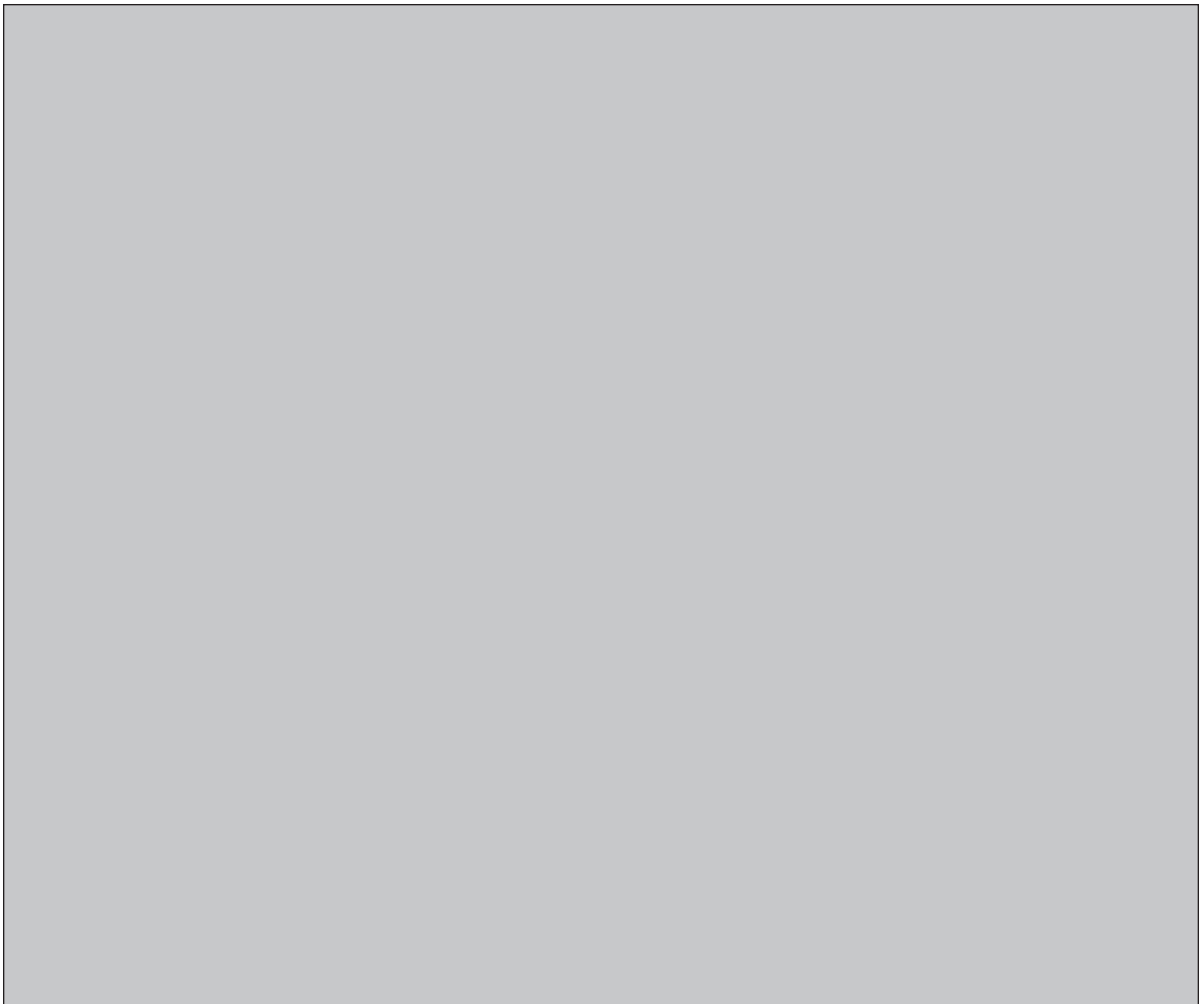


NWMO BACKGROUND PAPERS
6. TECHNICAL METHODS

**6-11 VALIDATION OF COST ESTIMATING PROCESS FOR
LONG-TERM MANAGEMENT OF USED NUCLEAR FUEL**

**ADH Technologies Inc.,
Charles River Associates**



NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts** – describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety** – provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment** – provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

Disclaimer

This report does not necessarily reflect the views or position of the Nuclear Waste Management Organization, its directors, officers, employees and agents (the "NWMO") and unless otherwise specifically stated, is made available to the public by the NWMO for information only. The contents of this report reflect the views of the author(s) who are solely responsible for the text and its conclusions as well as the accuracy of any data used in its creation. The NWMO does not make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information disclosed, or represent that the use of any information would not infringe privately owned rights. Any reference to a specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement, recommendation, or preference by NWMO.



***Validation of Cost Estimating Process
for Long-Term Management of Used
Nuclear Fuel***

Final Report

Prepared for:

***Nuclear Waste Management
Organization***

Submitted By:

ADH Technologies Inc.

&

Charles River Associates

April, 2004



TABLE OF CONTENTS

Glossary of Terms	3
1.0 Executive_Summary	4
2.0 Background	12
3.0 Origin of the Estimates	13
3.1 Validation of the Estimates	14
4.0 The Review Team	16
4.1 Team Members	16
5.0 Methodology	17
5.1 Estimating Practice	17
5.2 Process Applied	19
5.3 Other Activities	20
5.4 Detailed Estimate Review	20
6.0 General Observations	24
6.1 Order of Accuracy	24
6.2 Contingency	24
6.3 Selection Criteria	25
6.4 Application of Estimates	25
7.0 Results of Assessment	26
7.1 General Results	26
7.2 Comments on NWMO Validation Criteria	27
7.3 Specific Comments on Validation Criteria	28
8.0 Overall Assessment and Formal Opinion	42
8.1 Overall Assessment of the Estimates	42
8.2_Professional Opinion Letter	42
Reference Data	44
List of Attachments	45
Appendix 1 List of Documents Provided	47
Appendix 2 Background Regarding Reviewers	48
Attachment 1 DGR Document Trail	51
Attachment 2 CES Document Trail	52
Attachment 3 DGR Data Trail	53
Attachment 4 CES Data Trail	54
Accompanying CD Provided	

GLOSSARY OF TERMS

AACE	Association for the Advancement of Cost Engineering
ADH	ADH Technologies Inc.
AECL	Atomic Energy of Canada Limited
CES	Centralized Extended Storage
CIQS	Canadian Institute of Quality Surveyors
CRA	Charles River Associates
DGR	Deep Geologic Repository
HQ	Hydro Quebec
JWO	Joint Waste Owners
NBP	New Brunswick Power
NFWA	Nuclear Fuel Waste Act (the "Act")
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation
PMI	Project Management Institute
RES	Reactor Extended Storage
UFT	Used Fuel Transport
WBS	Work Breakdown structure
WEDS	Work Element Definition Sheet



1.0 Executive Summary

Background

The Nuclear Fuel Waste Act (NFWA) requires the NWMO to submit a report to the Government of Canada which includes comparison of costs, risks and benefits of at least three approaches for managing Canada's nuclear fuel wastes over the long-term.

In advance of the NWMO being established, Ontario Power Generation, Hydro-Québec, AECL and New Brunswick Power (the "Joint Waste Owners") -- anticipating their responsibilities under the NFWA to establish the NWMO and to ensure a comprehensive study is completed within the legislated timelines, commissioned work on the costing of the options in the then draft NFWA.

Specifically prior to the establishment of the NWMO the Joint Waste Owners commissioned some studies in 2001 and 2002 based on the anticipated requirements in the Act. These studies concerned the development of technical descriptions for the alternative approaches and associated cost estimates for three technical management methods. They developed conceptual designs for the technical methods in the Act, and the associated cost estimates.

It was intended that this costing work, once completed, would be made available to the NWMO for consideration as the NWMO conducts its assessment of the management approaches.

The Joint Waste Owners presented this body of work to the NWMO at the end of 2003, for use in the NWMO's study of management approaches.

The Cost Estimates

Estimates were prepared by the Joint Waste Owners for the following approaches to nuclear spent fuel management.

- Deep Geologic Repository (DGR)
- Reactor Extended Storage (RES)
- Centralised Extended storage (CES)
- Transportation of Spent Nuclear Fuel



These estimates represent the respective life cycle costs for the options including transportation cost if applicable. The life cycle cost includes cost of fuel waste storage, transportation and disposal. Key assumptions are that the total amount of spent fuel bundles to be managed is 3.7 million. A set of reports has been provided that document all the assumptions and estimate details.

The estimates for interim storage of used fuel at reactor sites have been calculated using waste volumes provided by respective owners and the application of OPG full unit interim storage costs to these volumes.

The estimate for transportation of the nuclear fuel waste, where applicable, to a final location, has been provided by Cogema Logistics. Cogema Logistics is French company with extensive experience in transportation of nuclear fuel waste in Europe.

The estimated cost of siting, design, construction, operation, extended monitoring, closure and decommissioning of the waste management facilities was provided by CTECH. At the time the estimates were prepared, CTECH was a joint venture of CANATOM (SNC-Lavalin, AECOM) and AEA Technologies (UK) (now RWE Nukem).

NWMO Commissions a Third-Party Review

The NWMO made a decision that before it could accept the cost estimates commissioned by the joint waste owners as appropriate for purposes of use in the NWMO's formal study of management options, it would invite a third-party review to validate the cost estimating process. This review and validation by a qualified third party was seen as essential to provide the NWMO with the assurance of the integrity of this costing work. The NWMO felt it particularly important to ensure that the estimates have been prepared in an appropriate manner and were developed consistent with established estimating standards, so that those using the estimate information in comparison and assessment of management options can be confident that they are referring to reliable estimates.



Accordingly, in January 2004 the NWMO launched a third-party review to validate the cost estimating process used by the Joint Waste Owners. The NWMO engaged a team consisting of ADH Technologies Inc. and Charles River Associates to undertake this review.

ADH Technologies Inc. is a well known management consulting and project management firm engaged in the nuclear industry. The firm provides specialized services advising clients in the nuclear sector in the fields of project management, project cost estimating, engineering, and business development. The company is founded and lead by individuals that have more than 25 years experience in the Canadian and international nuclear industry at the executive level. In particular, the company is experienced in the development and management of major nuclear projects up to the billion dollar range. The company also has extensive experience in project management of large industrial projects. The company is familiar with both government and private sector practices relating to large projects.

The focus of this project was to verify and validate the estimating methodology rather than the underlying assumptions. In addition, the review was to comment on the flexibility to update the estimates as assumptions or circumstances change in the future.

The NWMO set out eight specific criteria for validation as follows:

1. The reviewers will advise on the adequacy of the estimating standards adopted by the Joint Waste Owners for this estimation work.
2. The reviewers will assess the cost estimate documentation and comment on the quality and completeness.
3. The reviewers will map the document trail that supports the cost estimates.
4. The reviewers will comment on whether or not the estimates are structured such that they can be revised in the future as may be required, as the forecast of the used fuel volume or key estimating assumptions change.



-
5. The reviewers will document the extent to which the cost estimating process adhered to all steps in the estimating standard. They will discuss and rate the quality of each component of the standard that was followed in the development of the various estimates.
 6. The reviewers will make recommendations as to how the estimating process will “stand the test of time” and if it could be easily updated for each cost estimate with respect to:
 - Standards
 - Document trail
 - Data trail
 - Presentation
 - Data management
 7. The reviewers will assess the degree to which each estimate can stand alone, without the need of the team who produced it to provide further explanation and/or justification, as these estimates are made available by the NWMO in the public forum.
 8. The reviewers will deliver a signed opinion on the process and standards that were followed in deriving the various estimates.

Findings of the Third-Party Review

The cost estimates provided by Joint Waste Owners were contained in 13 reports and 6 CDs that contained summary reports, appendices, and detailed estimate data (Appendix 1). These documents and CD's were reviewed in detail by the review team.

The specific conclusions of the ADH Technologies Inc./Charles River Associates review team, in accordance with the NWMO original requirements are as follows:



1. Advise on the adequacy of the estimating standards adopted by the Joint Waste Owners for this cost estimating work

The Estimating Standards established for producing these estimates are those of the Joint Waste Owners and closely follow key estimating elements recommended by Professional Institutions. They are adequate Standards to guide the teams of Estimators from different Organizations to produce these Estimates in a similar manner with a common underlying quality in the finished product.

2. Assess the cost estimate documentation and comment on the quality and completeness

The documents showing estimating Instructions and resulting Cost Estimate Reports are complete, comprehensive and detailed. The estimating calculations supporting the Cost Estimate Reports are complex and detailed. The resulting numbers are clearly summarized and match those found in the Cost Estimate Reports.

3. Map the document trail that supports the cost estimates

The documents made available to Summarize, Explain and Display the content and calculations in the Cost Estimates are adequate for the purpose.

4. Comment on whether or not the estimates are structured such that they can be revised in the future as may be required, as the forecast of the used fuel volume or key estimating assumptions change

The estimates are structured and summarized in such a way that revisions to the fuel volume and key estimating assumptions could be undertaken.



5. Document how the actual estimating process adhered to all steps in the estimating standard.

The estimating process, as indicated by the sequential use and transfer of data from one document to another, reflects the estimating process laid out in these 'Instructions to the Estimators' as well as to accepted practices in the estimating discipline and industry use.

Discuss and rate the quality of how each key component of the standard was followed in the development of the various estimates.

Considering that there were different teams estimating different scopes of work and using different industry traditions the estimates appear to follow their processes satisfactorily.

6. Comment on how the estimate will stand the test of time and if it could be easily updated for each cost estimate with respect to:

- standards
- document trail
- data trail
- presentation
- data management

To stand the test of time the estimates will need to be updated to the current cost of the programme in the dollars of the year. The Document Trails, Data Trails, presentation and data management would only need updating if the estimating process was changed in the future.

7. Assess the degree to which each estimate can stand alone without the need of the team that produced it to



provide further explanation, suitable for the public forum.

The estimate Summary documents are clear and well presented and should be comprehensible to the public. The detailed Estimates would be difficult to follow and fully understand at the detail level by someone unfamiliar with estimating techniques. These estimates are suitable to be presented to the public together with a “How to read the estimates” guideline.

8. Deliver a signed opinion on the process and standards that were followed in deriving the various estimates

The formal opinion letter is included in section 8.2 of this report

The cost estimates by necessity are based on conceptual design information and a range of assumptions and experience. Hence all the estimates are conceptual and generally 'Order-of-Magnitude' quality, although some items are more detailed. The accuracy of the estimates is assessed to be within the range of plus or minus 33% including all the contingency allowances. This level of accuracy is typical of estimates that have been prepared based on conceptual design information. Industry practice uses estimates with this level of accuracy for assessment of options and comparison of approaches for engineering projects. Even though the level of detail is conceptual, when the contingencies have been included the overall accuracy of the estimates falls in this range. This falls somewhere between a Level 3 and Level 4 of the Cost Estimate Classification system of the AACE Recommended Standards and Practices, which is appropriate for projects at this stage of review. As such, the estimates are sufficiently detailed and accurate to be used for the purpose of comparing alternatives.

Having completed the overall assessment of the cost estimates the third-party review team finds the estimates suitable for their purpose of assessing the magnitude of the costs of alternative management methods, and to assist in directional decision making and the selection of preferred alternatives. The cost estimates have been prepared with an appropriate estimating methodology.



Hence they should be considered adequate for the NWMO's current options assessment process.



2.0 Background

Over the past two decades much work has been undertaken in Canada regarding the development of technologies and approaches for the long term management of spent nuclear fuel. These programs have resulted in a very large database of information and technology that is available to the NWMO for its deliberations. Among the various programs undertaken are:

- The AECL program to develop the Deep Geologic Repository (DGR) technology that was undertaken in the 1980's and early 1990's. This technology and program were the subject of detailed environmental assessment in the mid-1990's culminating with the Seaborn report.
- The development of technology for on-site storage of spent nuclear fuel in canisters systems or concrete monoliths. Systems of this kind developed by Ontario Power Generation and AECL respectively are in use on CANDU reactor sites in Canada and abroad.

Various other programs and approaches have been considered over the years in the development of the Canadian nuclear power program. There is also considerable international experience in the development of such technology and programs that have emerged as various countries establish their own policies and methodologies for management of spent nuclear fuel.



3.0 Origin of the Estimates

The Nuclear Fuel Waste Act (NFWA) requires the NWMO to submit a report to the Government of Canada which includes comparison of costs, risks and benefits of three approaches for managing Canada's nuclear fuel wastes.

In advance of NWMO being established the Joint Waste Owners (JWO), consisting of Ontario Power Generation (OPG), Hydro-Québec (HQ), New Brunswick Power (NBP) and Atomic Energy of Canada Limited (AECL) commissioned a study in 2001 based on requirements in the then draft NFWA to develop conceptual designs for the alternatives and associated engineering cost estimates.

Estimates were prepared for the following approaches to nuclear spent fuel management.

- Deep Geologic Repository (DGR)
- Reactor Extended Storage (RES)
- Centralised Extended storage (CES)
- Transportation of Spent Nuclear Fuel

These estimates represent the respective life cycle costs for the options including transportation cost if applicable. The life cycle cost includes cost of fuel waste storage, transportation and disposal. Key assumptions are that the total amount of sent fuel bundles to be managed is 3.7 million over 300 year life cycle. A set of reports has been provided that document all the assumptions and estimate details.

The estimates for interim storage of used fuel at reactor sites have been calculated using waste volumes provided by respective owners currently storing the material and the application of OPG full unit interim storage costs to these volumes.

The estimate for transportation of the nuclear fuel waste, where applicable, to its final disposal location, has been provided by Cogema Logistics. Cogema Logistics is French company with extensive experience in transportation of nuclear fuel waste in Europe.



The estimated cost of siting, construction, operation, extended monitoring, closure and decommissioning of the waste disposal facilities was provided by CTECH. At the time the estimates were prepared, CTECH was a joint venture of CANATOM (SNC-Lavalin, AECON) and AEA Technologies (UK) (now RWE Nukem).

3.1 NWMO Validation of Estimates

In order to support the process for assessing and selecting an option established by NWMO, it is prudent to undertake a review of the estimates that have been previously prepared. It is particularly important to ensure that the estimates have been prepared in an appropriate manner and were developed consistent with established estimating standards. A review of this nature is particularly important at the outset of the assessment and option selection phase of the NWMO's work so that those using the estimate information in comparison and assessment of options can be confident that they are referring to reliable estimates.

Accordingly, the NWMO launched a project to review and validate the cost estimating process in January 2004. The focus of this project is to verify and validate the estimating methodology rather than the underlying assumptions. In addition, the review was to comment on the usability of the estimates as circumstances change in the future. The NWMO set out eight specific criteria for validation as follows:

1. The reviewers will advise on the adequacy of the estimating standards adopted by the Joint Waste Owners for this estimation work.
2. The reviewers will assess the cost estimate documentation and comment on the quality and completeness.
3. The reviewers will map the document trail that supports the cost estimates
4. The reviewers will comment on whether or not the estimates are structured such that they can be revised in the future as may be required, as the forecast of the used fuel volume or key estimating assumptions change.



-
5. The reviewers will document how the process followed adhered to all steps in the estimating standard. They will discuss and rate the quality of each component of the standard that was followed in the development of the various estimates.
 6. The reviewers will make recommendations as to how the estimating process will “stand the test of time” and if it could be easily updated for each cost estimate with respect to:
 - Standards
 - Document trail
 - Data trail
 - Presentation
 - Data management
 7. The reviewers will assess the degree to which each estimate can stand alone, without the need of the team who produced it to provide further explanation and/or justification, as these estimates are made available by the NWMO in the public forum
 8. The reviewers will deliver a signed opinion on the process and standards that were followed in deriving the various estimates.

There are established standards and practices used in the estimating of large and complex projects. Moreover, nuclear projects carry their own characteristics associated with the unique risks and regulatory concerns. Many of these projects are of durations of years or even decades, which puts a particular premium on schedule reliability and its impact on the overall project cost. Schedule delays on long projects can have a profound effect on the interest during construction and corresponding costs of such facilities. Depending on the option being reviewed, there may be limited or no experience for similar projects to offer comparison since the technology and cost of the facility is new.



4.0 The Review Team

In order to perform the estimate validation project the NWMO issued an RFP for competitive bids to find a qualified organization for the project. Charles River Associates was invited to respond and established a team with ADH Technologies Inc. in order to field the best team for performing the work.

The team of Charles River Associates (CRA) and ADH Technologies Inc. (ADH) responded to a request for proposal issued by the NWMO on December 8, 2003. The objective of the request for Proposals was to engage an appropriately qualified organization or team to review and validate the estimating process used to estimate the cost of various approaches for the long term management of spent nuclear fuel. The CRA/ADH team submitted a proposal to undertake the work on December 22, 2003 and was awarded the contract in a letter from the NWMO dated January 14, 2004.

The work involves the review and assessment of estimate data and information that are contained in 13 reports and 6 CD ROMs.

The team has prepared this report in order to provide the NWMO with a standalone document for their use that addresses the requirements of the Request for Proposal and validates the estimating process used.

4.1 Team Members

The members of the estimate validating team require a range of experience in the process of estimating large engineering projects such as those under consideration by the NWMO. In particular, skills in estimating and cost control, project management, engineering, and economic analysis are important for fulfillment of the estimate validation exercise. The key members of the team who performed the estimate validation are:

Mr. A. D. Hink – ADH Technologies Inc. - Leader
Mr. M. Hunt – Ludlow Project Services Inc. – Estimating Specialist
Mr. P. Galiungi – Pierre Galiungi Consultants Ltd. – Project Management
Mr. Mr. I. Munro – Charles River Associates – Economics Specialist

Brief resumes of these individuals are included in Appendix 2.



5.0 Methodology

There are established practices and standards used in industry in preparing estimates for large complex engineering projects such as those represented by the options contemplated by the NWMO. The team is fully cognizant of these practices and has established a methodology for reviewing and assessing the validity of the estimating process. Although the amount of estimate data is quite voluminous, standardized review and assessment techniques were applied.

5.1 Estimating Practice

In industry associated with large engineered projects such as long-term nuclear waste management systems, there are established estimating standards. Organizations such as the Project Management Institute (PMI), the Association for the Advancement of Cost Engineering (formerly American Association of Cost Engineers (AACE)) and the Canadian Institute of Quantity Surveyors (CIQS) develop and maintain such standards. A key feature of these standards is that they have a classification system for estimates of large engineering projects that set out guidelines for estimates. Typically, the standards provide a classification system for estimates depending on how developed the underlying information is and the ultimate use of the resulting estimate. For some estimates, it is sufficient to have a minimum of scope definition and supporting data so that an overview of the particular project is obtained. Users may find this sufficient for feasibility assessment and concept comparison. At the other end of the spectrum of estimate classes there is a considerable amount of technical definition and supporting data, such as quantities of material available to the estimators. Such estimates are used for project implementation and detailed budgeting of the work.

One standard applicable to the NWMO spent fuel management options is the AACE Recommended Practice No. 17R-97 "Cost Estimate Classification System". In performing the work the CRA/ADH team referred to this standard as reference and guideline in assessing the validity of the estimating process used by NWMO. This standard classifies estimates in five levels and recommends their use in accordance to level of engineering definition used in the estimates (see Table 1).



Table 1 – Estimate Classification System

Estimate Class	Level of Definition	End Usage	Methodology	Expected Accuracy Range
Class 5	0% to 2%	Concept Screening	Capacity Factored, Judgment, Analogy	-20% to -50% +30 to +100%
Class 4	1% to 15%	Study or Feasibility	Equipment factored or parametric models	-15% to -30% +20% to +50%
Class 3	10% to 40%	Budget Authorization or Control	Semi-detailed unit costs with Assembly level line items	-10% to -20% +10 to +30%
Class 2	30% to 70%	Control or Bid	Detailed unit cost with forced detailed take-off	-5% to -15% +5% to +20%
Class 1	50% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	-3% to -10% +3% to +15%

Source: AACE Recommended Practice No. 17R-97, Cost Estimate Classification System

The estimates provided by the NWMO and reviewed by the CRA/ADH team are in the range of Class 3 or 4 in Table 1.



5.2 Process Applied

As a first step, the team acquired and read the documents in order to gain an overview understanding of the content and to familiarize itself with the information. This review was followed by a series of brainstorming discussions among team members to assess the strengths and weaknesses in the information and to confirm the review approach. Additional information required was noted and a meeting was requested with those responsible for preparing the estimates (the JWO) in order to clarify the team's understanding of the estimate packages.

Following on from the brainstorming sessions the team also began the process of "mapping" the data. This involved reviewing all the data and estimate documentation at the summary level and organizing the information into a format where the summary level estimates can be broken down to establish the associated scope, quantities, databases, and estimates that build up to the overall summary estimate. The team established a standardized process for this exercise.

The document packages included estimates for three different approaches for the disposal of spent nuclear fuel. Within each estimate there may be multiple alternatives, each with their own estimates, or alternatively, there may be multiple sites applying a particular approach which result in specific estimates for each site. In cases where the approaches require shipping of the spent nuclear fuel between sites there are separate estimates of the transportation costs that also need to be validated. The above mentioned method of reviewing the estimates was applied in all cases.

As the estimates were studied and broken down to their respective components to verify that there is a base to validate the overall estimating process, data that could not be found was assumed to be available to the estimators.

The estimates were then reviewed and an overall assessment was made by the team. The results were submitted to the NWMO, first in an interim report, and ultimately in the final report for the project.



5.3 Other Activities

In addition to the detailed estimate review other significant activities were performed during the project as follows:

- Acquisition and review of the documents. There are thirteen (13) reports and six (6) CD ROMS containing the estimate data. The documents are listed in Appendix 1. The team members have read all of the documents and oriented themselves to the information. In addition, the team has held two brainstorming sessions to establish missing or unclear information.
- The team requested and held a meeting with the NWMO and JWO, who compiled the estimates. These, in turn, were developed by contractors. The meeting was very useful and addressed several questions
- The team produced a map of the data and document trail that forms the basis of the estimates.
- After developing the methodology, data map, and clarifying the information provided, the team started breaking down the estimates into sub-elements to assess the validity of the process used in deriving the final estimates.
- An Interim report was produced at the half way point of the project.
- The Interim report was reviewed with the NWMO.

5.4 Detailed Estimate Review

Once the team established that the estimates were sufficiently complete and well developed to enable a thorough review, the team undertook several steps. In order to understand the steps taken it is important to establish the detailed structure of the data and documents. An example of the detailed structure of the estimates for the DGR is given in Figure 1. This gives a pictorial overview of the trail of the documents that were provided, what is contained in the documents,



and how the documents organize the information. The information for the other estimates, i.e. RES, CES, and Transportation, are similarly organized.

Using this trail of data and documentation the team took several steps to review the estimates as follows:

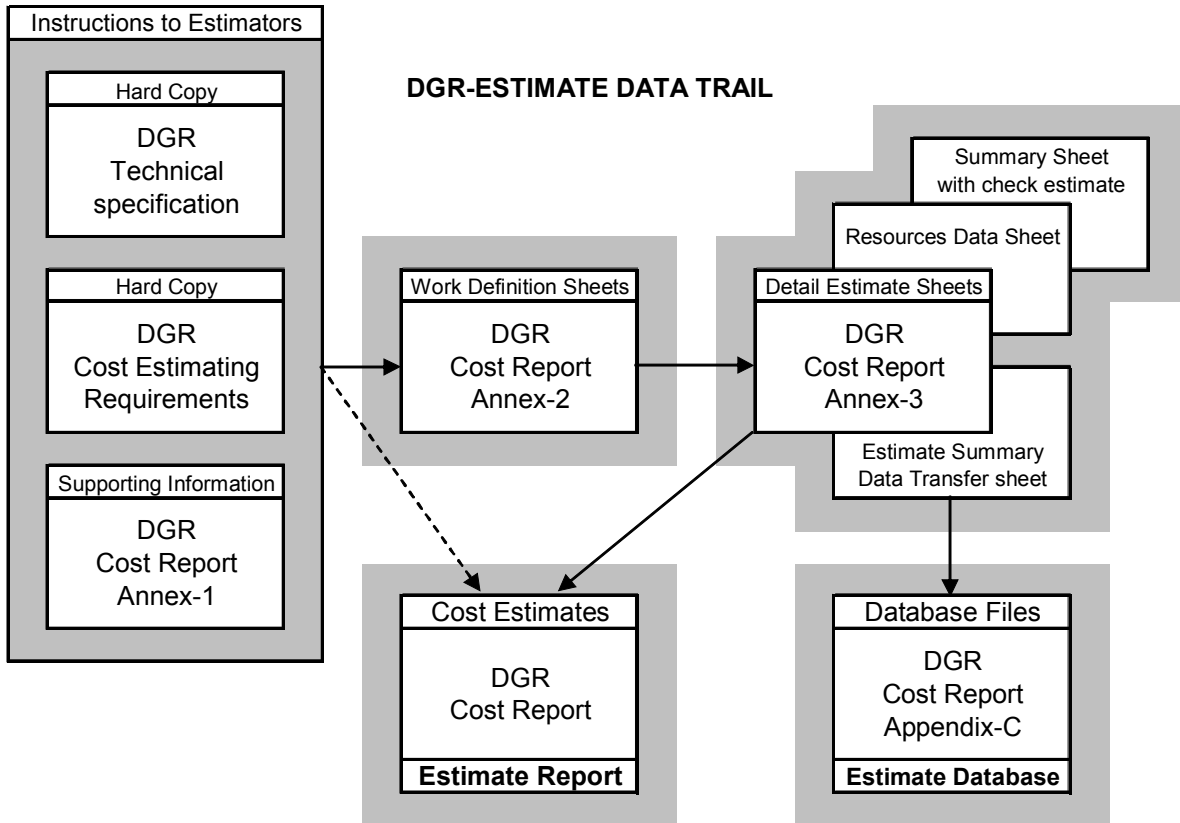
- The team first reviewed the Instructions that were provided to the Estimators by the JWO in commissioning the estimates. This involved reviewing a comprehensive document that contained a technical specification, a set of estimating requirements, assumptions, and additional supporting information.
- The team next reviewed the Cost Estimate reports provided with the estimates and determined the work breakdown structure that was used. The estimates are broken down into a series of detailed work definition data sheets that contain the building blocks which form the basis of the estimates. The sheets each describe the work, what the required deliverables are from that piece of work, and the corresponding assumptions and estimates. Comments on the basis for applying contingency to each element of the work are also presented.
- This information is compiled into a series of annexes to the estimates and summarized and rolled up to summary data level. At this stage the data is put onto a transfer sheet and is transferred to a database that keeps track of the data along a timeline leading to a cash flow for the estimate. The team assessed this system and reviewed this data to ensure that it is consistent with industry practice.
- The detailed review of the estimates entailed following the origin of sample work elements and compilation onto summary sheets and transfer to the database. This is very detailed work but enabled the reviewers to assess the degree of accuracy and quality of the overall estimating process since it involved reviewing the underlying basis of each element of the work. It also allowed the reviewers to determine if the estimate is consistent with appropriate estimating standards.



-
- The team did this for each of the estimates provided and then derived conclusions from overall assessment of the information. General observations, and more specific observations on the estimating process, estimate accuracy, and usability, were compiled into this report.



Figure 1 DGR Estimate Data Trail



6.0 General Observations

The team made a number of important observations regarding the estimates and their appropriate use. These are:

6.1 Order of Accuracy

The team reviewed the available documentation used as a basis for preparing the estimates. The basic engineering is sufficiently well developed for this level of decision. The engineering information for all alternatives permits bulk quantity take-offs. Quantities or dimensions are provided enabling estimators to use deterministic methods for estimating major items. Similarly, equipment lists were provided for major items.

All the estimates are conceptual and generally 'Order-of-Magnitude' quality (between Class 3 and 4 on the AACE classification system see Table 1), although some items are more detailed.

Accordingly, the technical information used to develop the estimates is sufficiently well developed to be considered adequate for strategic planning, project screening, alternative scheme analysis, confirmation of economic feasibility, and preliminary budgeting.

6.2 Contingency

Standard industry guidelines were provided to estimators to obtain a consistent application of contingency, taking into account availability of information, availability and accuracy of quantities, level of engineering and percentage of labour content. The team observed that a contingency was added to every item in the estimate. For the purpose of the NWMO's assessment and selection exercise, it is prudent.

It should be noted that the contingencies applied to each item of work are contingencies related to changes in the scope as defined rather than contingencies related to the risk of the project. These risks may arise from external factors such as environmental or regulatory factors that are not strictly addressed in the contingencies currently included in the estimates.



6.3 Selection Criteria

The estimates reviewed provide a good basis of comparison between the three options (or combinations thereof). They include construction and operating costs as well as siting, commissioning, and other costs which are included in the work breakdown structure.

6.4 Application of Estimates

For comparison of approaches, in combination with other factors, the estimates are suitable to support the decision on a spent fuel management option. However, there is a range of accuracy on the estimates that could become important in some circumstances. If, for example, after review of the options, the estimates become the sole determining factor for selecting the final option, more detailed review of the estimates would improve their individual accuracy.



7.0 Results of Assessment

7.1 General Results

The review process for the estimates noted a number of important items that are applicable to all the estimates. These points are as follows:

- The ultimate goal or structure of the estimates leads to the development of a cash flow over the life of the project under consideration. Hence users of the estimates can see the planned flow of cash over the project lifetime by time period.
- The cash flows are calculated at the Work Breakdown Structure (WBS) level 2 and are summarized as either “labour” or “material”.
- The labour is expressed as hours or dollars per hour if not originally calculated as such. In developing the estimates the estimators in some cases used a different original basis for the labour such as person years, which in turn was converted to hours.
- The RES estimates all appear to be factored from a set of cost estimate models. The models do not estimate for the specific reactor site or this is not in the data provided.
- The estimates for transportation from the reactor sites are all based on a common estimate model. The estimates do not include other models or this is not discernible from the data provided.
- All of the estimates are “order of magnitude” quality although some elements are more detailed.
- There is heavy influence in the estimates from the use of factors, ratios and broad assumptions. These have been applied consistently.
- The overall resulting estimate can be described as **indicative** and **directional**. However, there is sufficient detail and consistency that the estimates can be used for review and selection of options and directional decision making.



7.2 Comments on NWMO Validation Criteria

The NWMO requested that the reviewers undertake the following:

- 7.2.1 Advise on the adequacy of the estimating standards adopted by the Joint Waste Owners for this cost estimating work
- 7.2.2 Assess the estimate documentation and comment on the quality and completeness
- 7.2.3 Map the document trail that supports the cost estimates
- 7.2.4 Determine if the estimates are structured so they can be revised in the future as the fuel volume or key estimating assumptions change.
- 7.2.5 Document how the actual estimating process adhered to all steps in the process
- 7.2.6 Rate the quality of how each key component of the standard was followed in the development of the estimates
- 7.2.7 How will the estimate stand the test of time and can the following be easily updated: -
 - A - Standards
 - B - Document trail
 - C - Data Trail
 - D - Presentation
 - E - Data Management
- 7.2.8 Assess the degree to which the estimate can stand alone without the need of the team that produces it to provide further explanation, suitable for the public forum.
- 7.2.9 Deliver a signed opinion on the process and standards followed in deriving the various estimates.



7.3 Specific Comments on NWMO Validation Criteria

Comments on the first eight items of section 7.2 of the overall estimate validity follow. An overall assessment of the estimates and a formal opinion are given in the next section.



7.3.1 ‘Advise on the adequacy of the estimating standards adopted by the Joint Waste Owners for this cost estimating work’

The Estimating Standards established for producing these estimates are those of the Joint Waste Owners and closely follow key estimating elements recommended by Professional Institutions.

They are adequate Standards to guide the teams of Estimators from different Organizations to produce these Estimates in a similar manner with a common underlying quality in the finished product.

Estimating Standards for producing these estimates were provided by the Joint Waste Owners to their estimating staff and consultants in a file binder marked: -

“Instructions Provided to Consultants to Prepare Cost Estimates.”

Each Section included a report titled

“Cost Estimating Requirements for the update of the Conceptual Cost Estimate” for: -

- 1) Deep Geological Repository
File # 06819-00051.CDGR(UFM)-T5 – Rev-3a.(19 pages)
- 2) Centralized Extended Storage
File # 06819-00051.CCES (UFM)-T5 – Rev-2. (16 pages)
- 3) Reactor-Site Extended Storage
(No File. Estimate is Based on 2) Centralized Extended Storage)
- 4) Used Fuel Transportation System.
File # 06819-00030(UFM)-T5 – Rev-1. (15 pages)



These 'Cost Estimating Requirements' follow the same format and content including: -

- Purpose and Background
- Definitions
- Cost Estimating Assumptions
- Work Breakdown structure
- Work element Definition sheet
- Cost Categories
- Estimating Methodology
- Schedule and Cash flow
- Present Value analysis (CES & UFT)
- Reporting
- Electronic Transmittal of Cost Data
- Comparison to Other Cost Estimate Reports (UFT)
- Sample Cost Estimate Report (CES)
- Previous Cost Estimate Report (where applicable)
- Other Requirements
- Template for work element Definition Sheet (WEDS)
- Labour Rates for conceptual Cost Estimating Purposes



7.3.2 ‘Assess the estimate documentation and comment on the quality and completeness’

The documents showing estimating Instructions and resulting Cost Estimate Reports are complete, comprehensive and detailed.

The estimating calculations supporting the Cost Estimate Reports are complex and detailed. The resulting numbers are clearly summarized and match those found in the Cost Estimate Reports.

The detailed estimating documents (spreadsheets) that support the Cost Estimate Reports include complete WBS listings and calculations based on cost, quantity and schedule data from documents included in this study.

Detail estimate calculations also include data either assumed from experience or derived from other sources, such as results of other studies or ‘side calculations’.

A comprehensive and complete listing of all the resulting estimate data is included in a Database (Access) file for all the Used Fuel Programme Scenarios.

Estimate documentation with the exception of one or two documents was provided electronically in ‘Word’, ‘Excel’, Adobe’ or ‘Access’ formats.

They consist of the following:-

1- “Instructions Provided to Consultants to Prepare Cost Estimates”

Including the following sections for DGR, CES & UFT scenarios;

<u>Document</u>	<u>Relevant Sub-Sections</u>	<u>DGR</u>	<u>C/RES</u>	<u>UFT</u>
-----------------	------------------------------	------------	--------------	------------

-Graphic Display of the options		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
---------------------------------	--	--------------------------	--------------------------	--------------------------

-Technical Specification:-



-	Scope of Work	<input type="checkbox"/>		<input type="checkbox"/>
	CES & RES Concepts		<input type="checkbox"/>	
-	Technical Requirements	<input type="checkbox"/>		
-	System Requirements		<input type="checkbox"/>	<input type="checkbox"/>
-Cost Estimating Requirements				
-	Listed in 1. above	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-	Labour Rates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
-Supporting Information				
-	Estimating Documents	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	(EDO's) (Quantities & Costs)	<input type="checkbox"/>		
	EDO for CVSB option		<input type="checkbox"/>	
	Summary Schedule	<input type="checkbox"/>	<input type="checkbox"/>	
	Target Dates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Design Report Figures	<input type="checkbox"/>		
	(Drawings & Sketches)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2- Reports of Cost Estimates.

Summary Reports of the completed Estimates were compiled for:-

DGR - Deep Geological Repository

File # 1106/MD1805/REP/02 issue-1

By Canatom NPM Inc. & RWE Nukem Ltd

CES – Centralized Extended Storage.

File # 1105MD 18084/REP/11 issue-2

By Canatom NPM Inc. & RWE Nukem Ltd

RES – Reactor site Extended Storage.

File # 1105MD 18084/REP/16 issue-1

By Canatom NPM Inc. & RWE Nukem Ltd

UFT – Used Fuel Transportation.

File # 500276-B-00. Rev 00



By Cogema-Paris Division

The Cost Estimates are all summarized in similar comprehensive reports covering the following aspects of the Estimate. The authors of the reports had their own reporting style.

Canatom-RWE followed the same report format and sequence. The UFT report by Cogema covered the same subject matter in a different format and sequence:

<u>Summary of Subjects</u>	DGR	C/RES	UFT
Purpose of the Estimate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storage of Used Fuel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Estimating Assumptions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Level of Cost Estimation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Description of Alternatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schedule Estimates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cost Estimating Process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3- Detailed Estimating Calculations.

Detail Estimate data for each level-2 of the Work-Breakdown-Structure was collected and calculated in a Workbook and Worksheet spreadsheet format for each Used Fuel Storage Programme Alternative.

The workbook format consists of:-

- A Summary worksheet of Level-3 Worksheets
- A Unit Price Data Worksheet
- A full set of Estimate Worksheets for each level-3 of the WBS
- A Data Transfer Worksheet of Estimates & Cash-flow

The set of detailed worksheets each contains spreadsheet estimating calculations at the lowest detail level of the Work-Breakdown-Structure



definition and spread into a cash-flow profile by year over the life of the programme.

The detail worksheets contain the full WBS below level-2 calculated from quantities and unit prices and separated into:-

- Labour Cost
- Permanent Equipment & Materials
- Other Cost (Taxes, Expenses etc.)
- Contingency (as per formula for all estimates)

4- Estimate Details Database.

The completed estimate workbook data is transferred to a separate Database file set up in a relational-database-format using the MS-ACCESS software.

This format enables future editing and updates to the estimates and Cash Flow data.



7.3.3 Map the document trail that supports the cost estimates

The documents made available to Summarize, Explain and Display the content and calculations in the Cost Estimates are adequate for the purpose.

Except for a few 'Supporting documents' in the 'Instructions to the Estimators,' all the Documents are recorded electronically and provided on computer disks. Different Documents are recorded in different electronic formats.

The Document Trail follows the documented estimating process and completion: -

Instructions to Estimators Document

Work Definition Sheets Document

Estimate Workbook Spreadsheets Documents

Summary Work Sheet

Unit Price Work-Sheet

Estimate Detail Work-Sheets

Data Transfer Work-Sheets

Cost Estimate Database Document

Cost Estimate Summary Document



7.3.4 Are the estimates structured so they can be revised in the future as the fuel volume or key estimating assumptions change?

The estimates are structured and summarized in such a way that revisions to the fuel volume and key estimating assumptions could be undertaken.

A formula can be developed to show how any or all of the Summary Cost Estimates would vary as the Fuel Volume varied as well as variations in Key estimating assumptions such as Escalation. Currency Exchange rates and Schedules.

The Estimates are Described, Scoped, Compiled and Calculated in separate Documents with dependent data copied from one Document to the other as required to support the specific estimating tasks. However, the Estimates could not be automatically or globally revised at the detail level to drive an overall programme summary result.

Data within a document file is linked electronically and serves to 'drive' the calculation sequence to the result inside that document.

The Estimate Database document contains estimated data from the other documents in a relational format and is well suited to respond to Editing, Revising and Updating as well as the ability to produce a wide range of report formats and content as required by the user.



7.3.5 Document how the actual estimating process adhered to all steps in the process

The estimating process, as indicated by the sequential use and transfer of data from one document to another, reflects the estimating process laid out in these 'Instructions to the Estimators' as well as to accepted practices in the estimating discipline and industry use.

Samples of document and data trails are included in the attachments to this report.



7.3.6 Rate the quality of how each key component of the standard was followed in the development of the estimates.

Considering that there were different teams estimating different scopes of work and using different industry traditions the estimates appear to follow their processes satisfactorily.

Looking at the overall estimating processes as one, and assessing the traditional estimating steps on the process, the following ratings are applicable

The key components of the estimating process are:-

<u>Components</u>	<u>Quality*</u>
<i>Scope Definition</i>	<i>excellent</i>
<i>Basis of Estimate</i>	<i>good</i>
<i>Method of Estimating</i>	<i>acceptable</i>
<i>Quantity Measurement</i>	<i>good</i>
<i>Unit Pricing</i>	<i>acceptable</i>
<i>Estimate calculation & Summary</i>	<i>acceptable</i>
<i>Accuracy Assessment</i>	<i>acceptable</i>

** The quality criteria indicate the degree of acceptability of the underlying information used to develop each component of the estimates. "Acceptable" means the minimum standard for information and data used to develop that portion of the estimate has been met. "Good" means the information is well developed and normally expected in this class of estimate. "Excellent" means that information is very well developed and is*



more than would normally be expected for the class of estimate being reviewed.

The Estimates were produced by three different teams:-

DGR Team

CES and RES Team

UFT Team

The DGR Estimate was based on a single scope without alternatives.

The CES includes four storage alternatives at one site

The RES includes the four alternatives at each of the six sites

The RES estimates are factored as percentages of the CES estimates, based on Fuel volume at each site.

The UFT estimates include three transportation scenarios:-

Mostly by Road

Mostly by Rail

Mostly by Water



7.3.7 How will the estimate stand the test of time and can the following be easily updated:-

- Standards
- Document trail
- Data Trail
- Presentation
- Data Management

To stand the test of time the estimates will need to be updated to the current cost of the programme in the dollars of the year.

The Estimates are dated as of 2003 and the dollar values are stated as of 2002 and will need to be adjusted each year to reflect the statistical increase or decrease in the cost of this Programme

Updating the Standards would only be necessary should the NWMO decide to follow different standards to those listed in these estimating documents. The impact of such changes would entirely depend on their effect on key calculations in the estimates. The major impact would be if the NWMO decided to adopt standards to support a more definitive level of detail.

The Document Trails, Data Trails, presentation and data management would only need updating if the estimating process was changed in the future.



7.3.8 Assess the degree to which the estimate can stand alone without the need of the team that produces it to provide further explanation, suitable for the public forum.

The estimate Summary documents are clear and well presented and should be comprehensible to the public.

These Estimates would be difficult to follow and fully understand at the detail level by someone unfamiliar with estimating techniques.

This assessment was carried out at the detail level satisfactorily without reference to, or discussion with, the people who produced them.

An experienced estimator should have little difficulty following these estimates and understanding them.

These estimates are suitable to be presented to the public together with a 'How to read the estimates' guideline.



8.0 Overall Assessment and Formal Opinion

8.1 Overall Assessment of the Estimates

The overall assessment of the estimates is that they are suitable for the **review of options** and **directional decision making** subject to the comments in this report. They have been prepared with an appropriate estimating methodology. Hence they should be considered adequate for the NWMO's current options assessment process.

8.2 Professional Opinion

The formal opinion concerning the estimates is as follows:

>>> ~ ~ **Ludlow** ~ ~ >

Ludlow Project Services Inc.

2910 South Sheridan Way, Oakville, ON L6J 7G8

Phone: 905.338.0064 Fax: 905.338.0758 Email: projects@ludlowtec.com
www.ludlowtec.com

Professional Opinion

'Long Term Management of Used Nuclear Fuel'

I have reviewed the Cost Estimates for the 'Long Term Management of Used Nuclear Fuel' (dated January 2004) and ascertained the estimating process used to produce them. A set of estimate documents were provided by the NWMO to the 'ADH Technologies Inc.' review team for this purpose in February 2004.

The documents provided to third party estimators by the Joint Waste Owners include broad estimating guidelines that they followed in constructing these estimates. The individual methods of calculating the estimate details used by the third party estimators are acceptable in the industry for conceptual estimating.

The estimates are made up of the costs of Development, Construction and Operations for each of the scenarios and their alternatives. The major portion of all the estimates is the cost of Operations, which is largely estimated by costing out a staffing plan over the life of the programme. The cost of Development is estimated similarly. The cost of Construction follows a well-defined estimating process used throughout the construction Industry.

The resulting estimates and their details indicate that an estimating process was followed consistent with accepted industry standards.

The accuracy of these estimates is assessed as within the range of plus and minus 33% including all the contingency allowances. This falls somewhere between a Level 3 and 4 of the Cost Estimate Classification System section of the AACEI Recommended Practices & Standards.

These estimates are considered suitable for their purpose of assessing the magnitude of the cost of the scenarios and their alternatives and to assist in directional decision-making and the selection of preferred alternatives.

Signed by: Maurice J. Hunt PQS CCC



Dated: 23rd March 2004

>>> ~ ~ *Project Controls Solutions* ~ ~ >



REFERENCE DATA

1. List of documents provided by NWMO
2. Classification of Estimates (extract from AACE)
3. Samples of tracking cost items through documents:
 - a. DGR - 550-40 Construction
 - b. CES - 561-35 Public Affairs
 - c. UFT - Route Development-610-40
 - d. RES - 588-35 Public Affairs
4. Published estimating database by 'R. S. Means'
5. Published estimating database by 'Richardsons'



LIST OF ATTACHMENTS

Attachment 1	DGR Document Trail
Attachment 2	CES Document Trail
Attachment 3	DGR Data Trail
Attachment 4	CES Data Trail
Attachment 5	DGR Disk Document Trail (On separate disk)
Attachment 6	CES Disk Document Trail (On separate disk)
Attachment 7	RES Disk Document Trail (On separate disk)
Attachment 8	UFT Disk Document Trail (On separate disk)



APPENDICES



APPENDIX 1 List of Documents Provided

Title	Format
Cost Estimates for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel (Hydro Québec)	One hard copy of report One CD with worksheets
Cost Estimates for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel (AECL)	One hard copy of report One CD with worksheets
Cost Estimates for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel (NB Power)	One hard copy of report One CD with worksheets
Cost Estimates for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel (OPG)	One hard copy of report One CD with worksheets
Conceptual Designs for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel	Four CDs
Cost Estimates for Four Centralized Extended Storage Facility Alternatives for Used Nuclear Fuel	One hard copy of report One CD with report and appendices
Conceptual Designs for Four Centralized Extended Storage Facility Alternatives for Used Nuclear Fuel	Four CDs
Cost Estimate for a Deep Geologic Repository for Used Nuclear Fuel	One hard copy of report One CD with report and appendices
Conceptual Design for a Deep Geologic Repository for Used Nuclear Fuel	Four CDs
Cost Estimate for Transportation of Used Fuel to a Centralised Facility	One hard copy of report One CD with report and appendices
Conceptual Designs for Transportation of Used Fuel to a Centralised Facility	One hard copy of report
Logistics of Transportation of Used Fuel to a Centralised Facility	One hard copy of report



APPENDIX 2 Background Information Regarding the Reviewers

Resumes of the key members of the review team are as follows:

Mr. A. D. Hink, P.Eng.

Mr. Hink is a professional engineer with many years experience preparing major nuclear project estimates (see foregoing). He is highly respected as a developer of major projects from the initial marketing to the proposal preparation and presentation to the clients. He has undertaken this responsibility for a number of nuclear facilities in the past. The projects have been successfully implemented. In particular he has led the strategic planning function at the executive level for AECL and was responsible for waste management in this role.

Mr. Pierre Galiungi, P.Eng,

Mr. Galiungi is a professional engineer. He is a Fellow of the prestigious Institution of Civil Engineers, (FICE), and a Fellow of the Institution of Engineers of Australia (FIE) and carries the designation of European Engineer (Eur Ing). As indicated before, he has many years of hand-on experience as a construction manager and project manager with a true grasp of how projects are executed and how costs are generated. Mr. Galiungi has particularly strong skills at cost management and cost control. These skills, combined with his experiences make Mr. Galiungi particularly well suited to review estimates with a view to judging their completeness and that proper consideration is given to risk elements.

Mr. Maurice Hunt

Maurice Hunt is a Certified Cost Engineer (CCC), a Professional Quantity Surveyor registered to practice in Ontario and a Construction Estimator Certified by CIQS. Educated in Electrical Engineering in the UK Royal Navy and an experienced designer of electrical control systems for Process Plants and several nuclear Plants in the UK.



He is recognized by his peers as a leader in Process Plant Estimating & Planning and has served as Director and President of AACI-Toronto as well as Secretary of AACE-Canada Inc. He served on the Education board of AACE and Toronto-OIQS. He teaches Estimating and Cost Control for AACEI and Industrial clients locally and nationally.

Mr. Ian Munro

Ian Munro is a Principal with Charles River Associates. Mr. Munro is an economist who frequently does work in the energy sector. He has been a lead contributor to recent CRA efforts for the NWMO regarding the economic and financial aspects of long term management of high level nuclear waste.



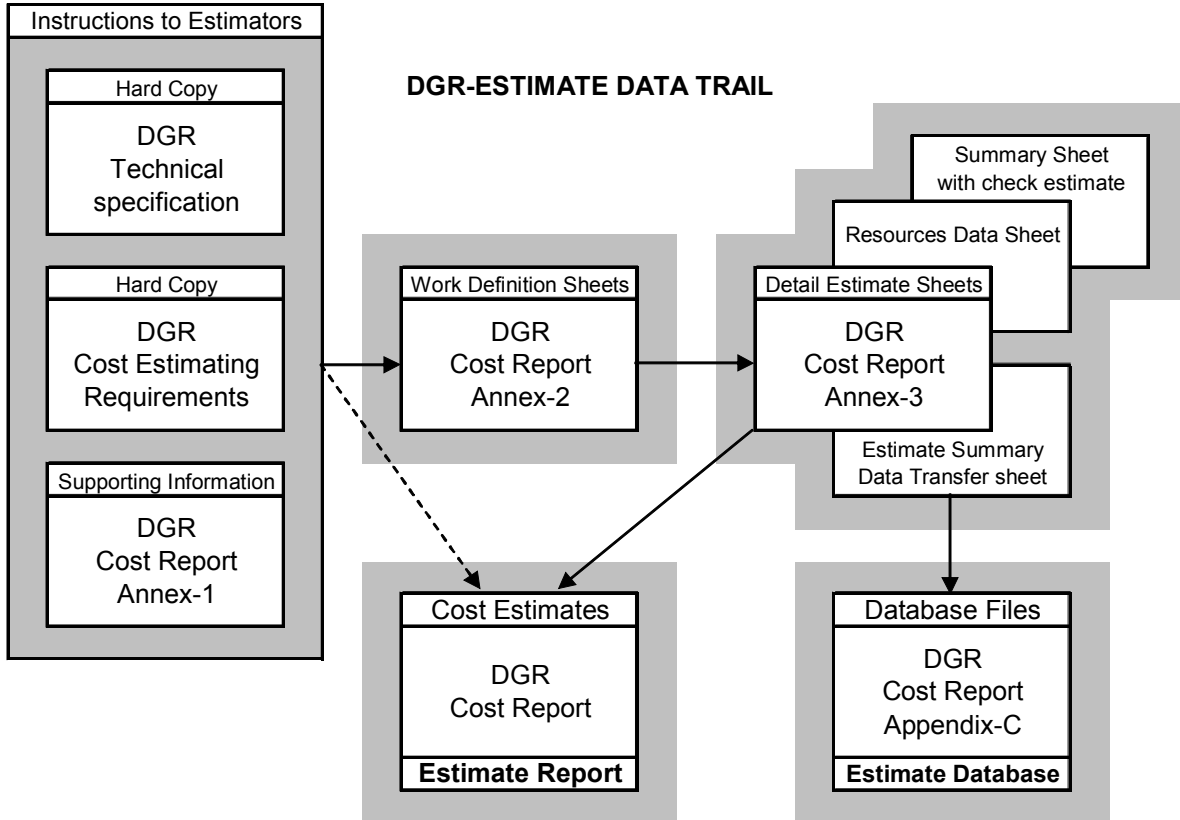
ATTACHMENTS

The following attachments are examples of the data and document trail reviewed.

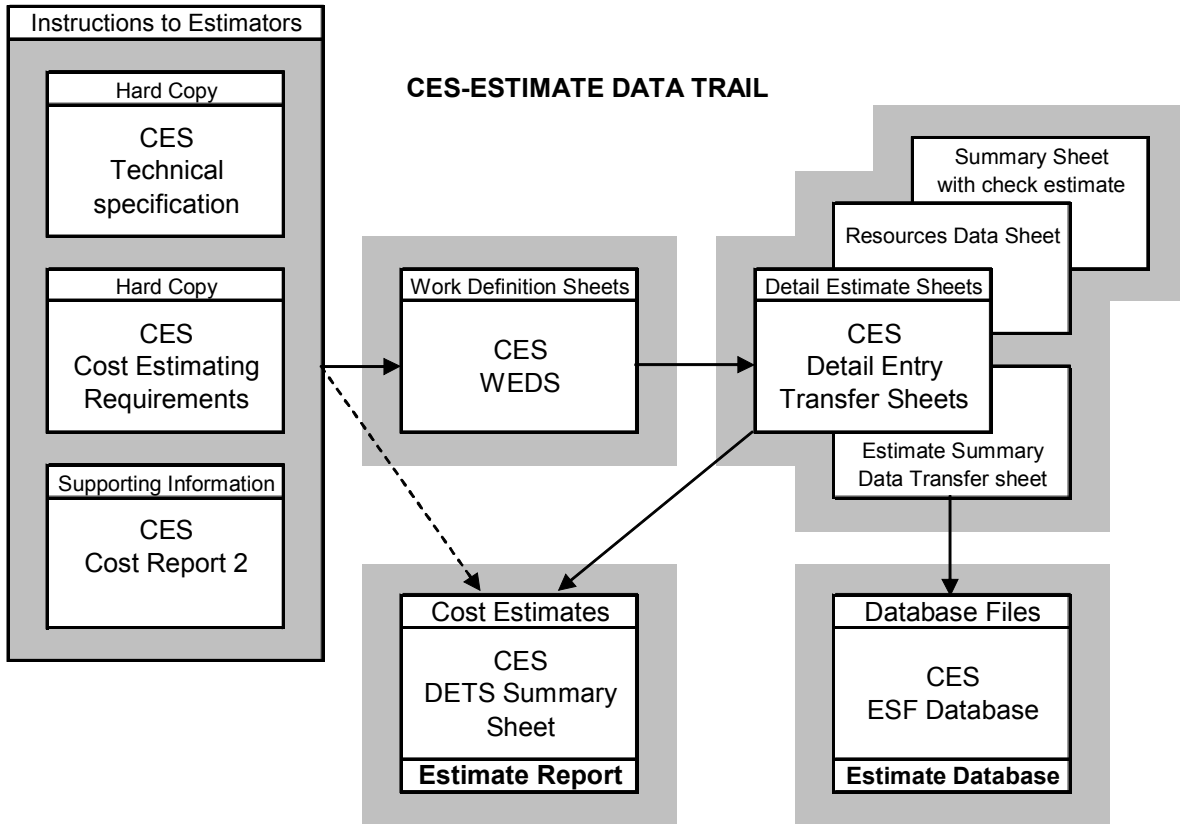
Due to complexity full data is provided on an accompanying CD.



Attachment 1 DGR Document Trail

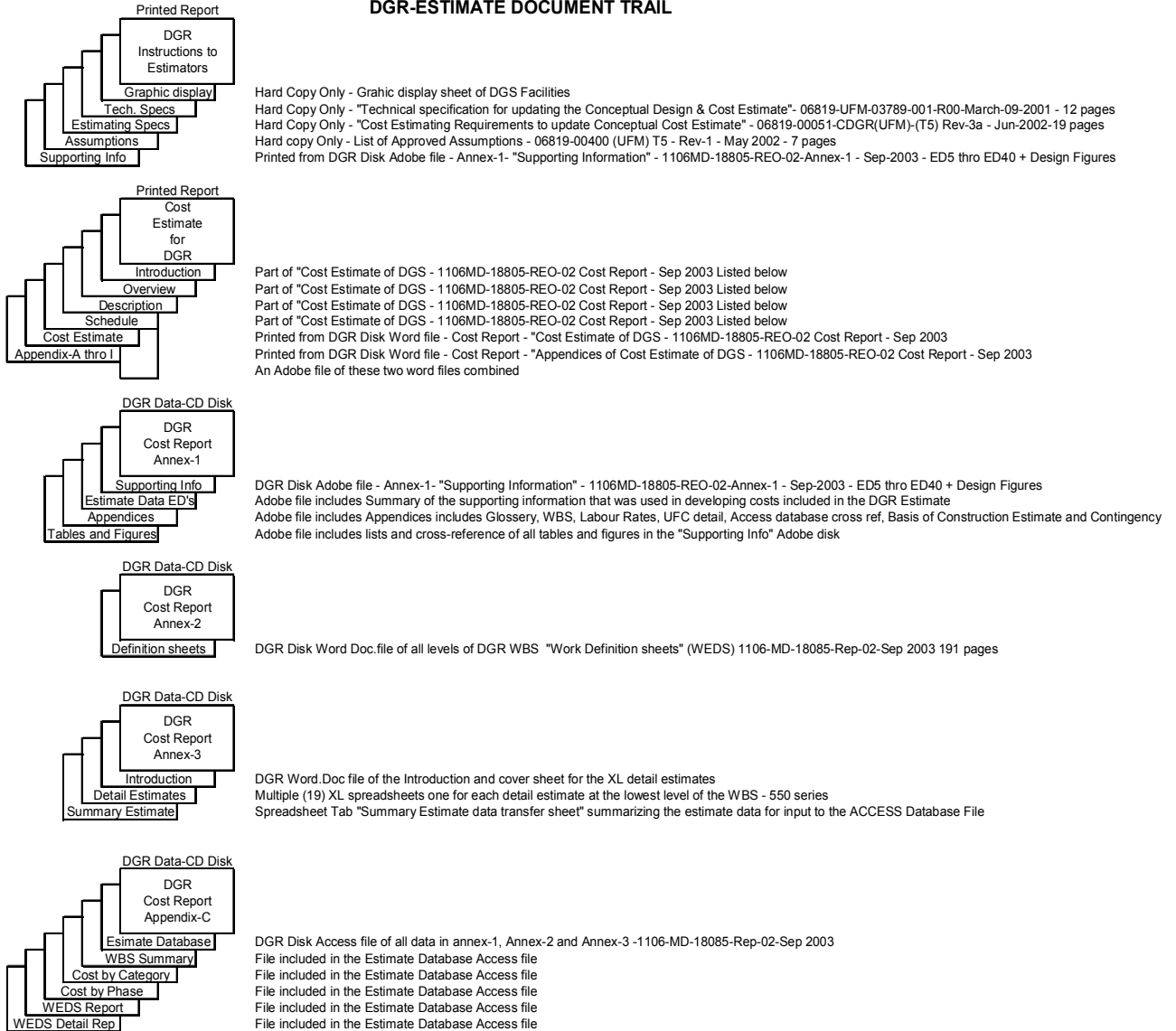


Attachment 2 CES Document Trail



Attachment 3 DGR Data Trail

DGR-ESTIMATE DOCUMENT TRAIL



Attachment 4 CES Data Trail

