.5.3 Waste Shaft

This shaft will be sunk some years after the Service and Maintenance Complex Exhaust Shaft, after the site is proven acceptable by underground characterization. It will be located in the general area of the Service Shaft, and for the purposes of this estimate has assumed to be constructed by sinking. Because of the shaft's proximity to the Service Shaft and the Maintenance Complex Exhaust Shaft, it is recommended that a raise and slash method be investigated during detailed engineering.

The shaft will be 6150 mm finished diameter, concrete lined. It will accommodate a single large cage with counterweight and limited number of service lines.

The shaft will be upcast, but will not be a major airway.

The subgrade section of the headframe will accommodate retractable beams for banking the cage to eliminate rope stretch effects while loading and unloading used fuel containers. Because of the very heavy loads being handled on railcars, special provisions will be incorporated to index the rails in the cage very closely to the rails on the station. The basement will be 6 m deep to accommodate the banking equipment.

A collarhouse is not included as the hoist outline necessitates enough room inside the headframe to park one railcar.

One major door is provided in the tower, leading into the collarhouse approach to the cage. There is enough room inside the tower walls to access the counterweight compartment.

The hoist particulars are listed below.

Hoist Service: Counterweighted Cage

Type: Koepe
Diameter: 6200 mm
Payload: 95,200 kg
Hoist Speed: 2.5 m/s
Power: 1500 kw
Ropes: six (6) at 54 mm diameter each

The cage will be of conventional construction as the used fuel container casks provide all radiation-shielding provisions. A roll-up metal door will be provided for use when personnel must be on the cage. Railcars will be held in position by mechanically operated stop devices acting on the cage rails.

2.5.4 Upcast Ventilation Shaft

The shaft will be constructed by sinking.

There will be no permanent fixtures in the shaft.

The shaft will be 3660 mm finished diameter, concrete lined.

A single drum hoist will be temporarily installed for sinking, using stage ropes for guides.

The headframe will be a temporary steel structure erected on a flat pad, to which an exhaust elbow will later be installed to connect to the permanent fan.

APPENDIX I

Contents of Annex 1

Contents