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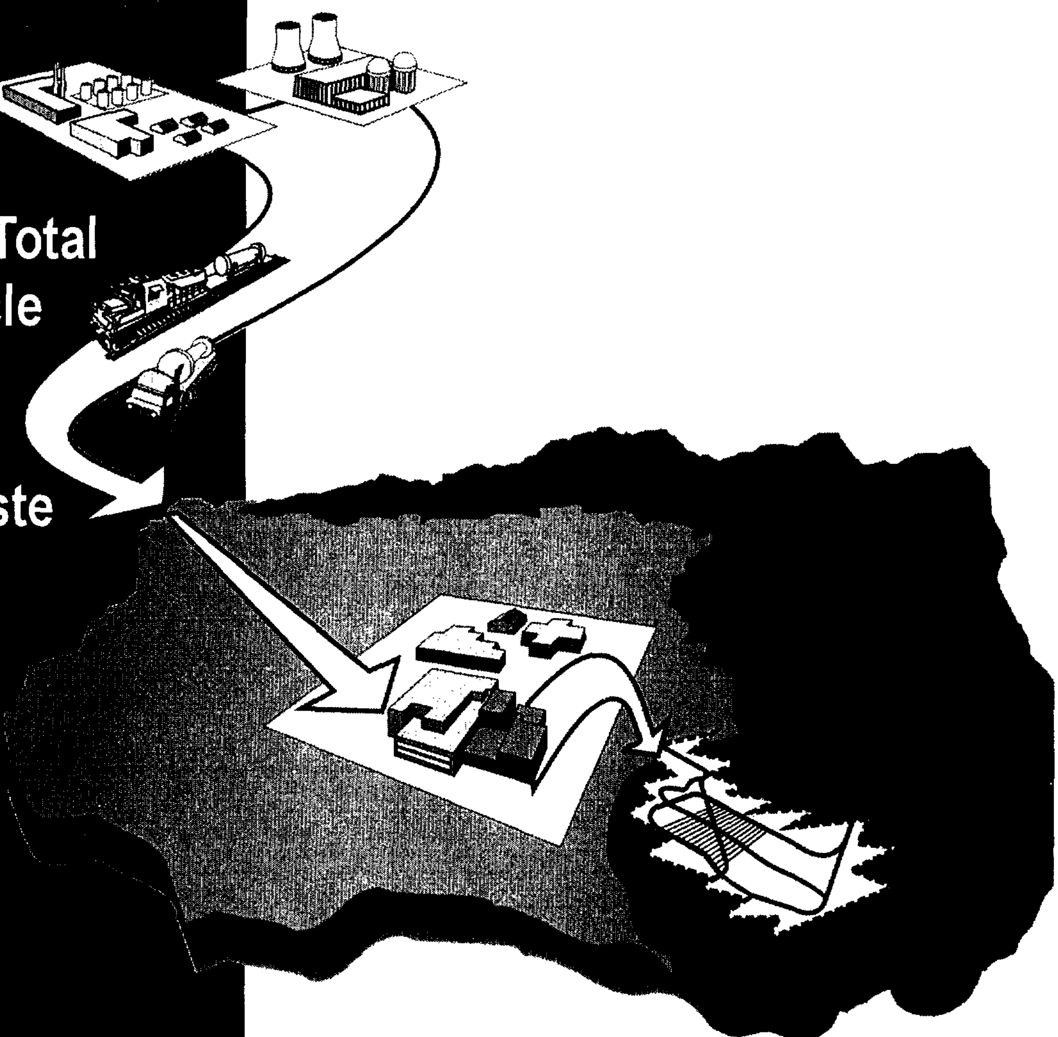

Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program

December 1998

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D.C. 20585

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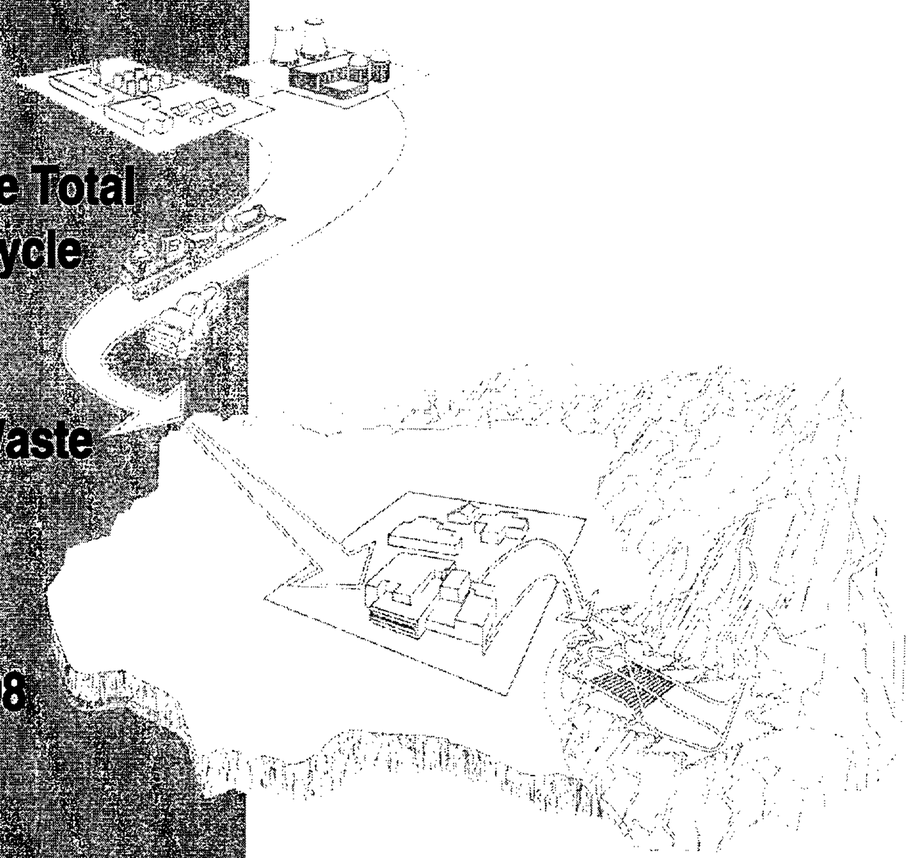

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Office of Civilian Radioactive Waste Management
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LETTER FROM THE DIRECTOR

The *Analysis of the Total System Life Cycle Cost (TSLCC) of the Civilian Radioactive Waste Management Program* represents the Office of Civilian Radioactive Waste Management's most recent estimate of the costs to dispose of the Nation's spent nuclear fuel (SNF) and high-level radioactive waste (HLW). This TSLCC analysis projects all Program costs through 2116 for a surrogate, single repository. The *Viability Assessment of a Repository at Yucca Mountain* [DOE/RW-0508] considers a specific repository site to dispose of up to 70,000 metric tons heavy metal (MTHM). However, projections of the amount of SNF and HLW from United States commercial and defense sources indicate that more than 70,000 MTHM will require ultimate disposition in a monitored geologic repository. The design and emplacement concepts in this TSLCC analysis are the same as those presented in the Viability Assessment, expanded to accommodate all of the projected SNF and HLW.

Since the enactment of the Nuclear Waste Policy Act (NWPA) in 1983 through fiscal year 1998, the Program has expended $5.9 billion in year of expenditure dollars. The total estimate to complete the Program, from fiscal year 1999 through permanent closure of a repository, is estimated at $36.6 billion in constant 1998 dollars. This TSLCC analysis differs from the previous TSLCC analysis published in 1995, as several key assumptions have changed. First, additional waste from U.S. Department of Energy (DOE)-owned and managed SNF and HLW and the disposition of surplus weapons plutonium have been included. Second, the repository would remain open for at least 100 years following initial waste emplacement and would have the capability to be kept open, with appropriate maintenance and monitoring, for up to 300 years. Costs are included in this analysis for 100 years of monitoring. Third, unlike the 1995 TSLCC analysis that relied heavily on the use of Multi-Purpose Canisters, this analysis provides the capability to dispose of a wide range of canistered and uncanistered SNF, as well as HLW.

The TSLCC analysis provides the basis for assessment of the adequacy of the Nuclear Waste Fund Fee as required by the NWPA. The *Nuclear Waste Fund Fee Adequacy: An Assessment* [DOE/RW-0509] is published as a separate report and is available on the Office of Civilian Radioactive Waste Management's Home Page [http://www.rw.doe.gov]. In addition, this TSLCC is the basis for the calculation of the Government's share of disposal costs for DOE-owned and managed SNF and HLW. The cost estimates in this TSLCC reflect the Department's best estimates – given the scope of the work identified and planned schedule of required activities. Future budget requests for the Program have yet to be established, and in any event, will be determined through the annual Executive and Congressional budget process.

Sincerely,

Lake H. Barrett, Acting Director
Office of Civilian Radioactive
Waste Management

Dated: December 1998

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1. INTRODUCTION AND SUMMARY

1.1 PURPOSE AND SCOPE

This report documents the findings of a comprehensive analysis of the Total System Life Cycle Cost (TSLCC) of one concept for the Civilian Radioactive Waste Management System (CRWMS). This estimate is consistent with the *Viability Assessment of a Repository at Yucca Mountain* (VA) design basis and cost estimate (DOE 1998c), extended to address total system costs for all waste planned for disposal in a geologic repository for the total system life cycle. Its purpose is to provide a cost estimate that aids in financial planning, to provide policy makers information for determining the course of the program, and to provide input to the fee adequacy analysis (DOE 1998b). The concept is based on the program's most current plans, strategies, and policies (DOE 1998a). However, since this estimate spans over 100 years, the concept should be viewed as representative of the waste management system that will ultimately be developed.

This TSLCC analysis was developed as a companion document to the VA (DOE 1998c). The VA draws on what the U.S. Department of Energy (DOE) (referred to as the Department) waste management program has learned over 15 years of scientific investigation and design work at Yucca Mountain. The VA, the first comprehensive description of the repository, demonstrates how it is expected to safely contain waste in its geologic setting at Yucca Mountain. The TSLCC estimate is based on acceptance and disposal of approximately 86,300 metric tons of heavy metal (MTHM) of commercial spent nuclear fuel (SNF), including mixed oxide (MOX) fuel. The estimate is also based on 2,570 MTHM of government-managed SNF, including naval SNF, and approximately 20,000 canisters of vitrified high-level waste (HLW), including some canisters containing immobilized plutonium waste forms (IPWF) contained in HLW glass. The VA cost estimate, Volume 5, provides the cost of completing the design, licensing, construction, operations, monitoring, closure, and decommissioning of the repository. Volume 5 is based on a system limited to disposing of 70,000 MTHM, as opposed to the TSLCC which presents the cost for disposing all waste planned for disposal in a geologic repository. Volume 4 of the VA describes the plan and cost estimate for work that remains to be done to complete an application to the Nuclear Regulatory Commission (NRC) for a license to construct a repository. The TSLCC maintains consistency with the VA, using the VA assumptions, designs, and costs as a subset of the total system. A comparison between the VA and TSLCC scope is provided in Table 1, and a comparison between the VA cost estimate and the TSLCC estimate is provided in Table B-2 of Appendix B.

The reference design, as presented in the VA, was selected as the basis of this TSLCC analysis. The reference design consists of a one-repository system without interim storage. Yucca Mountain was assumed to be the location for the repository since it is the only location that the Department is authorized by law to characterize. This, however, does not constitute a pre-decision on the determination of Yucca Mountain as an acceptable site for the repository. The Department is aware that existing law prohibits emplacement in the first repository of a quantity of spent fuel containing in excess of 70,000 MTHM, until such time as a second repository is in operation. However, we do not have current cost information, designs, or authorization for a

Table 1. Comparison of Viability Assessment and Total System Life Cycle Cost Scope

Cost Element	VA Cost Estimate Scope	TSLCC Scope
Historical Costs (1983-1998)	Not Included	Included
Repository	63,000 MTHM Commercial SNF 2,333 MTHM DOE SNF 8,326 Canisters HLW 10,500 Waste Packages 24 Years of Operations Partial Repository Development and Evaluation Costs (License Application Plan FY99-02)	86,317 MTHM Commercial SNF 2,570 MTHM DOE SNF 20,004 Canisters HLW 15,706 Waste Packages 32 Years of Operations Total program and all Repository Development and Evaluation Costs
Waste Acceptance, Storage & Transportation	Not Included	Included
Nevada Transportation	Not Included	Included
Program Integration	Not Included	Included
Institutional	Not Included	Included

second repository. Therefore, consistent with the 1995 TSLCC, a one-repository system, without interim storage, has been assumed.

This TSLCC estimate should not be interpreted as a final estimate. It represents a snapshot in time based on the current reference design as presented in the VA and based on numerous assumptions presented in the *Assumptions Document for Development of Total Systems Life Cycle Cost* (CRWMS M&O 1998a). In order to perform the cost analysis, numerous assumptions were required with respect to waste management system design and operations where decisions have not yet been made. These assumptions are critical to the resulting cost estimate, and any changes in assumptions could influence the resulting estimate, either upward or downward. The program is in the early stages of development, and design concepts for items such as the repository surface facility, underground layouts, and disposal containers are preliminary. The techniques used to estimate the total system cost are appropriate to the level of design development and entail a corresponding level of uncertainty. Assumptions used in this analysis should not be interpreted as Office of Civilian Radioactive Waste Management (OCRWM) or DOE policy.

The costs in this analysis represent a preliminary estimate based on the VA design approach and the assumptions concerning development and operation of the system specified in this report. Alternative designs and approaches for implementing the repository system have been and will continue to be analyzed. These analyses have shown that there are various ways for the program to proceed on schedule with various cash flow profiles, including lower yearly funding requirements for the near-term years. Alternative implementation options include: early acceptance of waste; varying receipt rates; modular construction of the surface and underground repository facilities; varying the amount of spent fuel in lag storage; and using an approach to transportation with lower initial capital investment than the rail branch to the Yucca Mountain site assumed in current plans. Although these options can lower near-term repository cash flow profiles, they generally increase the TSLCC and vary costs to utilities for storage at their sites, depending on the rates of acceptance at the repository.

The results contained in the TSLCC analysis provide input to the Fee Adequacy Analysis (DOE 1998b) to determine whether fees being paid by commercial nuclear generating sources are sufficient to fund the program throughout its entire life cycle. This TSLCC analysis provides cost information for assessing the adequacy of the fee paid by commercial nuclear utilities to the Nuclear Waste Fund (NWF). Fee adequacy depends on data and assumptions relative to funding and revenues, interest and inflation rates, as well as annual expenditure profiles. Funding for the disposal of commercial SNF comes from the NWF, and funding for the disposal of defense high-level waste, DOE and naval SNF, and immobilized plutonium waste forms comes from the Defense Nuclear Waste Disposal appropriation. The New York State Energy Research and Development Authority also will pay the cost for disposal of HLW currently stored at West Valley.

This TSLCC analysis is organized as follows:

Section 1. INTRODUCTION AND SUMMARY: This section introduces the reader to the overall purpose and scope of this analysis, and summarizes the results and conclusions. This section also provides a brief description of the reference design and provides the approach and the assumptions utilized to perform the analysis.

Section 2. MONITORED GEOLOGIC REPOSITORY COSTS: This section discusses the repository costs included for each of six phases of the system life cycle.

Section 3. WASTE ACCEPTANCE AND TRANSPORTATION COSTS: This section discusses the costs associated with Waste Acceptance and Transportation costs for each of three phases, and for the construction of the Nevada rail.

Section 4. PROGRAM INTEGRATION COSTS: This section describes program-level activities, and discusses costs associated with those activities.

Section 5. INSTITUTIONAL COSTS: This section provides a description of Payments Equal to Taxes (PETT), Benefits, 180(c) grants, and financial assistance, and discusses costs associated with these items.

Section 6. COST SHARE ALLOCATION: This section presents the cost share allocations for life cycle costs for civilian, government-managed nuclear material, and West Valley HLW programs.

Section 7. REFERENCES: This section contains a reference list.

Appendix A: ACRONYMS: This section contains an acronym list for this report.

Appendix B: 1998 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY: This section provides a summary of the 1998 TSLCC estimate by major cost categories, with breakouts of historical, future, and contingency costs. This section also contains a table comparing the TSLCC estimate with the VA cost estimate.

Appendix C: ANNUAL COST PROFILE: This section presents the annual cost profile for the entire life cycle of the program. Profiles are provided in both table and graphic formats.

Appendix D: COST COMPARISON WITH 1995 TSLCC: This section provides a cost comparison between the 1995 TSLCC (DOE 1995b) and the results of this analysis.

1.2 SUMMARY OF RESULTS AND CONCLUSIONS

Our national strategy maintains a clear focus on the long-term objective of waste disposal in a geologic repository. The scientific study of Yucca Mountain thus far indicates that a repository can be designed and built at the site that would safely isolate spent nuclear fuel and high-level radioactive waste and protect the public and the environment for tens of thousands of years. This section summarizes the current life cycle cost estimate for OCRWM's management and disposal of the nation's spent nuclear fuel and high-level radioactive waste.

The total estimated future cost to complete the program is $36.6 billion, in constant 1998 dollars from 1999 through closure and decommissioning, assumed to be in 2116. A total of $5.9 billion was spent on the total program through Fiscal Year 1998 in year of expenditure (YOE) dollars. Table 2 provides a summary of major CRWMS cost categories. Costs are represented in terms of areas of work scope over the life of the program in Figure 1. Figure 1 represents historical costs, both in YOE and constant 1998 dollars, and all future costs in constant 1998 dollars. The program is assumed to run from its inception in 1983 through closure and decommissioning of the repository in 2116. Major program milestones are depicted along the bottom axis of Figure 1. Subsequent sections of this TSLCC analysis provide details concerning each major cost category and key assumptions related to its cost estimation. A further breakout of costs for the CRWMS is provided in Appendix B.

This TSLCC estimate is based on acceptance and disposal of about 86,300 MTHM of commercial SNF, 2,570 MTHM of government-owned SNF, and approximately 20,000 canisters of vitrified HLW. The estimate of commercial SNF assumes existing nuclear power reactors operate for their planned service life under current NRC licenses. While little additional generation of HLW is expected at DOE sites in the future, quantities of HLW canisters may vary due to uncertainties in the planned processing and vitrification of the wastes.

Near-term (1998-2002) costs reflect estimates of work scope defined in Volume 4 of the VA. Beyond the year 2002, costs reflect estimates for licensing activities, repository design, construction, operation, monitoring, closure and decommissioning, and the development and operation of a transportation system for SNF and HLW. Estimates reflect the reference design used in the VA for emplacing robust waste packages in an engineered geologic repository.

Table 2. Summary of Results (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Monitored Geologic Repository	$4,910	$20,620	$3,590	$24,210
Waste Acceptance, Storage & Transportation	$480	$5,100	$810	$5,910
Nevada Transportation	$0	$520	$270	$790
Program Integration	$1,480	$2,290	$220	$2,510
Institutional	$210	$2,590	$600	$3,190
Total	**$7,080**	**$31,120**	**$5,490**	**$36,610**

Note: The TSLCC total includes the VA cost estimates of $1.1 billion YOE from Volume 4 and $18.7 billion 1998$ from Volume 5. Historical costs total $5.9 billion YOE.

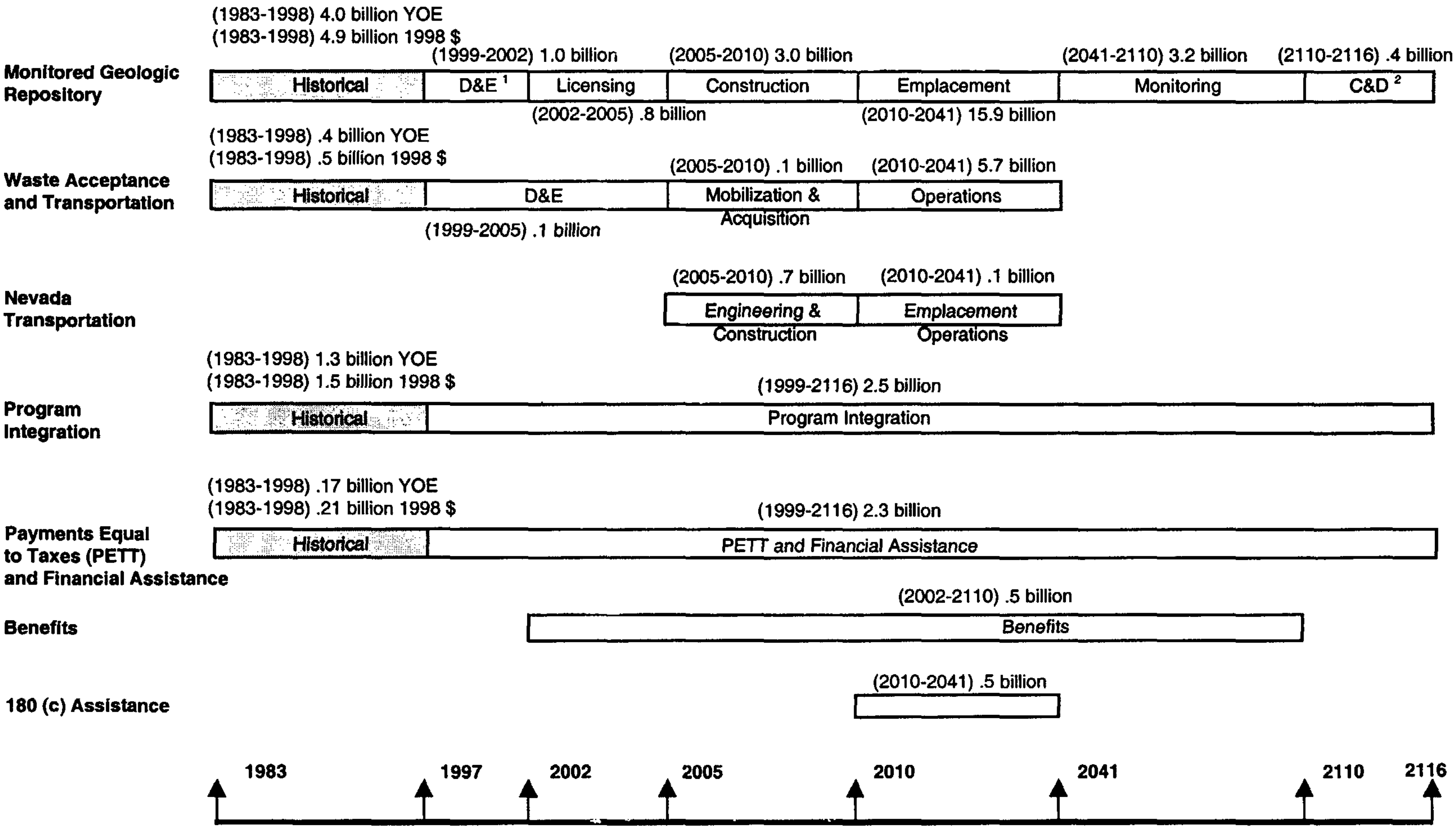
This 1998 TSLCC estimate provides a snapshot of the total system cost to implement the reference design as extrapolated to accommodate all expected amounts of SNF and HLW generated. It represents the best judgement of total costs for a scenario to satisfy the long-term objective of waste disposal in a geologic repository beginning in 2010. As a necessity, this estimate makes assumptions for decisions that have not yet been made. It assumes technical findings of site suitability, and results of technical investigations that will not be complete for several years. The assumptions utilized to develop this estimate are consistent with the VA. However, the cost volume of the VA (Volume 5) is a subset of the TSLCC because it does not account for historical costs, emplacement of all planned waste, Transportation costs, or Program Integration and Institutional costs.

1.3 SYSTEM DESCRIPTION – REFERENCE DESIGN

The VA describes the current reference design in detail. The discussion that follows provides a brief overview of the scope represented by this cost estimate. In the current reference design, radioactive waste would be transported to the repository at Yucca Mountain by truck or rail in specially designed, shielded shipping casks licensed by the NRC. At the repository, the waste will be removed from the shipping casks and placed in long-lived waste packages for disposal; carried into the underground repository by special rail cars; placed on supports in emplacement drifts; and potentially monitored for up to 300 years before the repository is finally closed. This estimate assumes the repository is monitored for 100 years after the start of emplacement. Figure 2 illustrates the reference design system and assumed time phasing for system implementation.

1.3.1 Surface Facilities

Surface facilities are designed to receive the waste and prepare it for final disposal, and to support the excavation, construction, loading, and ventilation of the repository tunnels. The



1983 - President signed NWPA and OCRWM established.
1997 - End of Historical Period.
1998 - Viability Assessment sent to Congress.
2000 - Environmental Impact Statement finalized.
2001 - Site Recommendation decision.
2002 - License Application submitted to the NRC.
2005 - Construction authorization received from the NRC.
2010 - Acceptance and emplacement begins.
2041 - Emplacement completed. Monitoring begins.
2110 - Closure and Decommissioning begins.
2116 - End of Program

[1] Development and Evaluation
[2] Closure and Decommissioning

Figure 1. Time-Phased Cost Summary in Constant 1998 Dollars

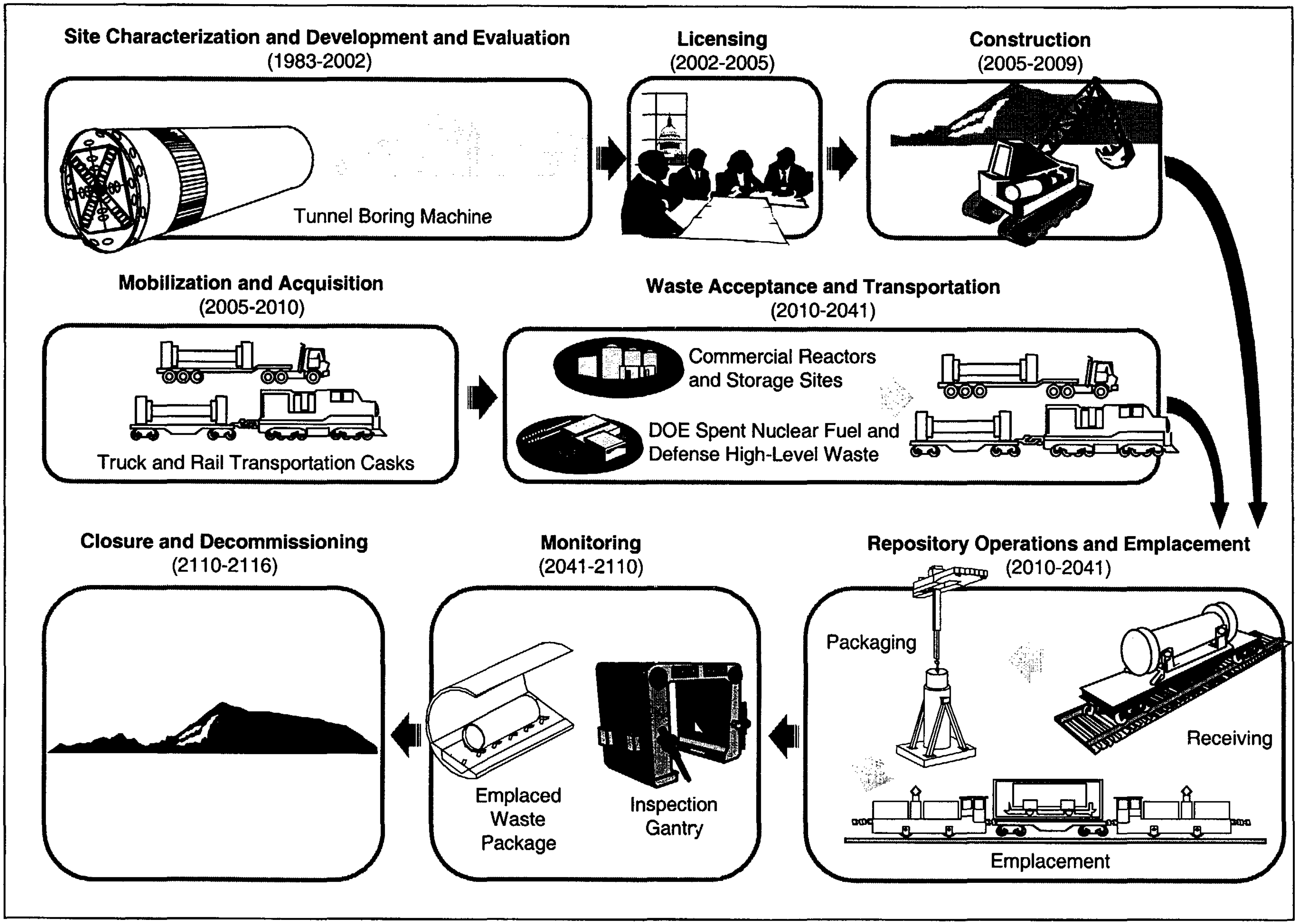


Figure 2. Radioactive Waste Management System Implementation

entire surface layout would cover approximately 100 acres. The main area, shown in Figure 3, would be located at the north entrance to the underground repository. This area would contain the facilities and equipment to remove waste from shipping containers, put it in disposal containers, and place the waste packages on special rail cars for transport underground. A second area, located at the south entrance, would accommodate the facilities to support the excavation and construction of underground tunnels. Facilities that house the air intake and exhaust fans for ventilating the tunnels would be in different areas near the top of the mountain.

Operationally, waste would arrive at the repository by truck or rail in shielded shipping casks licensed by the NRC. The casks would be inspected in the carrier preparation building before being moved to the waste handling building. In the waste handling building, the waste would be transferred to disposal containers and loaded into a shielded transporter for movement underground. All workers would be shielded from exposure to radioactive waste, and all waste would be handled remotely and transported in shielded containers.

1.3.2 Subsurface Facilities

The repository subsurface would consist of approximately 110 miles of tunnels that would be lined with reinforced concrete. The main tunnels are designed for moving people, equipment, and waste packages. The ventilation tunnels are designed for moving air for workers and to cool the repository. The emplacement drifts would accommodate the waste packages. Two gently sloping access ramps and two vertical ventilation shafts would connect the underground and surface areas. Figure 4 shows the underground layout with an insert depicting engineered barriers.

Waste emplacement would begin in 2010, after construction of surface facilities, the main tunnels, ventilation system, and initial emplacement drifts. Additional drifts would be constructed while waste is being emplaced. The current VA design would accommodate 70,000 metric tons of waste, a limit imposed by the *Nuclear Waste Policy Act* (NWPA) (DOE 1995c), until a second repository is in operation, if a second repository is required. It is assumed for this cost estimate, that the first repository could be expanded to accommodate existing and expected future waste if a second repository is not required.

Figure 5 shows a notional layout for the subsurface to dispose of all waste planned for geologic disposal. Differences between the layout in Figure 5 and the VA subsurface design include a greater emplacement area and more drifts for an increase in total commercial SNF. The required emplacement area increases from 740 acres to approximately 1015 acres with nearly 25 miles of additional emplacement drifts. In order to achieve the additional area and drifting, the main northern access drift is extended approximately 2,100 feet. This results in an overall increase of 1.6 miles of additional main drifts. Emplacement operations would last 32 years instead of the 24 years planned for the VA waste quantity, and a total of approximately 15,700 waste packages would be emplaced instead of the 10,500 assumed for the VA.

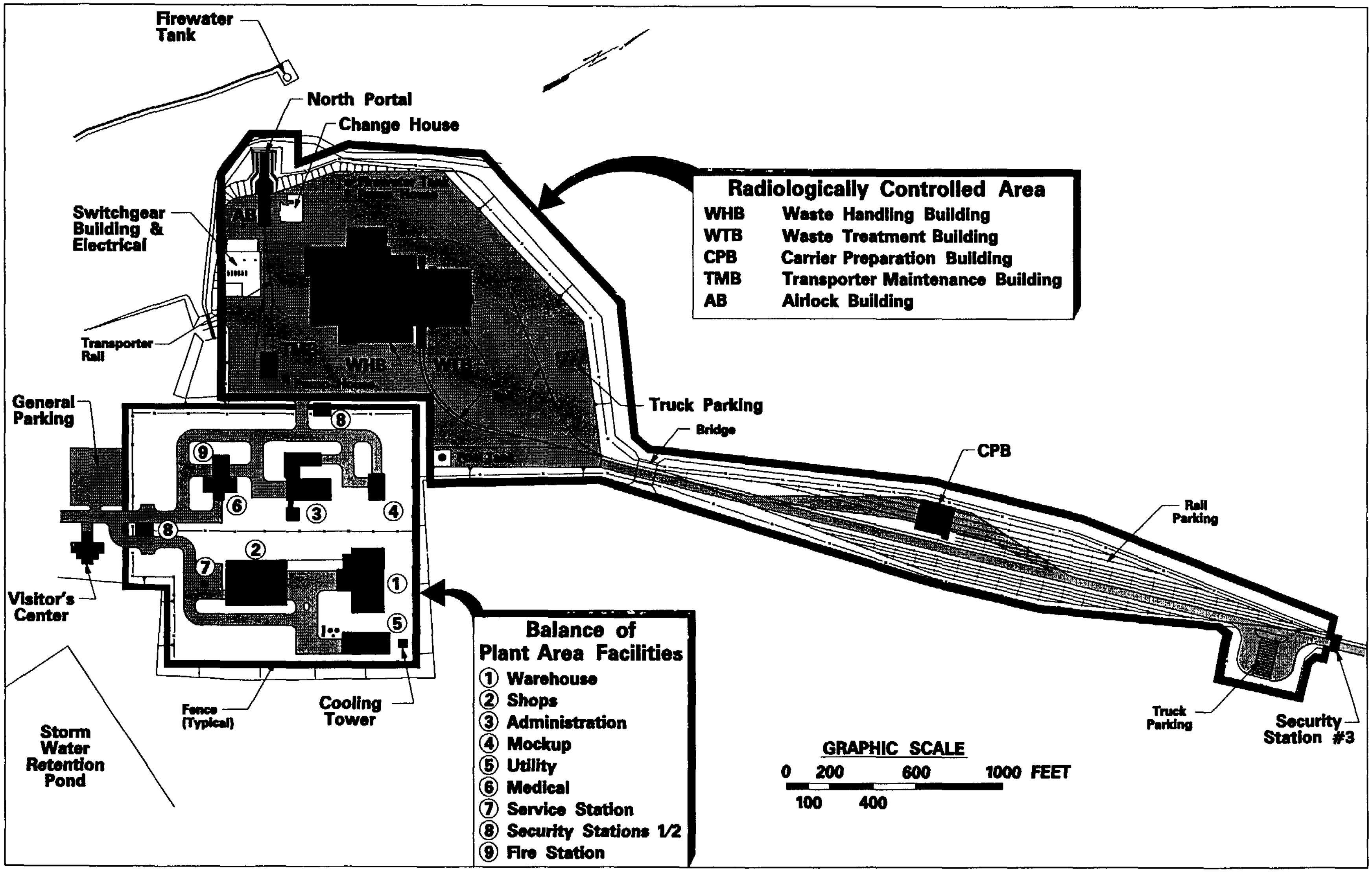


Figure 3. North Portal Surface Facilities

Figure 4. Underground Layout Shown with Engineered Barrier Cutaway

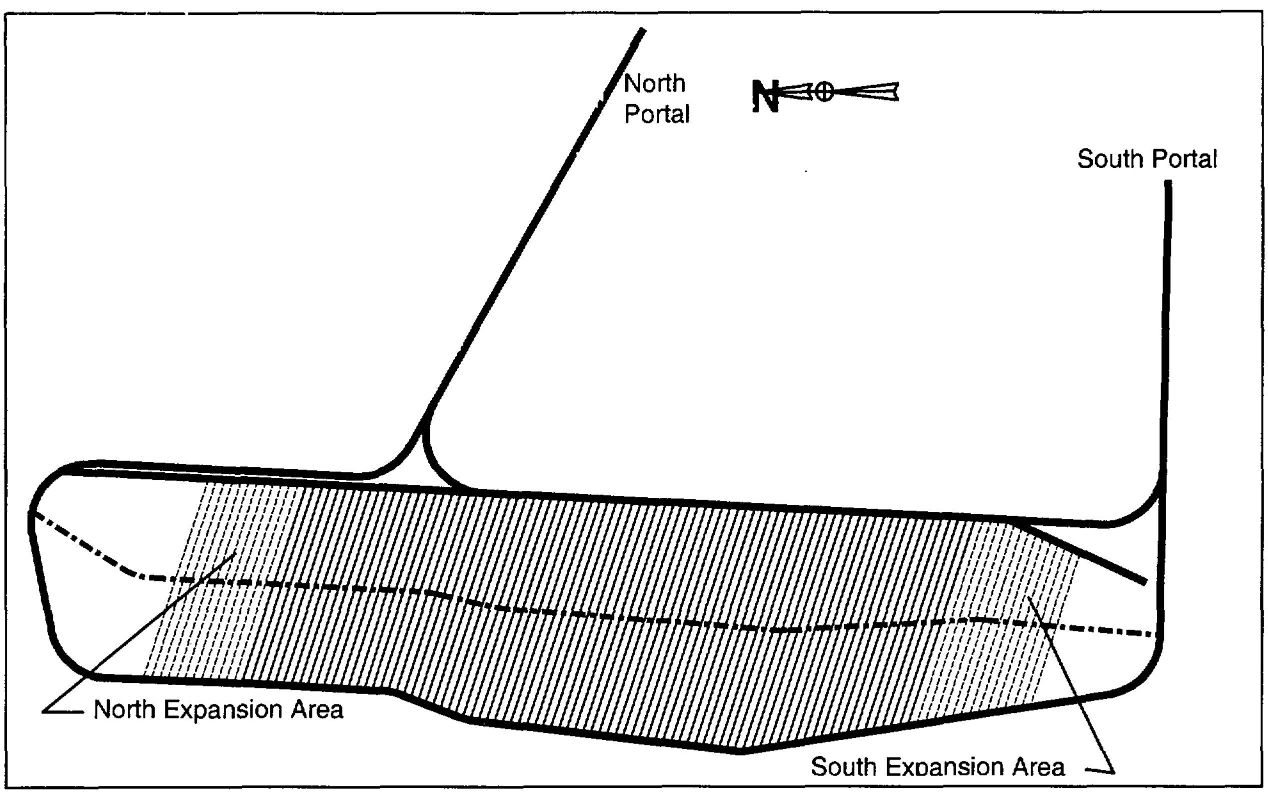


Figure 5. Notional Layout of Subsurface to Dispose of Total System Life Cycle Cost Waste Quantities

Transportation underground would be on specialized rail transporters. Locomotives would haul the shielded transporter with its waste package from the waste handling building underground to the entrance of an emplacement drift. A remotely operated gantry would lift the waste package up, carry it along the drift, and lower it onto its supports.

1.3.3 Engineered Barrier System

The engineered barrier system is designed to augment the barriers provided by the natural geologic system. The reference repository design features a robust, long-lived waste package, and includes the waste form, concrete tunnel floor (or invert), and steel and concrete support pedestals for the waste package. A typical example of a waste package is shown in Figure 6.

The waste packages would have two layers: a structurally strong outer layer of carbon steel nearly four inches thick, and a corrosion-resistant inner layer of a high nickel alloy about three-fourths of an inch thick. These two layers would work together to preserve the integrity of the waste package for thousands of years.

The waste forms inside the waste package would provide additional barriers against transport of radionuclides away from the repository. Most spent nuclear fuel includes metal cladding that is highly resistant to corrosion. Defense high-level radioactive waste would be formed into glass logs which resist corrosion. Immobilized plutonium waste forms are also resistant to corrosion.

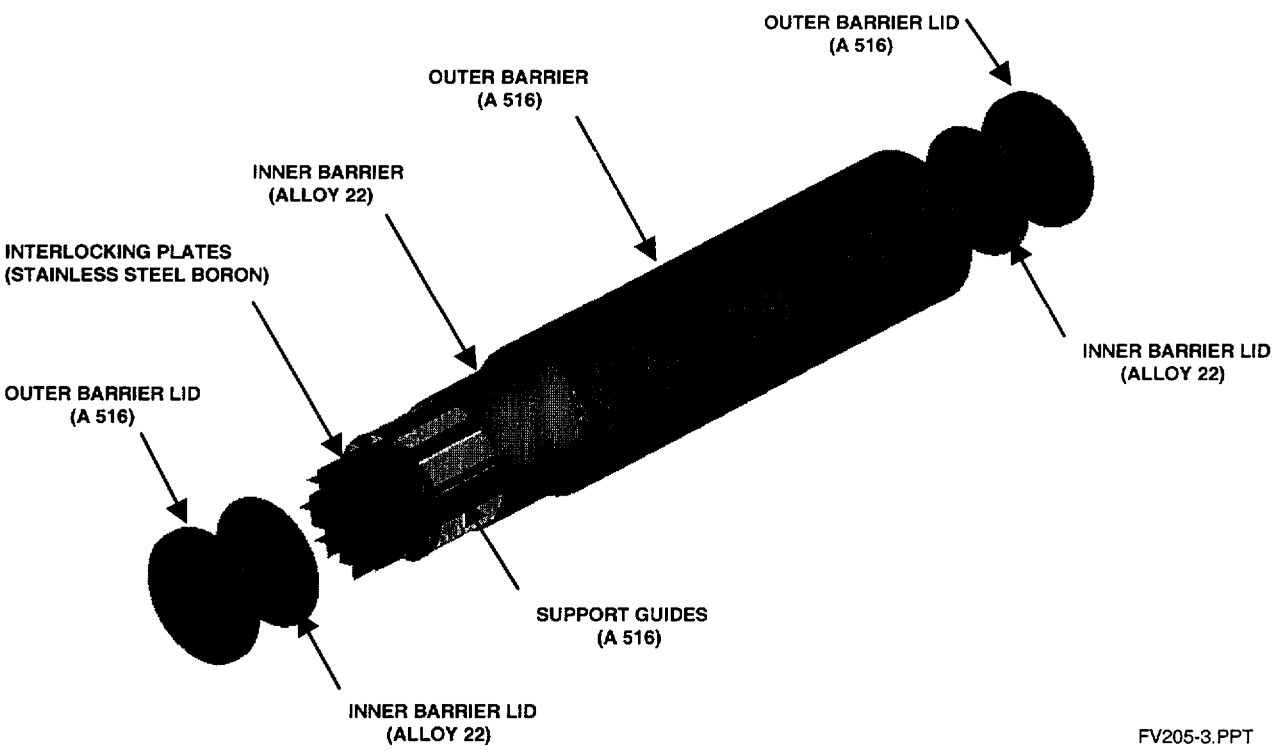


Figure 6. Waste Package for Uncanistered Fuel

Although the reference design appears to achieve the objectives of protecting workers, the public, and the environment at an acceptable cost, the design process is continuing. The Department is evaluating several options that might increase the ability of the engineered barrier system to contain waste. These include the following:

- Drip shields that would be made of non-corroding ceramic material and would add an additional layer of protection to keep water from dripping on the waste packages.
- Ceramic coating on the waste packages that would further retard corrosion.
- Backfill consisting of crushed rock or other granular material that would be placed around the waste packages in the emplacement drifts just prior to repository closure. Backfill would help protect the waste packages and drip shields. This estimate does not include costs for these design options under consideration.

1.3.4 Confirmation and Retrieval

Activities to confirm that a repository is working as expected would begin long before the first waste is emplaced. In the current site characterization phase, information concerning Yucca Mountain and the surrounding environment is being collected and compiled to provide a baseline against which to compare what happens after the repository is built and waste is emplaced. Using mathematical models based on the collected data and analyses of the engineered components, scientists are able to forecast the probable behavior of the engineered system and the effects of the repository on the Yucca Mountain environment.

When repository operations begin, remote sensors will monitor the waste packages, emplacement drifts, and surrounding rock. The monitoring data will be compared to the baseline to determine the observed effects of the repository, and the observed effects will be compared to the model predictions. These confirmation activities will determine whether the repository is performing as expected and will continue until the repository is closed and sealed.

If a problem is detected prior to closing the repository, remedial action or retrieval of the waste would be possible using remotely operated equipment. NRC currently requires that the repository be designed to allow the retrieval of waste at any time up to 50 years after waste operations begin. Any retrieval of waste would follow, in reverse order, the same steps taken in emplacing the waste and, for the most part, would use the same systems and equipment. This cost estimate does not include costs for retrieval.

After the last package is placed underground, the repository could be monitored for many decades, perhaps even centuries, to confirm that everything is performing as expected. Permanently installed sensors would monitor waste packages, emplacement drifts, and the surrounding rock, providing the data required to confirm performance. A remotely operated inspection gantry would track conditions in the waste package tunnels.

1.3.5 Repository Closing

To provide future generations the option of closing the repository or monitoring it for long periods of time, the repository could be designed so it could be kept open from 50 to 300 years after the beginning of emplacement. This analysis assumes the repository is kept open 100 years after the start of emplacement.

Permanently closing the repository would require the sealing of all shafts, ramps, exploratory boreholes, and other underground openings. These actions would discourage any human intrusion into the repository and prevent water from entering and radionuclides from escaping through these openings.

At the surface, all radiological areas would be decontaminated, all structures taken down, and all site-generated wastes and debris disposed of at approved sites. The surface area would be restored as closely as possible to its original condition. Permanent monuments would be erected around the site to warn any future generations of the presence and nature of the buried wastes.

1.4 PROGRAM ASSUMPTIONS

The TSLCC cost analysis is based on the *Assumptions Document for Development of TSLCC* (CRWMS M&O 1998a). The TSLCC Assumptions Document contains the VA cost analysis assumptions and the waste acceptance, storage and transportation cost assumptions. The VA cost estimate is a subset of the TSLCC. The TSLCC uses the VA cost assumptions, but expands on them to include additional waste above the 70,000 MTHM limit in the NWPA. The TSLCC also includes assumptions for waste acceptance and transportation, Nevada transportation, program integration, and Institutional costs.

1.5 REPOSITORY ASSUMPTIONS

This analysis assumes, for cost estimating purposes, a single repository at Yucca Mountain capable of handling all projected waste streams of SNF and HLW currently forecasted. The subsurface layout is an extrapolation of the current Yucca Mountain design described in the VA. The NWPA (DOE 1995c) specifies that the need for a second repository will be assessed between 2007 and 2010.

NRC regulations for licensing the repository (10 CFR 60) require that a geologic repository be designed for waste retrieval starting any time up to 50 years after initiation of waste emplacement operations. Compliance with these requirements means that the repository must be designed to be kept open for a number of years after the last waste has been emplaced.

Future generations will decide how long to maintain the repository in an open, monitored condition, whether to retrieve the waste, and when to permanently close the repository. To ensure future decision-makers have flexibility regarding these decisions, the Department is designing the repository with the capability to be closed as early as approximately 50 years from the initiation of waste emplacement, approximately 20 years after emplacement of the last waste package. This estimate assumes closure and decommissioning beginning 100 years after the start of emplacement. All structures will be designed so as not to preclude a future decision to extend retrievability beyond a 100-year period should future decision-makers choose to obtain additional repository performance data. Additional cost would be incurred to keep it open longer.

It is assumed that a repository draft environmental impact statement is completed for the Yucca Mountain site during 1999, the final environmental impact statement is completed in 2000, and a technical site suitability evaluation is completed in 2001. The current repository design uses an areal mass loading of waste, which is an average amount of uranium in a given area to maintain temperatures within established limits, of approximately 85 MTHM/acre. For purposes of this estimate, it is assumed that the repository will be granted a high thermal-loading license prior to emplacement operations. Variation from these milestone events and assumptions would impact the costs. Emplacement rates at the repository were assumed to be the same as the rate at which the repository receives waste. These rates are shown in Tables 3, 4, and 5.

The VA cost estimate is a subset of the TSLCC. There are three key differences between the TSLCC assumptions and the VA cost assumptions. The first difference is that the TSLCC addresses the costs for management and disposal of more wastes than the VA. The VA, Volume 5, provides an estimate of disposal costs for only 70,000 MTHM of waste, including 63,000 MTHM of commercial SNF, 2,333 MTHM of DOE SNF, and 8,326 canisters of HLW. The TSLCC includes an additional 23,317 MTHM of commercial SNF, an additional 237 MTHM of DOE SNF, and 11,678 additional canisters of HLW. The second difference is the inclusion of all waste acceptance and transportation costs for bringing the waste to the repository, program integration costs, and Institutional costs. The last difference is the inclusion of all costs from program inception in 1983 to License Application (LA) in 2002. Figure C-1 in Appendix C illustrates the relationship of total system costs to the LA plan and VA repository costs, on an annual basis.

1.6 WASTE ACCEPTANCE AND TRANSPORTATION ASSUMPTIONS

As a basis for planning, OCRWM uses the no-new-orders, end of reactor life case, referenced in the *WAST Cost Estimate Assumptions Document* (CRWMS M&O 1998d). For commercial SNF, this case does not assume additional early reactor shutdowns or service life extensions that would reduce or increase projected quantities of SNF, respectively. Commercial SNF, DOE SNF, and HLW pickup is assumed to begin in 2010. Initial acceptance rates for DOE SNF and HLW are assumed to be low until 2015. Commercial fuel pickup allocation assumes fuel is picked up from the sites with the oldest fuel first, in accordance with the Annual Capacity Report (ACR) (DOE 1995a) and agreements with the utilities. Table 3 shows the acceptance rate for commercial SNF by MTHM per year.

All commercial SNF is stored at utility sites prior to being transported to the Monitored Geologic Repository (MGR). Storage costs at utility sites are not included in this TSLCC analysis. The cost of mixed oxide SNF transportation casks and transportation from utility sites to the MGR is included in this TSLCC analysis as part of the commercial allocation. MOX SNF is assumed to be transported in a commercial 21-PWR uncanistered fuel cask containing only 9 assemblies.

Table 3. Acceptance Rates of Commercial Spent Nuclear Fuel

Year	Acceptance Rate (MTHM/year)
1999 – 2009	0
2010	400
2011	600
2012	1,200
2013	2,000
2014	3,000
2015 – 2040	3,000
2041	1,117
Total	**86,317**

DOE SNF contains many different types of fuel assemblies with varying characteristics. It is assumed that all DOE SNF arrives at the repository in disposable canisters. These canisters will contain various quantities of fuel assemblies depending upon fuel types and characteristics. Transportation casks for DOE SNF are assumed to contain from one to six disposable canisters per cask, depending upon fuel type. Details concerning canisterization of DOE SNF are pending.

The quantity of DOE SNF, presented in Table 4, was based on a DOE-furnished Integrated Database (CRWMS M&O 1998b), and was used in the development of transportation related costs. Transportation costs of DOE materials are included in the TSLCC analysis, with the assumption that transportation is to be via general rail freight. Development and procurement of transportation casks for DOE SNF are not part of the CRWMS as these casks will be designed and purchased by the Department without funds from the NWF. Therefore, these costs are excluded from the TSLCC estimate. Prior to acceptance into the transportation system, DOE SNF is placed in canisters at the DOE facilities managing the nuclear material. The costs for transportation of naval SNF are not included in the TSLCC. The U.S. Navy will provide transportation of naval SNF to the MGR. Table 4 shows the acceptance rate for DOE SNF by number of canisters per year.

Table 4. Acceptance Rates of Department of Energy Spent Nuclear Fuel

Year	Acceptance (canisters)
2010	1
2011	1
2012	3
2013	6
2014	8
2015	109
2016	150
2017	116
2018	206
2019	172
2020	200
2021	204
2022	144
2023	141
2024	161
2025	232
2026	237
2027	229
2028	236
2029	253
2030	250
2031	253
2032	248
2033	138
2034	100
2035	59
Total	**3,857**

HLW included in the TSLCC analysis is based on projections of vitrified tank wastes from Hanford, Savannah River Site (SRS), Idaho National Engineering & Environmental Laboratory (INEEL), and the West Valley (WV) Demonstration Project (CRWMS M&O 1998b). Table 5 provides acceptance rates by canisters for HLW. All HLW is transported to the repository in rail transportation casks, which will be certified by the NRC. HLW rail transportation costs are based on round-trip general freight shipping charges. Costs for vitrification of HLW by the DOE facilities that manage these tasks are not included in this estimate. The costs for transportation cask design, acquisition, and transport of HLW from the DOE producer sites to the MGR are included in the total program costs. Defense HLW includes 18 metric tons of IPWF. This equals approximately 635 HLW canisters containing plutonium that are back-filled with vitrified HLW. There will be two cask designs utilized for HLW transportation. Hanford waste will be transported in casks containing nominal 15-foot canisters. The remaining waste (SRS, INEEL, and WV) will be transported in casks containing nominal 10-foot canisters. Each cask will hold five HLW canisters.

Table 5. Acceptance Rates of High-Level Waste

Year	Acceptance (Canisters)
2010 – 2014	150
2015	355
2016	376
2017 – 2018	430
2019	420
2020 – 2025	395
2026 – 2028	375
2029 – 2031	455
2032	450
2033	255
2034 – 2035	1,475
2036	1,471
2037 – 2040	1,450
2041	1,457
Total	**20,004**

The analysis assumes that 19 transportation cask designs are required, as shown in Table 6. Specifically, the assumed cask designs include 2 for commercial legal weight truck (LWT) transportation, 10 for commercial SNF rail, 5 for DOE SNF rail transportation, and 2 for HLW rail transportation. Cask design assumptions are based on the fuel type, whether for a Pressurized Water Reactor (PWR) or a Boiling Water Reactor (BWR), size, and thermal properties of all fuel assemblies expected to be transported to the repository for disposal. Currently, none of the 19 assumed transportation cask designs are NRC approved. However, sufficient time is available for vendor development and certification of transportation casks to support planned shipments in 2010. Costs for acquisition, maintenance, refurbishment, and decommissioning of transportation casks are considered in the estimate with the exception of DOE casks which will be procured and maintained separately. Contingencies on cask cost estimates are assumed to be sufficient to procure any specialty casks required to accommodate assemblies that cannot be accommodated by 1 of the 19 designs.

Table 6 provides an estimate of the size of the required transportation cask fleet. This cost estimate assumes a competitive private sector approach for the transportation of waste to the repository. This approach assumes DOE contracts with four separate Regional Servicing Contractors (RSCs), who acquire a cask fleet and provide shipping for their region. This estimate does not assume any sharing of transportation assets between regions. Actual cask fleet size will be determined upon contracting with RSCs. DOE may authorize an RSC to service up to two regions. The cost estimate assumes rail shipments are transported via general freight.

Table 6. Transportation Cask Fleet

Commercial Legal Weight Truck	Quantity
BWR – 9 assembly capacity	6
PWR – 4 assembly capacity	8
Commercial Rail	
Large – PWR 24 or 26 assembly capacity Large – BWR 61 assembly capacity	22
Medium – PWR 21 assembly capacity Medium – BWR 44 assembly capacity	21
Small – PWR 12 assembly capacity Small – BWR 24 assembly capacity	52
P-High Heat – 7 assembly capacity	4
South Texas – 12 assembly capacity	4
Yankee Rowe – 36 assembly capacity	1
Big Rock – 74 assembly capacity	1
HLW Rail	
Long (five 15-foot canisters)	14
Short (five 10-foot canisters)	12
DOE-SNF Rail	
4 canister capacity	3
3 canister capacity	4
6 canister capacity	2
5 canister capacity	1
1 canister capacity	1

1.7 COSTING APPROACH

The cost estimate makes assumptions regarding technical and policy decisions, some of which will not be made until after the Secretary of Energy issues a Site Recommendation to the President in 2001. The schedule assumes NRC authorization for construction approval in 2005, followed by NRC approval to receive and possess waste prior to the start of emplacement in 2010. Estimates reflect the reference design and do not include a centralized federal interim storage facility. Despite these necessary simplifying assumptions, the TSLCC estimate represents a reasonable projection of total program costs.

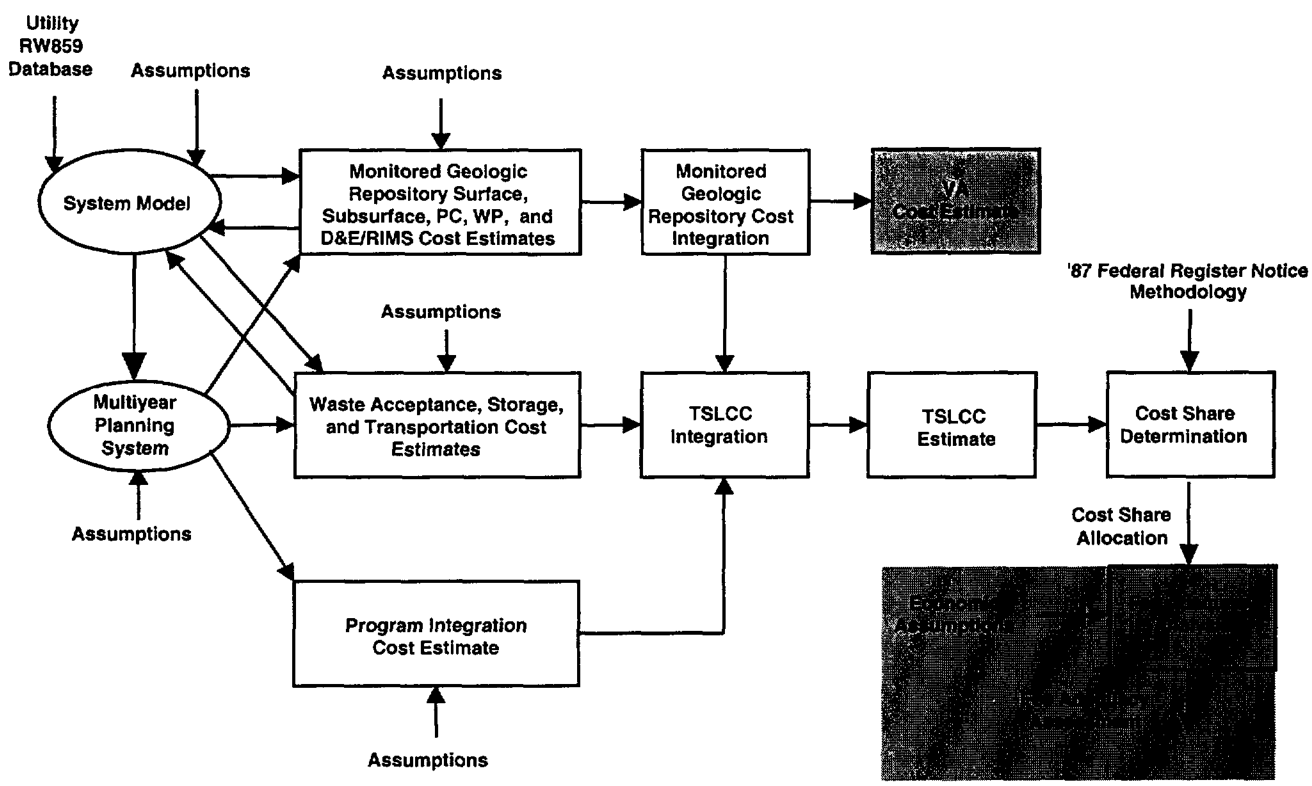
The approach for developing the TSLCC is diagramed in Figure 7. First, assumptions for the MGR, Waste Acceptance, Storage and Transportation (WAST), and Program Integration are developed and coordinated across the program. These assumptions are used in a system model for developing a life cycle waste stream, and used for updating a multi-year planning scope and cost baseline. Assumptions, a system model, and cost estimates from the multi-year planning system provide a basis for the MGR, WAST, and Program Integration cost estimates.

The MGR cost estimate is comprised of integrated costs from five scope elements:

- Surface
- Subsurface
- Performance Confirmation (PC)
- Waste Package (WP)
- Development and Evaluation (D&E)
- Regulatory, Infrastructure, and Management Support (RIMS).

The three estimates are integrated into the TSLCC cost estimate. The TSLCC estimate is used, in conjunction with the August 20, 1987 *Federal Register Notice* (52 FR 31508) methodology, to determine the civilian and defense shares of the total cost. The cost shares and economic assumptions of the future are combined to produce a Fee Adequacy Assessment (DOE 1998b).

Various cost estimating techniques were applied on the basis of design maturity. Estimates for the more mature designs were based on bottom-up estimates, while the conceptual designs with a lower maturity level utilized a factoring or parametric technique. To account for cost uncertainty of differing levels of design maturity, cost-estimating contingency factors were specifically applied to each cost element. In some cases, contingencies were varied at the cost element level, and in other cases contingencies were applied at the unit procurement item level. A breakdown of contingencies for various cost categories and elements is contained in Appendix B.



Note: The shaded areas represent work scope covered in other documents.

Figure 7. Total System Life Cycle Cost Estimate Development

All future cost estimates are presented in constant 1998 dollars for ease of comparison and to eliminate the effects of inflation for a program with a duration over 100 years. Historical sunk costs are noted in YOE dollars, and are escalated to 1998 dollars, using economic escalation indices for DOE construction projects to put all funds in constant year dollars. Estimates are rounded to the nearest $10 million, except for West Valley cost allocation estimates. Fee adequacy analyses that use data from this report address the effect of cost escalation and inflation, both on program costs and NWF revenues.

2. MONITORED GEOLOGIC REPOSITORY COSTS

The repository design considered in this analysis consists of both surface and subsurface operations and facilities. Table 7 provides, by phase, historical costs, the future costs without contingency, and the contingency costs for the repository. Detailed costs for each of the phases in Table 7 are presented in the remainder of Section 2. Figure C-1, in Appendix C, provides a TSLCC annual cost profile and a graphic annual cost comparison of the TSLCC with the LA plan cost estimate and the VA cost estimate.

Table 7. Total Repository Costs by Phase (in Millions of 1998$)

Phase	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Development & Evaluation (1983-2002)	$4,910	$990	$0	$990
Licensing (2002-2005)	$0	$670	$90	$760
Pre-Emplacement Construction (2005-2010)	$0	$2,460	$490	$2,950
Emplacement Operations (2010-2041)	$0	$13,580	$2,310	$15,890
Monitoring (2041-2110)	$0	$2,590	$630	$3,220
Closure and Decommissioning (2110-2116)	$0	$330	$70	$400
Total	**$4,910**	**$20,620**	**$3,590**	**$24,210**

Note: Historical costs are $4,030 million in YOE dollars, and 1998 historical costs are an estimate.

2.1 REPOSITORY DEVELOPMENT AND EVALUATION

The repository Development and Evaluation phase began with program inception and continues until the submittal of a license application in 2002. Repository D&E activities include all of the site characterization and preliminary design development activities associated with the repository. Previously, D&E included all program costs, except engineering and construction costs, until emplacement operations began in 2010, at which time D&E would end. For the 1998 TSLCC, the definition of repository D&E has been narrowed. Cost elements previously included in D&E, which occur after LA, are contained in a new cost element, Regulatory, Infrastructure, and Management Support.

Historical costs are divided into two categories: the costs associated with the repository at Yucca Mountain, and all other costs for site characterization activities. The other repository historical costs include technical support, the repository technology program, and the salt and basalt sites that were formerly considered for the first repository program. Future costs are projected only for a repository based upon the Yucca Mountain site. All site characterization activities at other sites have been terminated in accordance with the NWPA, Section 161. Repository D&E costs are summarized in Table 8.

Table 8. Repository Development and Evaluation Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2002)	Contingency Cost	Total Future Cost (1999-2002)
Repository D&E at Yucca Mountain	$3,210	$990	$0	$990
Other Repository D&E	$1,700	$0	$0	$0
Repository D&E Total	**$4,910**	**$990**	**$0**	**$990**

Note: Historical costs total $4,030 million in YOE dollars, and 1998 historical costs are an estimate.

2.2 LICENSING

The repository licensing phase begins with the submittal of the LA in 2002 and continues until construction authorization in 2005. This phase includes activities supporting limited procurement activities, such as acquisition of long-lead construction materials and equipment for surface and subsurface facilities. Table 9 details the costs for the licensing phase.

Table 9. Repository Licensing Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2002-2005)	Contingency Cost	Total Future Cost (2002-2005)
Surface	$120	$30	$150
Subsurface	$90	$0	$90
Waste Package Fabrication	$40	$0	$40
Performance Confirmation	$100	$30	$130
Regulatory, Infrastructure, and Management Support	$320	$30	$350
Licensing Total	**$670**	**$90**	**$760**

2.3 PRE-EMPLACEMENT CONSTRUCTION

The pre-emplacement construction phase covers the period from construction authorization in 2005 through early 2010. This phase includes costs for final procurement, construction design, and Title III designs. Construction costs are included for site preparation and construction of surface and subsurface facilities. Additionally, costs are included for startup and training. Table 10 details the costs for the pre-emplacement phase.

Table 10. Repository Pre-Emplacement Construction Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2005-2010)	Contingency Cost	Total Future Cost (2005-2010)
Surface	$900	$280	$1,180
Subsurface	$860	$120	$980
Waste Package Fabrication	$50	$0	$50
Performance Confirmation	$190	$50	$240
Regulatory, Infrastructure, and Management Support	$460	$40	$500
Pre-Emplacement Construction Total	**$2,460**	**$490**	**$2,950**

2.4 EMPLACEMENT OPERATIONS

The emplacement operations phase covers the period from 2010-2041. It includes all costs for staffing, maintenance, supplies, and utilities during waste emplacement; completing the underground facilities; and procurement of waste packages. Table 11 details the costs for the emplacement phase.

Table 11. Repository Emplacement Operations Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2010-2041)	Contingency Cost	Total Future Cost (2010-2041)
Surface	$3,790	$530	$4,320
Subsurface	$3,230	$430	$3,660
Waste Package Fabrication	$4,870	$970	$5,840
Performance Confirmation	$810	$270	$1,080
Regulatory, Infrastructure, and Management Support	$880	$110	$990
Emplacement Operations Total	**$13,580**	**$2,310**	**$15,890**

2.5 MONITORING

The monitoring operations phase covers the period from 2041-2110. It includes all costs for staffing, maintenance, supplies, and utilities during this phase. It also includes the recovery costs for specimens of waste package material which will be used for performance confirmation during this phase. Table 12 details the costs for the monitoring phase.

Table 12. Repository Monitoring Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2041-2110)	Contingency Cost	Total Future Cost (2041-2110)
Surface	$570	$230	$800
Subsurface	$950	$130	$1,080
Waste Package Fabrication	$20	$0	$20
Performance Confirmation	$680	$190	$870
Regulatory, Infrastructure, and Management Support	$370	$80	$450
Monitoring Total	**$2,590**	**$630**	**$3,220**

2.6 CLOSURE AND DECOMMISSIONING

The closure and decommissioning phase covers the period from 2110-2116. It includes all costs to permanently seal the underground repository; backfill shafts, ramps, mains, and extension drifts; dismantle surface facilities; and construct monuments. Table 13 details the costs for the closure and decommissioning phase.

Table 13. Repository Closure and Decommissioning Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2110-2116)	Contingency Cost	Total Future Cost (2110-2116)
Surface	$100	$30	$130
Subsurface	$180	$30	$210
Waste Package Fabrication	$0	$0	$0
Performance Confirmation	$0	$0	$0
Regulatory, Infrastructure, and Management Support	$50	$10	$60
Closure & Decommissioning Total	**$330**	**$70**	**$400**

The NRC currently requires that the repository be designed to allow the retrieval of waste at any time up to 50 years after waste operations begin. However, the cost for the contingency of retrieving waste packages is not included in this analysis.

3. WASTE ACCEPTANCE AND TRANSPORTATION COSTS

Waste acceptance and transportation elements of the radioactive waste management system will accept commercial spent fuel, including MOX fuel, from commercial reactors; DOE spent fuel and HLW from DOE sites; and HLW and SNF from West Valley; and will transport the materials to the repository. The operational waste acceptance element provides the interface between the CRWMS and the utilities and DOE sites to maintain contracts and agreements, verify records, verify loading and accept the waste, and maintain material control and accounting. The operational transportation element is responsible for the shipment of spent fuel and HLW to the repository. Transportation costs do not include the cost for shipping naval SNF to the repository. Under the current plan, commercial reactors will store commercial SNF on site until acceptance and transport to the repository. Table 14 summarizes all waste acceptance and transportation costs, including Nevada rail construction and operation costs.

Table 14. Summary of Waste Acceptance and Transportation Costs by Phase (in Millions of 1998$)

Phase	Historical (1983-1998)	Future Cost w/o Contingency (1999-2041)	Contingency Cost	Total Future Cost (1999-2116)
Development & Evaluation (1983-2005)	$480	$50	$0	$50
Mobilization, Acquisition, and Construction (2005-2010)	$0	$560	$280	$840
Waste Acceptance and Transportation Mobilization and Acquisition	$0	$120	$20	$140
Nevada Transportation Engineering and Construction	$0	$440	$260	$700
Operations & Acquisition (2010-2041)	$0	$5,010	$800	$5,810
Waste Acceptance and Transportation Operations and Acquisition	$0	$4,930	$790	$5,720
Nevada Transportation Operations	$0	$80	$10	$90
Total	**$480**	**$5,620**	**$1,080**	**$6,700**

Note: Historical costs total $390 million in YOE dollars, and the 1998 historical cost is an estimate.

3.1 WASTE ACCEPTANCE, STORAGE AND TRANSPORTATION DEVELOPMENT AND EVALUATION

The D&E phase for the waste acceptance and transportation elements began with program inception and will continue until the acquisition of transportation equipment begins in 2005. D&E activities include planning technical assistance for training pursuant to the NWPA, Section 180(c), establishing contracts with RSCs, establishing waste form criteria for DOE wastes, systems engineering, technology demonstration, quality assurance, and environmental safety and health activities. Costs for the storage and MPC elements were for activities that have been canceled or suspended, and additional costs are not expected in the future. Table 15 provides costs for D&E activities.

Table 15. Waste Acceptance, Storage and Transportation Development and Evaluation Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2005)	Contingency Cost	Total Future Cost (1999-2005)
Storage	$200	$0	$0	$0
National Transportation	$210	$30	$0	$30
Waste Acceptance	$20	$10	$0	$10
Multi-Purpose Canister Project	$40	$0	$0	$0
Project Management & Integration	$10	$10	$0	$10
Total	**$480**	**$50**	**$0**	**$50**

Note: Historical costs total $390 million in YOE dollars, and the 1998 historical costs are an estimate.

3.2 WASTE ACCEPTANCE AND TRANSPORTATION MOBILIZATION AND ACQUISITION

The WAST project mobilization and acquisition phase begins in 2005, and continues until acceptance operations begin in 2010. After contracts are awarded for mobilization and acquisition, the RSCs will perform the waste acceptance and transportation activities. The activities in this phase include establishing agreements with each site regarding schedule, procuring and licensing of transportation hardware, and contracting for rail and truck shipments of spent fuel to the repository. Table 16 shows the costs for the mobilization and acquisition phase.

Table 16. Waste Acceptance and Transportation Mobilization and Acquisition Costs (in Millions of 1998$)

Cost Element	Future Cost w/o Contingency (2005-2010)	Contingency Cost	Total Future Cost (2005-2010)
National Transportation	$100	$20	$120
Waste Acceptance	$10	$0	$10
Project Management & Integration	$10	$0	$10
Total	**$120**	**$20**	**$140**

3.3 WASTE ACCEPTANCE AND NATIONAL TRANSPORTATION OPERATIONS

The operations phase begins in 2010, when acceptance and transportation of spent fuel and HLW from sites to the repository starts. The operations phase concludes in 2041 when all spent fuel and HLW have been transported to the repository. During this phase, continuing acquisition of transportation hardware occurs to handle increases in throughput and transportation equipment replacement. Table 17 shows the costs for waste acceptance and national transportation during the operations phase. Costs associated with routine and emergency response technical assistance are presented in Section 5.3.

Table 17. Waste Acceptance and Transportation Acceptance Operation Costs (in Millions of 1998$)

Cost Element	**Future Cost w/o Contingency (2010-2041)**	**Contingency Cost**	**Total Future Cost (2010-2041)**
National Transportation	$4,880	$780	$5,660
Waste Acceptance	$50	$10	$60
Total	**$4,930**	**$790**	**$5,720**

The cost basis for shipping nuclear waste has been updated for this estimate (CRWMS M&O 1997). There is historical precedence that indicates that lower costs may be achievable; however, there is uncertainty regarding the ultimate shipping rates that will be effective when shipment of SNF and HLW occurs on an ongoing basis. For this estimate, some increase in costs based on a re-analysis of shipping rate uncertainty is assumed.

3.4 NEVADA TRANSPORTATION

The Nevada transportation engineering and construction phase begins in 2002 and concludes in 2010 with the start of emplacement operations. Activities include the design and construction of a branch rail line in Nevada to the repository site. Since no specific rail routing has been determined, the estimated cost is the average cost of five studied route options. An overall contingency of 60 percent was included to allow for cost estimating uncertainty (15 to 25 percent) and route uncertainty. Nevada rail transportation operations begin in 2010, and continue until the end of emplacement in 2041. Table 18 shows the Nevada transportation costs.

Table 18. Nevada Transportation Costs (in Millions of 1998$)

Cost Element	**Future Cost w/o Contingency (2002-2041)**	**Contingency Cost**	**Total Future Cost**
Engineering & Construction (2002-2009)	$440	$260	$700
Emplacement Operations (2010-2041)	$80	$10	$90
Total	**$520**	**$270**	**$790**

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4. PROGRAM INTEGRATION COSTS

Program Integration activities funded from the NWF include Quality Assurance (QA), Systems Integration and Regulatory Compliance, represented as Program Management and Integration (PM&I), and Human Resources and Administration. Program Integration activities that are outside of the Office of Civilian Radioactive Waste Management (OCRWM) budget and are funded from the NWF include NRC costs, the Nuclear Waste Technical Review Board (NWTRB), and the Nuclear Waste Negotiator (NWN) costs. Table 19 summarizes Program Integration costs.

Table 19. Program Integration Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Program Management & Administration	$1,210	$1,900	$220	$2,120
Quality Assurance	$90	$520	$60	$580
Program Management & Integration	$960	$1,140	$130	$1,270
Human Resources & Administration	$160	$240	$30	$270
Non-OCRWM NWF Costs	$270	$390	$0	$390
NRC Costs	$240	$360	$0	$360
NWTRB	$20	$30	$0	$30
NWN	$10	$0	$0	$0
Total	**$1,480**	**$2,290**	**$220**	**$2,510**

Note: Historical costs total $1,260 million in YOE dollars, and the 1998 historical costs are an estimate.

4.1 QUALITY ASSURANCE

The OCRWM program maintains a mandatory QA program to identify and ensure implementation of requirements that protect the health and safety of the public, workers, and the environment. The QA program must meet NRC requirements. Extensive development and review of technical and implementing documentation, as well as effective implementation of the requirements, will be necessary to ensure sound data and engineering, and to support eventual licensing of facilities by the NRC. Through QA audits, the QA program independently verifies that the various designs and scientific activities incorporate the necessary regulatory requirements. The QA program includes work scope related to providing QA program management advice and planning, establishing and maintaining the OCRWM QA program and implementing procedures, and conducting QA verification activities. QA activities are assumed to continue through closure and decommissioning of the repository in 2116.

4.2 PROGRAM MANAGEMENT AND INTEGRATION

Program Management and Integration activities support the Program Director in communicating program policy to key audiences internal and external to the DOE, and in articulating the rationale for strategy and plan changes to program stakeholders. Support is provided for the Program Director's interactions with Congress and the Office of Management and Budget

(OMB) during the appropriations processes. Program Management and Integration staff also support interactions with the NWTRB in its independent evaluation of the program's technical and scientific activities.

Program Management and Integration has five areas of work: Systems Engineering and Integration, Regulatory Compliance, Planning, International Waste Management Technology, and Program Control.

The cost for the salaries, travel expenditures, and overhead charges of Federal employees who support the OCRWM program, located at all sites, is included in the Program Management and Integration cost estimate.

Future PM&I costs are projected to decrease relative to historical costs for this element. There is a high integration component during the development and evaluation phase of the program. Program Integration costs are expected to decrease as the program proceeds with implementation, and will be significantly reduced during the monitoring phase.

4.3 HUMAN RESOURCES AND ADMINISTRATION

Human Resources and Administration manages a diverse set of personnel development, communication, financial, and information management programs. These include QA training for headquarters personnel, submittal of the Annual Report to Congress, management of the NWF investment portfolio, public information and education activities, administration of scholarship programs, and implementation of information management systems.

4.4 NUCLEAR REGULATORY COMMISSION COSTS

NRC costs cover that agency's operating costs for participating in the Civilian Radioactive Waste Management Program. Funds for NRC activities that support the program are appropriated separately by Congress as part of the NRC budget rather than the DOE budget. The CRWMS portion of the NRC budget is paid from the NWF. Consequently, NRC costs are included in the TSLCC analysis. NRC costs began in 1989 and are assumed to continue through closure and decommissioning of the repository in 2116.

4.5 NUCLEAR WASTE TECHNICAL REVIEW BOARD

The costs for the NWTRB cover the formation and operation of an independent establishment in the Executive branch of government. The Board, consisting of 11 members appointed by the President, evaluates the technical and scientific validity of the activities undertaken by the Secretary of Energy. Funds for the Board's activities are appropriated from the NWF. The Board's activities began in 1990 and are assumed to continue through receipt of SNF at the repository in 2010.

4.6 NUCLEAR WASTE NEGOTIATOR

The costs for the Office of the Nuclear Waste Negotiator covered the formation and operation of an independent establishment within the Executive branch of government. The Negotiator, appointed by the President, attempted to find a state or Indian tribe willing to host a Monitored Retrievable Storage (MRS) facility at a technically qualified site. The funds for these activities were appropriated from the NWF. The Negotiator's activities began in 1990 and were terminated in 1995.

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5. INSTITUTIONAL COSTS

Cost elements defined as Institutional costs cover scope that is prescribed by the NWPA, but do not affect design, construction, operations, monitoring, or closure activities of the MGR. The four cost elements detailed in this section are Payments Equal to Taxes, Benefits, 180(c) assistance, and financial assistance.

Table 20. Institutional Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Payments Equal To Taxes (PETT)	$40	$1,700	$540	$2,240
Benefits	$0	$470	$0	$470
180(c) Assistance	$0	$390	$60	$450
Financial Assistance	$170	$30	$0	$30
Total	$210	$2,590	$600	$3,190

Note: Historical costs total $180 million in YOE dollars, and the 1998 historical costs are an estimate.

5.1 PAYMENTS EQUAL TO TAXES

The NWPA authorized the Secretary of Energy to grant to affected states and units of local government an amount each fiscal year equal to the amount a state or affected unit of local government, respectively, would receive if authorized to tax DOE activities the same as commercial activities. States and units of local government are entitled to payments equal to taxes (PETT) for real property and industrial activities, including site characterization activities and development and operation of a repository. PETT payments are neither a tax nor a payment of tax, but rather a payment under the NWPA.

The commencement date for repository-related PETT eligibility was May 28, 1986, the date the President approved sites in Nevada, Texas, and Washington as candidates for site characterization. The termination date for PETT eligibility for repository-related site characterization activities at the Texas and Washington sites was December 22, 1987, the date the amended NWPA suspended site characterization at the two sites. The State of Nevada and local jurisdictions in Nevada and California remain eligible for PETT through facility decommissioning of the repository site at Yucca Mountain in 2116.

On July 27, 1994, the Director of OCRWM signed a negotiated PETT settlement agreement with Nye County, Nevada, for the tax period from May 28, 1986 through tax year 1998-1999. PETT payments to the State of Nevada and other local jurisdictions in Nevada and California for 1999 through 2116 are based on estimates provided by the Yucca Mountain Site Characterization Project Office. Assumed PETT payments average $10 million per year plus a 32 percent contingency. Annual PETT payments will depend on negotiations with local jurisdictions based on activities at the site. The results of the Nye County PETT negotiations and projections of remaining PETT payments to other affected counties in Nevada and California are summarized in Table 21.

Table 21. Payments Equal to Taxes Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Payments Equal To Taxes (PETT)	$40	$1,700	$540	$2,240

Note: Historical costs total $40 million in YOE dollars, and the 1998 historical cost is an estimate.

5.2 BENEFITS

The NWPA allows the Secretary of Energy to enter into benefits agreements with the State of Nevada or affected Indian tribes pertaining to a repository for the acceptance of HLW or SNF. The Act states that the state or Indian tribe in which the repository is located is eligible to receive annual payments commencing on the date a repository site agreement is signed, and ending with the decommissioning of the repository. In return for these benefits, the state or Indian tribe waives its rights to disapprove the recommendation of a specific site.

Annual benefits amounts are established in the NWPA. Payments made prior to the acceptance of SNF will be at the rate of $10 million per year; payments made after the receipt of SNF will be at the rate of $20 million per year. These payments are not indexed for inflation; therefore, annual payments are adjusted to constant 1998 dollars for purposes of this estimate. It is assumed, for the purposes of this estimate, that the Secretary of Energy enters into a benefits agreement with the State of Nevada in 2002. Annual payments will then be made to the state at the rate of $10 million per year from 2002 through 2009. From first spent fuel receipt at the repository in 2010, until closure of the repository in 2110, annual payments to the state will be $20 million/year. The NWPA, Section 172(a), requires that a six-member Review Panel be established to advise the Secretary on matters relating to the proposed repository, including issues relating to design, construction, operation, and decommissioning of the facilities. The Review Panel and associated costs are assumed to begin with panel selection in 2001. The benefits costs, based on the NWPA, are summarized in Table 22.

Table 22. Benefits Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2110)	Contingency Cost	Total Future Cost (1999-2110)
Benefits	$0	$470	$0	$470

5.3 180(c) ASSISTANCE

Section 180(c) of the NWPA directs OCRWM to provide resources for planning, technical assistance, and training to states and tribal lands passed through by the shipment of spent nuclear fuel. Table 23 provides an estimate of Section 180(c) assistance costs.

Table 23. 180(c) Assistance Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2041)	Contingency Cost	Total Future Cost (1999-2041)
180(c) Assistance	$0	$390	$60	$450

5.4 FINANCIAL ASSISTANCE

The program has been providing the state of Nevada, local counties, and educational institutions with financial assistance from 1983 through the present. Table 24 provides an estimate of financial assistance costs.

Table 24. Financial Assistance Costs (in Millions of 1998$)

Cost Element	Historical (1983-1998)	Future Cost w/o Contingency (1999-2116)	Contingency Cost	Total Future Cost (1999-2116)
Financial Assistance	$170	$30	$0	$30

Note: Historical costs total $140 million in YOE dollars, and the 1998 historical cost is an estimate.

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6. COST SHARE ALLOCATION

The CRWMS is funded on a full-cost recovery basis, with generators of waste funding their respective disposal costs. The allocation of estimated CRWMS costs to civilian, government-managed nuclear material (inclusive of DOE SNF and HLW), and West Valley HLW programs is shown in Table 25. The allocation is based on the methodology summarized below, as published in the August 20, 1987 *Federal Register Notice* (52 FR 31508). Table 25 aggregates costs according to *Federal Register Notice* methodology, which is a different aggregation than displayed in the other tables in this report. In Table 24, PETT, Benefits, and Nevada transportation costs are included with the repository costs. Historical second repository costs are included with the Program – Unassigned costs.

Table 25. Summary of Civilian Radioactive Waste Management System Cost Share Allocations (in Millions of 1998$)

Category	Cost Share Allocation			
	Government-Managed Nuclear Material	**West Valley**	**Civilian**	**Total**
Monitored Geologic Repository	**$8,550**	**$85**	**$24,120**	**$32,755**
Assigned	$4,490	$45	$12,670	$17,205
Unassigned	$4,060	$40	$11,450	$15,550
Allocation Percent	26.1%	0.26%	73.6%	100%
Waste Acceptance, Storage, and Transportation	**$1,260**	**$50**	**$5,470**	**$6,780**
Assigned	$1,130	$45	$4,920	$6,095
Unassigned	$130	$5	$550	$685
Allocation Percent	18.6%	0.73%	80.7%	100%
Program - Unassigned	**$1,000**	**$15**	**$3,140**	**$4,155**
Allocation Percent	24.1%	0.36%	75.6%	100.0%
Total	**$10,810**	**$150**	**$32,730**	**$43,690**
Aggregate Allocation Percent	24.7%	0.34%	74.9%	100%

Note: Totals may not add or compare with other totals due to independent rounding. West Valley percentages are displayed to an additional decimal place due to their relative magnitude.

In accordance with the *Federal Register Notice* methodology, the costs of activities carried out solely for the disposal of a specific type of waste, whether civilian or government-managed, is directly assignable to the waste generators. The remainder of the program costs is appropriately shared so that there is no cross-subsidization between waste generators, ensuring that each bears the full cost of disposal of its wastes. The *Federal Register Notice* identifies, in detail, the method to be used in estimating the disposal fees for the HLW share of total system costs.

The cost allocation is based on the concept of full-cost recovery, with sharing formulas applied to all applicable system cost components. The cost allocation decomposes system components, to a meaningful level that allows an assignment of a share methodology. For example, the costs of facilities and services carried out solely for disposal of government-managed nuclear materials, such as transportation of DOE SNF and HLW, and the fabrication of disposal containers for DOE SNF and HLW, are directly allocated to the government-managed share of the TSLCC. Common costs for facilities and services used for both commercial and government-managed nuclear materials are allocated as a percentage of the total for the shared account. The percentage used to calculate the shared cost account is called a cost-sharing factor.

The cost accounts are grouped into one of three categories: assignable direct costs, assignable common variable costs, or common unassigned costs.

Assignable direct costs are incurred solely for the disposal of DOE SNF, HLW, or commercial SNF, and are allocated in total to their respective cost share account.

Assignable common variable costs are allocated among the civilian, government-managed nuclear material, and WV shares by appropriately applying cost-sharing factors, piece count, and areal dispersion, a measure of below ground space requirements, to the specific waste generator cost accounts. Sharing costs by means of a piece count factor is based on the number of waste packages emplaced in the repositories. Sharing costs by means of areal dispersion is based on the repository disposal area required for DOE SNF, HLW, or commercial SNF disposal divided by the total required disposal area.

Common unassigned costs are the remaining costs that cannot be either directly allocated or allocated on the basis of the cost-sharing factors described above. These unassigned costs are allocated by deriving cost-sharing factors based on the ratio of assignable DOE SNF, HLW, or commercial SNF costs to the total assignable costs for the following cost categories: assignable repository costs, assignable transportation costs, or assignable D&E costs. These cost-sharing factors are then applied to the respective common unassigned cost accounts.

7. REFERENCES

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APPENDIX A

ACRONYMS

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ACRONYMS

A

ACR	Annual Capacity Report

B

BWR	Boiling Water Reactor

C

CRWMS	Civilian Radioactive Waste Management System

D

D&E	Development and Evaluation
DOE	U.S. Department of Energy

H

HLW	High-Level Waste
HQ	Headquarters

I

INEEL	Idaho National Engineering & Environmental Laboratory
IPWF	Immobilized Plutonium Waste Form

L

LA	License Application
LWT	Legal Weight Truck

M

MGR	Monitored Geologic Repository
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
MOX	Mixed-Oxide
MTHM	Metric Ton(s) of Heavy Metal

N

NRC	Nuclear Regulatory Commission
NWF	Nuclear Waste Fund
NWN	Nuclear Waste Negotiator
NWPA	Nuclear Waste Policy Act, as amended
NWTRB	Nuclear Waste Technical Review Board

O

OCRWM	Office of Civilian Radioactive Waste Management
OMB	Office of Management and Budget

P

PETT	Payments Equal to Taxes
PM&I	Project Management & Integration
PWR	Pressurized Water Reactor

Q

QA	Quality Assurance

R

RSC	Regional Servicing Contractor
RIMS	Regulatory, Infrastructure, and Management Support

S

SNF	Spent Nuclear Fuel
SRS	Savannah River Site

T

TSLCC	Total System Life Cycle Cost

V

VA	Viability Assessment

W

WA	Waste Acceptance
WAST	Waste Acceptance, Storage and Transportation
WBS	Work Breakdown Structure
WV	West Valley

Y

YOE	Year of Expenditure

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APPENDIX B

1998 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY

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1998 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY

Table B-1 provides a breakout of the 1998 TSLCC total cost estimate in constant 1998 dollars. The total estimated future cost to complete the program is $36.6 billion. A total of $5.9 billion was spent through 1998 in YOE dollars. Escalating historical expenditures to 1998 constant year dollars ($7.1 billion), plus the cost to complete of $36.6 billion, results in a total system life cycle cost estimate for the CRWMS of $43.7 billion dollars (1998$). The future cost of $36.6 billion includes $5.5 billion in contingency costs.

Contingencies have been included in the estimate to account for current design maturity and uncertainty associated with a program spanning over 120 years. The table shows the base and contingency cost components, as well as the contingency factors (percentages) applied.

Table B-2 provides a breakout of VA costs, from VA Volumes 4 and 5, relative to total system life cycle costs. The TSLCC estimate includes costs for scope elements not addressed in the VA such as historical costs, and costs for transportation and program integration. VA Volume 4 costs of $1,080 million (1998$), which was de-escalated from the $1,140 million (YOE), was distributed into four categories. The work scope in VA Volume 4 is primarily technical of which $990 million was categorized as D&E. Other work scope in VA Volume 4 contained $30 million for QA, which is categorized as Program Integration, and $60 million in Institutional payments, divided between PETT and financial assistance payments.

The $4.51 billion TSLCC increment above from the VA Volume 5 cost of $18.72 billion is due to accepting additional commercial SNF, DOE SNF, and HLW that requires 8 additional years of operation. The $1.15 billion increment to the VA $5.43 billion surface facility cost is attributed to an extra 8 years of operations at a higher throughput rate due to increased quantities of HLW. The $1.15 billion increment does not include any modifications to the surface facilities. The $1.02 billion increment to the VA $5.0 billion subsurface facility cost is attributed to an extra 8 years of operations and would include additional excavation to handle increased amounts of SNF. The subsurface layout would vary from the VA design as discussed in Section 1.3.2. The $1.89 billion increment to the VA $4.06 billion waste package fabrication cost is attributed to additional SNF. The $0.26 billion increment to the VA $2.06 billion performance confirmation cost is attributed to the addition of an observation drift and additional instrumentation. The $0.19 billion increment to the VA $2.16 billion RIMS cost is attributed to the support necessary for a longer emplacement operations period.

Table B-1. 1998 TSLCC Estimate Summary (in Millions of 1998$)

Cost Element	WBS/Cost Account	Historical (1983-1998)	Future Cost w/o Conting.	Contingency Cost	Total Cost	Contingency Percentages
Monitored Geologic Repository Costs	**1.2**	**$4,910**	**$20,620**	**$3,590**	**$29,120**	**0 - 40%**
Development & Evaluation (1983-2002) Costs		**$4,910**	**$990**	**$0**	**$5,900**	**0%**
Single Repository (MGR) (Yucca Mtn. Site)	1.2	$3,210	$990	$0	$4,200	0%
Other First Repository Characterization	NA	$1,590	$0	$0	$1,590	0%
Second Repository	2	$110	$0	$0	$110	0%
Surface Facilities		**$0**	**$5,480**	**$1,100**	**$6,580**	**14 - 40%**
Licensing		$0	$120	$30	$150	24%
Pre-Emplacement Construction		$0	$900	$280	$1,180	31%
Emplacement Operations		$0	$3,790	$530	$4,320	14%
Monitoring Operations		$0	$570	$230	$800	40%
Closure & Decommissioning		$0	$100	$30	$130	30%
Subsurface Facilities		**$0**	**$5,310**	**$710**	**$6,020**	**0 - 17%**
Licensing		$0	$90	$0	$90	0%
Pre-Emplacement Construction		$0	$860	$120	$980	14%
Emplacement Operations		$0	$3,230	$430	$3,660	13%
Monitoring Operations		$0	$950	$130	$1,080	14%
Closure & Decommissioning		$0	$180	$30	$210	17%
Waste Package Fabrication		**$0**	**$4,980**	**$970**	**$5,950**	**0 - 20%**
Licensing		$0	$40	$0	$40	0%
Pre-Emplacement Construction		$0	$50	$0	$50	0%
Emplacement Operations		$0	$4,870	$970	$5,840	20%
Monitoring Operations		$0	$20	$0	$20	0%
Closure & Decommissioning		$0	$0	$0	$0	0%
Performance Confirmation		**$0**	**$1,780**	**$540**	**$2,320**	**0 - 30%**
Licensing		$0	$100	$30	$130	30%
Pre-Emplacement Construction		$0	$190	$50	$240	26%
Emplacement Operations		$0	$810	$270	$1,080	33%
Monitoring Operations		$0	$680	$190	$870	28%
Closure & Decommissioning		$0	$0	$0	$0	0%
Regulatory, Infrastructure, & Mgmt. Services		**$0**	**$2,080**	**$270**	**$2,350**	**9 - 22%**
Licensing		$0	$320	$30	$350	9%
Pre-Emplacement Construction		$0	$460	$40	$500	9%
Emplacement Operations		$0	$880	$110	$990	13%
Monitoring Operations		$0	$370	$80	$450	22%
Closure & Decommissioning		$0	$50	$10	$60	20%
Waste Acceptance, Storage & Transportation	**3**	**$480**	**$5,100**	**$810**	**$6,390**	**0 - 20%**
Development & Evaluation (1983-2005) Costs		**$480**	**$50**	**$0**	**$530**	**0 - 10%**
Storage (no ISF Facility)		$200	$0	$0	$200	0%
Transportation		$210	$30	$0	$240	0%
Waste Acceptance		$20	$10	$0	$30	0%
MPC Project		$40	$0	$0	$40	0%
PM&I		$10	$10	$0	$20	0%
Mobilization and Acquisition (2005-2010)		**$0**	**$120**	**$20**	**$140**	**0 - 20%**
National Transportation		$0	$100	$20	$120	20%
Waste Acceptance		$0	$10	$0	$10	0%
PM&A		$0	$10	$0	$10	0%
Operations (2010-2042)		**$0**	**$4,930**	**$790**	**$5,720**	**16 - 17%**
National Transportation		$0	$4,880	$780	$5,660	16%
Waste Acceptance		$0	$50	$10	$60	20%
Nevada Transportation	**1.2**	**$0**	**$520**	**$270**	**$790**	**13 - 60%**
Engineering & Construction		$0	$440	$260	$700	60%
Operations		$0	$80	$10	$90	13%
Program Integration		**$1,480**	**$2,290**	**$220**	**$3,990**	**0 - 12%**
Program Management & Administration	**9**	**$1,210**	**$1,900**	**$220**	**$3,330**	**12%**
Quality Assurance	9.1	$90	$520	$60	$670	12%
Program Management & Integration	9.2	$960	$1,140	$130	$2,230	11%
Human Resources & Administration	9.3	$160	$240	$30	$430	13%
Non-OCRWM NWF Costs		**$270**	**$390**	**$0**	**$660**	**0%**
NRC Costs	NA	$240	$360	$0	$600	0%
NWTRB	NA	$20	$30	$0	$50	0%
NWN	NA	$10	$0	$0	$10	0%
Institutional Costs		**$210**	**$2,590**	**$600**	**$3,400**	**0 - 32%**
Payments Equal to Taxes (PETT)	1.2.10	$40	$1,700	$540	$2,280	32%
Benefits	1.2.10	$0	$470	$0	$470	0%
180 (c) Assistance	3	$0	$390	$60	$450	15%
Financial Assistance	1.2.10	$170	$30	$0	$200	0%
TOTAL CRWMS COST		**$7,080**	**$31,120**	**$5,490**	**$43,690**	

Table B-2. Comparison of Viability Assessment Cost Estimate with Total System Life Cycle Cost Estimate (in Millions of 1998$)

Cost Element	VA Cost	TSLCC Increment	TSLCC Total
Historical Costs (1983-1998)	$0	$7,080	$7,080
Repository Future Costs	$19,700	$4,510	$24,210
Development & Evaluation[1]	$990	$0	$990
Surface	$5,430	$1,150	$6,580
Subsurface	$5,000	$1,020	$6,020
Waste Package Fabrication	$4,060	$1,890	$5,950
Performance Confirmation	$2,060	$260	$2,320
Regulatory, Infrastructure, Management Support	$2,160	$190	$2,350
WAST Future Costs	$0	$5,910	$5,910
Nevada Transportation	$0	$790	$790
Program Integration Future Costs[1]	$30	$2,480	$2,510
Institutional Future Costs	$60	$3,130	$3,190
PETT[1]	$30	$2,210	$2,240
Benefits	$0	$470	$470
180(c) Assistance	$0	$450	$450
Financial Assistance[1]	$30	$0	$30
Total[2]	**$19,790**	**$23,900**	**$43,690**

1. VA Volume 4 costs of $1,080 million in constant 1998 dollars ($1,138 million YOE) have been decomposed into these 4 categories.
2. The VA Volume 5 total cost estimate is $18,716 million in constant 1998 dollars.

Note: The 1998 historical cost is an estimate.

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APPENDIX C

ANNUAL COST PROFILE

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Figure C-1 shows the annual life cycle cost profile[1] that has been decomposed into four distinct categories. The first category shows the annual historical expenditures in YOE dollars from program inception through 1998, where the 1998 expenditures are an estimate. The second category shows the annual costs for the LA plan (VA Volume 4) in 1998 dollars. The third category shows the annual costs for VA Volume 5. The fourth category shows the TSLCC estimate for 1999 through 2116 as an increment to the LA Plan and VA costs.

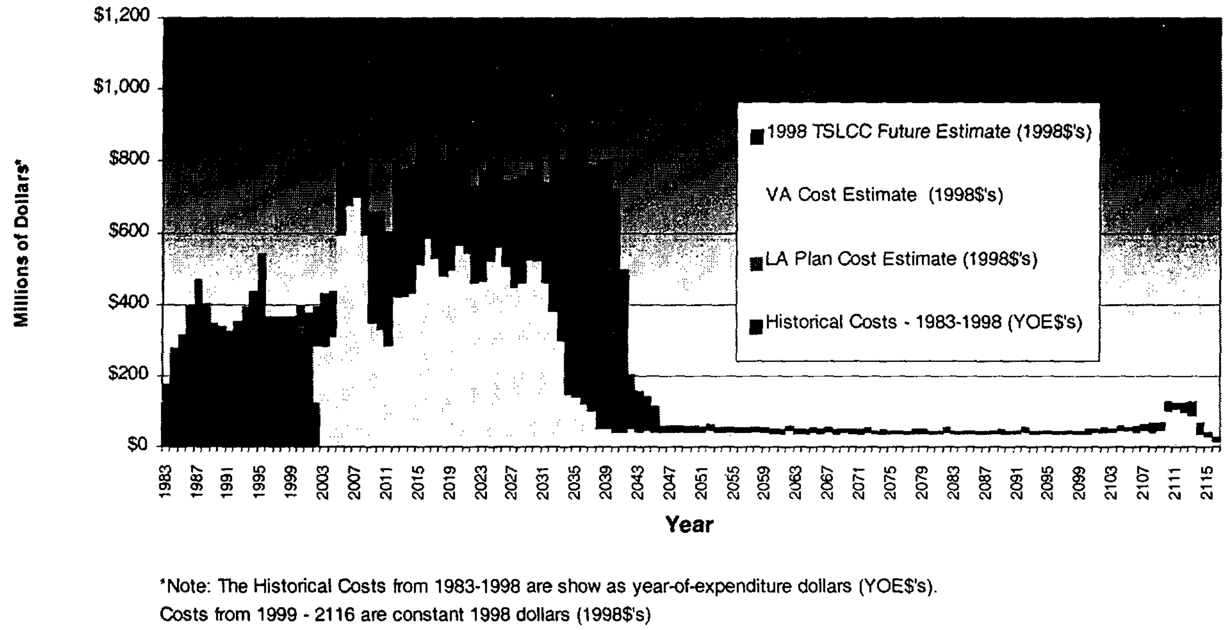

Figure C-1. Comparison of Annual Total System Costs with License Application Plan Costs and Viability Assessment Costs

[1] These cost estimates reflect DOE's best projections, given the scope of work identified and planned schedule of required activities. Future events and information could result in changes to both costs and schedules. Future budget requests for the program have yet to be established and will be determined through the annual Executive and Congressional budget process.

Table C-1. Annual Cost Profile (in Millions of 1998$)

Year	MGR	WAST[1]	PI & I[2]	Total
1983	$244	$5	$13	$263
1984	$325	$17	$55	$397
1985	$342	$25	$79	$446
1986	$441	$21	$94	$555
1987	$525	$31	$85	$641
1988	$385	$33	$110	$528
1989	$284	$41	$115	$441
1990	$240	$42	$131	$413
1991	$211	$41	$131	$383
1992	$208	$52	$148	$408
1993	$243	$47	$159	$449
1994	$288	$38	$153	$478
1995	$384	$37	$155	$576
1996	$249	$33	$97	$379
1997	$280	$9	$82	$371
1998	$275	$7	$84	$366
1999	$281	$2	$82	$366
2000	$312	$6	$92	$410
2001	$284	$5	$98	$386
2002	$273	$24	$99	$396
2003	$285	$47	$96	$429
2004	$312	$31	$91	$434
2005	$610	$70	$100	$780
2006	$760	$250	$120	$1,130
2007	$620	$130	$120	$870
2008	$590	$170	$140	$900
2009	$360	$160	$140	$660
2010	$370	$160	$140	$670
2011	$310	$170	$120	$600
2012	$470	$210	$120	$800
2013	$420	$230	$120	$770
2014	$440	$230	$120	$790
2015	$540	$230	$130	$900
2016	$560	$240	$120	$920
2017	$530	$210	$120	$860
2018	$470	$210	$120	$800
2019	$530	$210	$120	$860
2020	$550	$170	$120	$840
2021	$530	$180	$110	$820
2022	$450	$170	$110	$730
2023	$500	$160	$110	$770
2024	$540	$160	$110	$810

Year	MGR	WAST	PI & I	Total
2025	$550	$160	$110	$820
2026	$490	$160	$100	$750
2027	$490	$160	$100	$750
2028	$500	$160	$100	$760
2029	$510	$160	$100	$770
2030	$550	$160	$100	$810
2031	$480	$160	$100	$740
2032	$530	$200	$100	$830
2033	$500	$190	$100	$790
2034	$600	$190	$110	$900
2035	$570	$180	$100	$850
2036	$560	$180	$100	$840
2037	$530	$170	$100	$800
2038	$540	$160	$100	$800
2039	$540	$170	$100	$810
2040	$450	$170	$90	$710
2041	$300	$120	$80	$500
2042	$150	$20	$30	$200
2043	$130	$0	$30	$160
2044	$120	$0	$30	$150
2045	$100	$0	$20	$120
2046	$40	$0	$20	$60
2047	$50	$0	$20	$70
2048	$40	$0	$20	$60
2049	$50	$0	$10	$60
2050	$40	$0	$10	$50
2051	$40	$0	$10	$50
2052	$50	$0	$10	$60
2053	$40	$0	$10	$50
2054	$40	$0	$10	$50
2055	$40	$0	$10	$50
2056	$40	$0	$10	$50
2057	$40	$0	$10	$50
2058	$40	$0	$10	$50
2059	$40	$0	$10	$50
2060	$40	$0	$10	$50
2061	$40	$0	$10	$50
2062	$50	$0	$10	$60
2063	$40	$0	$10	$50
2064	$40	$0	$10	$50
2065	$40	$0	$10	$50
2066	$40	$0	$10	$50

Table C-1. Annual Cost Profile (in Millions of 1998$) (Continued)

Year	MGR	WAST[1]	PI & I[2]	Total
2067	$40	$0	$10	$50
2068	$40	$0	$10	$50
2069	$40	$0	$10	$50
2070	$40	$0	$10	$50
2071	$40	$0	$10	$50
2072	$40	$0	$10	$50
2073	$40	$0	$10	$50
2074	$40	$0	$10	$50
2075	$40	$0	$10	$50
2076	$40	$0	$10	$50
2077	$40	$0	$10	$50
2078	$40	$0	$10	$50
2079	$40	$0	$10	$50
2080	$40	$0	$10	$50
2081	$40	$0	$10	$50
2082	$40	$0	$10	$50
2083	$40	$0	$10	$50
2084	$40	$0	$10	$50
2085	$40	$0	$10	$50
2086	$40	$0	$10	$50
2087	$40	$0	$10	$50
2088	$40	$0	$10	$50
2089	$40	$0	$10	$50
2090	$40	$0	$10	$50
2091	$40	$0	$10	$50
2092	$40	$0	$10	$50

Year	MGR	WAST	PI & I	Total
2093	$40	$0	$10	$50
2094	$40	$0	$10	$50
2095	$40	$0	$10	$50
2096	$40	$0	$10	$50
2097	$40	$0	$10	$50
2098	$40	$0	$10	$50
2099	$40	$0	$10	$50
2100	$40	$0	$10	$50
2101	$40	$0	$10	$50
2102	$40	$0	$10	$50
2103	$40	$0	$10	$50
2104	$50	$0	$10	$60
2105	$50	$0	$10	$60
2106	$50	$0	$10	$60
2107	$50	$0	$20	$70
2108	$40	$0	$20	$60
2109	$50	$0	$20	$70
2110	$100	$0	$30	$130
2111	$100	$0	$20	$120
2112	$100	$0	$20	$120
2113	$110	$0	$20	$130
2114	$50	$0	$20	$70
2115	$30	$0	$20	$50
2116	$20	$0	$10	$30
Total[3]	29,180	7,200	7,310	43,690

1. The WAST total includes the Nevada Transportation costs.
2. The PI&I column combines the Program Integration and Institutional costs.
3. Column totals do not add exactly do to rounding.

Note 1: For TSLCC purposes, costs have been rounded to $10M dollars for the 2005 through 2116 time period. Program Integration includes non-OCRWM costs that are not part of OCRWM budget requests.

Note 2: These cost estimates reflect DOE's best projections, given the scope of work identified and planned schedule of required activities. Future events and information could result in changes to both costs and schedules. Future budget requests for the program have yet to be established and will be determined through the annual Executive and Congressional budget process.

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APPENDIX D

COMPARISON WITH 1995 TOTAL SYSTEM LIFE CYCLE COST

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COMPARISON WITH 1995 TOTAL SYSTEM LIFE CYCLE COST

This section provides a comparison of the results of the current TSLCC estimate with the last TSLCC estimate (DOE 1995b). The current estimate of $43.7 billion in constant 1998 dollars compares with the 1995 TSLCC estimate of $36.3 billion, escalated to 1998 dollars. Table D-1 provides a summary comparison of the results of the current TSLCC estimate with the 1995 TSLCC estimate. Costs from the 1995 estimate are mapped to 1998 TSLCC categories where applicable. The changes reorder the lowest level cost elements under different summary categories, and add some additional cost elements. The most significant changes redistributed elements of D&E costs, and moved the PETT, Benefits, 180(c) costs, and financial assistance costs under a new top-level cost element called Institutional costs. Explanations of differences between the two estimates are provided in subsequent sections.

D.1 SUMMARY COST COMPARISON WITH 1995 TOTAL SYSTEM LIFE CYCLE COST

Significant program changes since the 1995 TSLCC that have increased program costs include: additional waste quantities and types; updates to the repository design basis; a reanalysis of cost uncertainties associated with waste transportation; and an extended monitoring period. Additional wastes include approximately 2,570 MTHM of DOE SNF, including naval fuels; IPWF; increased quantities and sizes of HLW canisters; and increased quantities of commercial SNF. This analysis assumes disposal of approximately 86,300 MTHM of commercial SNF, an increase of approximately 2,360 MTHM over the 1995 TSLCC projection of total commercial SNF inventory.

Program changes since the last TSLCC that reduced costs include the elimination of Multi-Purpose Canister (MPC) development and acquisition, and reductions in the scope of program management, development, and site characterization efforts. However, there are offsetting cost increases with the elimination of the MPC. This significantly increases the amount of uncanistered fuel to be transported and disposed of, changes transportation technology and assumptions relating to transportation modes, and substantially changes the design of the repository surface facility and mix of repository waste packages. Reductions in program management, development, and characterization efforts reduced anticipated D&E costs.

The total system life cycle cost estimate increased by $7.4 billion in 1998 dollars, or 20 percent. The extended monitoring period, which increased from 50 to 100 years, accounts for $2.5 billion, or 34 percent of the increase. Scope changes due to increased quantities of waste account for approximately $1.1 billion 1998 dollars in directly quantifiable changes. This includes $0.7 billion in waste packages and $0.4 billion for transportation. Some additional cost increases are due to both waste quantity changes and other system changes; they are therefore not separately quantifiable. Changes from the 1995 TSLCC are shown in Table D-1. Major changes are described in the following discussion. The elimination of the MPC reduces costs by $6.2 billion for MPC development and acquisition, but results in increased costs in other cost categories. The most notable MPC-related effects are in disposal container cost increases to provide structural support for individual fuel assemblies, and in redesign of the surface facilities. Other factors, such as facility redesign for non-MPC related issues and improved design drawings and associated cost estimates, also impacted surface facility cost estimates. Surface facility increases

Table D-1. Comparison of 1998 and 1995 Total System Life Cycle Costs (in Millions of 1998$)

Cost Element	TSLCC 1995		TSLCC 1998	Delta
	1994 $	1998 $	1998 $	1998 $
Monitored Geologic Repository Costs	**$18,035**	**$19,680**	**$29,120**	**$9,440**
Development & Evaluation (1983-2002) Costs	**$8,071**	**$8,880**	**$5,900**	**($2,980)**
Single Repository (MGR) (Yucca Mountain Site)	$6,531	$7,190	$4,200	($2,990)
Other First Repository Characterization	$1,437	$1,580	$1,590	$10
Second Repository	$103	$110	$110	$0
Surface Facilities	**$3,268**	**$3,600**	**$6,580**	**$2,980**
Licensing	$0	$0	$150	$150
Pre-Emplacement Construction	$604	$670	$1,180	$510
Emplacement Operations	$2,462	$2,710	$4,320	$1,610
Monitoring Operations	$75	$80	$800	$720
Closure & Decommissioning	$127	$140	$130	($10)
Subsurface Facilities	**$2,750**	**$3,030**	**$6,020**	**$2,990**
Licensing	$0	$0	$90	$90
Pre-Emplacement Construction	$357	$400	$980	$580
Emplacement Operations	$2,017	$2,220	$3,660	$1,440
Monitoring Operations	$157	$170	$1,080	$910
Closure & Decommissioning	$219	$240	$210	($30)
Waste Package Fabrication	**$3,684**	**$4,060**	**$5,950**	**$1,890**
Licensing	$0	$0	$40	$40
Pre-Emplacement Construction	$0	$0	$50	$50
Emplacement Operations	$3,683	$4,060	$5,840	$1,780
Monitoring Operations	$1	$0	$20	$20
Closure & Decommissioning	$0	$0	$0	$0
Performance Confirmation	**$103**	**$110**	**$2,320**	**$2,210**
Licensing	$0	$0	$130	$130
Pre-Emplacement Construction	$0	$0	$240	$240
Emplacement Operations	$64	$70	$1,080	$1,010
Monitoring Operations	$39	$40	$870	$830
Closure & Decommissioning	$0	$0	$0	$0
Regulatory, Infrastructure, & Management Services	**$0**	**$0**	**$2,350**	**$2,350**
Licensing	$0	$0	$350	$350
Pre-Emplacement Construction	$0	$0	$500	$500
Emplacement Operations	$0	$0	$990	$990
Monitoring Operations	$0	$0	$450	$450
Closure & Decommissioning	$0	$0	$60	$60
Waste Acceptance, Storage & Transportation	**$9,749**	**$10,740**	**$6,390**	**($4,350)**
Development & Evaluation (1983-2005) Costs	**$1,039**	**$1,160**	**$530**	**($630)**
Storage (no ISF Facility)	$243	$270	$200	($70)
Transportation	$370	$410	$240	($170)
Waste Acceptance	$85	$100	$30	($70)
MPC Project	$141	$160	$40	($120)
PM&I	$200	$220	$20	($200)
Mobilization and Acquisition (2005-2010)	**$0**	**$0**	**$140**	**$140**
National Transportation	$0	$0	$120	$120
Waste Acceptance	$0	$0	$10	$10
PM&A	$0	$0	$10	$10
Operations (2010-2042)	**$8,710**	**$9,580**	**$5,720**	**($3,860)**
National Transportation	$1,945	$2,140	$5,660	$3,520
Waste Acceptance	$1,246	$1,370	$60	($1,310)
MPC Project	$5,519	$6,070	$0	($6,070)
Nevada Transportation	**$831**	**$920**	**$790**	**($130)**
Engineering & Construction	$711	$780	$700	($80)
Operations	$120	$140	$90	($50)
Program Integration	**$3,411**	**$3,760**	**$3,990**	**$230**
Program Management & Administration	**$2,824**	**$3,110**	**$3,330**	**$220**
Quality Assurance	$282	$310	$670	$360
Program Management & Integration	$313	$350	$2,230	$1,880
Human Resources & Administration	$2,229	$2,450	$430	($2,020)
Non-OCRWM NWF Costs	**$587**	**$650**	**$660**	**$10**
NRC Costs	$533	$590	$600	$10
NWTRB	$45	$50	$50	$0
NWN	$9	$10	$10	$0
Institutional Costs	**$1,072**	**$1,190**	**$3,400**	**$2,210**
Payments Equal to Taxes (PETT)	$308	$340	$2,280	$1,940
Benefits	$417	$460	$470	$10
180 (c) Assistance	$347	$390	$450	$60
Financial Assistance	$0	$0	$200	$200
TOTAL CRWMS COST	**$33,098**	**$36,290**	**$43,690**	**$7,400**

account for $3.0 billion, subsurface facilities $3.0 billion, and waste packages $1.9 billion. Performance confirmation costs account for $2.2 billion of the increase, and PETT estimates account for $2 billion. Transportation and waste acceptance costs increased $1.9 billion overall, due both to scope changes and changes in the estimate of costs for a given scope.

D.1.1 Extended Monitoring

The 1995 TSLCC assumed that closure and decommissioning activities would begin in 2060, 50 years after the beginning of emplacement. This 50-year duration is consistent with NRC requirements for retrievability. However, the current TSLCC estimate assumes an extended monitoring period to 2110 to allow future generations additional time to make the final decision on repository closure. The current TSLCC assumes closure and decommissioning activities take 5 years less than in the previous estimate. This extra 50 years of monitoring adds $2.5 billion in constant 1998 dollars to the total system cost. This additional cost is distributed over most elements of cost, with the exception of transportation-related costs.

D.1.2 Monitored Geologic Repository

The cost of the repository increased by $9.4 billion from the previous estimate. This estimate includes increases of $3.0 billion in surface facility costs, $3.0 billion in subsurface facility costs, $1.9 billion in waste package fabrication costs, and $2.2 billion in performance confirmation costs. There is a net decrease of $0.7 billion in the combined repository D&E and Regulatory, Infrastructure, and Management Support categories.

The $3.0 billion estimated increase for repository surface facilities results from several factors, including significant design changes since the 1995 estimate which are attributable to requirements to handle more waste forms and to increased facility robustness. The current surface facility design provides considerable flexibility to accommodate variations in the mix of waste forms that are received, and in the types and sizes of transportation casks arriving at the facility. The previous design was based on receiving and handling primarily MPCs, which required less bare fuel handling and thus a less complex facility. More detailed analysis of worker safety requirements increased the use of remote handling systems. Maturation of the design and a more rigorous cost estimating process also resulted in identification of cost increases. The operating basis was increased to three shifts, five days a week, and operating costs increased proportional to the increase in building capabilities, activities, and size.

Subsurface costs increased $3.0 billion due to additional drift excavation to accommodate additional waste packages and a decrease in assumed areal mass loading (i.e., wastes are placed further apart), and emplacement drift ground support improvements. Areal mass loading was changed from 100 MTHM/acre in the 1995 TSLCC to 85 MTHM/acre, consistent with the VA design basis. Emplacement drift ground support was increased through the use of concrete liners and inverts to improve performance and provide for extended drift accessibility. The ramps and mains will be lined with concrete to ensure long life and low maintenance for the duration of the subsurface preclosure activities. Contingency factors were reduced reflecting maturation of the subsurface design and operating experience in the Exploratory Studies Facility at Yucca Mountain.

Overall costs for waste packages increased by $1.9 billion. The increase is due to three primary factors. Changes in the system design basis from handling large quantities of disposable MPCs containing spent fuel assemblies to handling large amounts of uncanistered fuel alters the types and relative quantities of waste packages. Disposal container fabrication costs increased with the need for large quantities of disposal containers with internal basket structures to hold the fuel assemblies previously contained in MPCs. The second source of change is an increase in unit costs due to a change in inner barrier materials. The final source of change is from increased waste types and quantities. Additional waste inventory accounts for approximately $0.7 billion of the increase, with the remainder resulting from modifications in waste package mix and unit costs.

The estimate for performance confirmation increased by $2.2 billion. There was limited scope definition for this element of the program when the 1995 estimate was developed. The current design efforts for performance confirmation have identified the range of potential parameters for confirmation. The estimated cost of performance confirmation may be reduced as design proceeds and performance confirmation scope is narrowed to those parameters critical to confirmation of waste isolation performance.

The decease in the combined D&E and Regulatory, Infrastructure, and Management Support cost elements from the single D&E cost element in the 1995 TSLCC resulted from a more mature system definition, tighter integration of the MGR work scope, and shifting financial assistance to Institutional costs.

D.1.3 Waste Acceptance and Transportation

The net change in the waste acceptance and transportation cost estimate is an increase of $1.8 billion in 1998 dollars, excluding Nevada transportation and MPC changes addressed below. The cost estimate for national transportation increased $3.5 billion, but this is offset by a $1.3 billion reduction in waste acceptance scope. Approximately $0.35 billion of the increase is due to transportation costs associated with the additional waste inventory. Commercial SNF accounts for $0.1 billion, HLW for $0.09 billion, and DOE SNF for $0.18 billion, with a small reduction (approximately $0.02 billion) in West Valley transportation costs. WAST D&E decreased by $0.6 billion mostly due to scope reductions.

A number of changes in transportation models, assumptions, and data inputs were made for the 1998 TSLCC. The principal changes include an update to the rail shipping cost algorithm, the assumption that rail transportation is by general freight, the contracting of transportation services by RSCs, adjustments to the shipping modal split (sites that ship by rail or truck), and inclusion of additional hardware and security costs. In the aggregate, these changes account for an approximate increase of $1.8 billion 1998 dollars without including the decrease for MPCs. The updated rail shipping cost algorithm, based on an analysis of recent information from the railroads, is responsible for most of the cost increase.

D.1.4 Nevada Transportation

The estimate for a branch rail line in Nevada was reduced by $130 million through refinements to estimates for potential rail routes. The estimated cost is an average of five possible routes being studied. Route uncertainty is reflected in a contingency of 60 percent. DOE has no preferred route for rail access to the site.

D.1.5 Program Integration

Program Integration costs increased by $230 million. Program Integration scope reductions in the development, construction and operations timeframes are offset by increases in the estimate for quality assurance, and by the addition of costs during the extended monitoring period.

Program Integration costs were categorized as "Other D&E" in the 1995 TSLCC. For this estimate, usage of the term "Development and Evaluation" has been restricted to the program phase that includes all activities prior to licensing, construction, and acquisition. Program Management and Administration, and various non-OCRWM costs are separately identified under Program Integration for the life of the program, rather than being categorized under the D&E cost element. Repository and WAST D&E are each included with their respective scope elements in Table D-1. This usage clarifies program scope, particularly during the operations and monitoring periods.

For Yucca Mountain work scope, the D&E phase ends after the Yucca Mountain LA is submitted in 2002. For WAST scope, the D&E phase ends with the start of mobilization for national transportation in 2005, coincident with award of contracts for mobilization and acquisition. Program-level D&E scope follows the project phases.

D.1.6 Institutional Costs

PETT costs have increased by $2.0 billion in constant 1998 dollars for the 1998 TSLCC. This increase reflects two changes in estimating PETT costs from the 1995 TSLCC, and additional payment years for extending the monitoring period. For the 1998 TSLCC, Nevada state sales and use taxes previously included in estimates for surface facilities, subsurface facilities, waste package fabrication, and other cost elements, were moved to PETT. The second change was an increase in assumed PETT costs to account for increased Federal activity at the site. The 1995 TSLCC estimate for PETT payments was based on a negotiated agreement between the DOE and Nye County, Nevada that extends through tax year 1998-1999. After 1999, the 1995 TSLCC estimate assumed payments totaling $5 million in constant dollars would be paid to local Nevada jurisdictions for property taxes. For the 1998 TSLCC, base payments are assumed to be approximately $10 million per year. A 32 percent contingency has been added to address uncertainty. Actual PETT payments will depend on negotiations with local jurisdictions based on activities at the site.

The estimated cost for 180(c) assistance increased $60 million from the 1995 TSLCC. This increase resulted from a change in methodology for calculating annual outlays.

The 1998 TSLCC separately identifies as an Institutional cost $200 million for financial assistance. These costs were included in the 1995 TSLCC as part of the repository D&E cost element.

D.1.7 Multi-Purpose Canisters

The elimination of MPCs from the system resulted in a direct cost reduction of $6.2 billion in constant 1998 dollars. However, this reduction is offset by increased surface facility costs, uncanistered waste package costs, and other system impacts. The direct cost tradeoffs are not specifically quantifiable.

D.2 ASSUMPTION DIFFERENCES

The 1998 TSLCC estimate is based on assumptions that differ from those utilized in the 1995 TSLCC. Table D-2 provides a summary of differences in assumptions between the 1995 TSLCC estimate and the 1998 TSLCC estimate.

D.3 CHANGES IN COST SHARE ALLOCATIONS

Changes in program scope and in the total system life cycle cost estimate resulted in changes to the civilian and DOE cost shares. The civilian share allocation decreased from 80.2 percent to 74.9 percent, and the share for DOE SNF and HLW increased from 19.4 percent to 24.7 percent of total costs. The West Valley share was unchanged at 0.34 percent. The changes in cost shares result primarily from the addition of DOE SNF, increased DOE HLW, and the elimination of civilian share costs associated with MPCs.

Table D-2. Differences Between the 1995 and 1998 Total System Life Cycle Cost Assumptions

TOPIC	1995 TSLCC	1998 TSLCC
SNF Waste Stream		
SNF Discharge Projection	1993 RW-859 Data	1995 RW-859 Data
MGR Receipt Rate	See DOE 1995b	See Table 3, Table 4, Table 5
Waste Acceptance		
Total Amount Accepted	83,954 MTHM SNF 18,046 defense HLW canisters (5,453 SRS, 2,733 INEEL, 9,860 Hanford, WA) 300 canisters West Valley HLW	86,300 MTHM Commercial SNF 19,657 defense HLW canisters (5,390 SRS, 1,190 INEEL, 12,442 Hanford, WA, 635 Pu HLW SRS) 276 canisters West Valley HLW 71 Argonne National Laboratory (ANL) HLW 2570 MTHM DOE SNF (3,857 canisters, including 300 naval canisters)
Start Fuel Pickup	2010	2010
Last Fuel Pickup	2040	2041
Transportation		
Cask Capacities	LG Rail 21 PWR/40 BWR—SM Rail 12 PWR/24 BWR LWT 4 PWR/9 BWR HLW 5 canisters	Rail 26 PWR/61 BWR, 12 PWR/24 BWR DPCs 24/61, 21/44, 12/24 PWR/BWR LWT 4 PWR/9 BWR, various Special Casks HLW 5 canisters, DOE SNF (1 to 6 canisters)

Table D-2. Differences Between the 1995 and 1998 Total System Life Cycle Cost Assumptions (Continued)

TOPIC	1995 TSLCC	1998 TSLCC
Transportation Modal Split* * Formerly counted reactors, now count pools.	4 Reactor Pool Facilities and 4 DOE Storage Sites Ship by Commercial Truck 23 Facilities Ship by SM Rail 92 Facilities Ship by LG Rail	11 Reactor Pool Facilities and 2 DOE Storage Sites Ship by Commercial Truck 46 Pool Facilities Ship by SM Rail 43 Pool Facilities Ship by LG Rail
Cask Life (year) / Annual Utilization (days)	RX Rail 40 / 220 LWT 25 / 240 HLW 25 / 225	RX Rail 25 / 270 LWT 25 / 300 HLW 40 / 255 DOE SNF 25 / 270
Rail Shipping	Commercial SNF – Dedicated rail one-way HLW – Dedicated rail both ways	General freight for all rail shipments
Travel Speed	Truck 960 miles/day Rail Dedicated – ~20 miles/hour Rail General Freight – ~10 miles/hour	Truck 960 miles/day Rail General Freight – ~10 miles/hour
Monitored Geologic Repository		
Monitoring Phase	From end of emplacement to 50 years after the beginning of emplacement.	From end of emplacement to 100 years after the beginning of emplacement.
Closure and Decommissioning Phase	11 years	6 years
Waste Package Capacity	12 PWR/24 BWR 21 PWR/40 BWR (MPC or Waste Package) 4 HLW	12 PWR/24 BWR 21 PWR/44 BWR (Waste Package) 5 HLW including IPWF 5 HLW co-disposed with1 DOE SNF DOE SNF various
Emplacement Method	Large in-drift Waste Packages	Large in-drift Waste Packages
Cask Maintenance Facility	Integrated with Repository Facilities	Limited maintenance Integrated with Repository Facilities; Responsibility of RSCs
Number of Cask Shipments	From Reactor Rail (large) 5,567 PWR/3,206 BWR From Reactor Rail (small) 1,015 PWR/1,712 BWR From Reactor Truck 1,207 PWR/3 BWR HLW 3,670	From Reactor Rail (Uncanistered fuel) 5,616 From Reactor Rail (DPC) 5,425 From Reactor Truck 3,037 HLW 4,003 DOE SNF 1,252
PETT Estimate Included	Yes	Yes
Benefits	Repository payments from 2001 to 2071	Repository payments from 2002 to 2116
Review Panel	From 2000-2015	From 2000-2116
Program Integration (Other CRWMS D&E) Contingency	From 2001-2015	From 2010-2116
Number of Waste Packages	Large - 5,567 PWR/3,206 BWR Small - 1,015 PWR/1,712 BWR 209 PWR/1 BWR (Waste Packages) 4,600 HLW 16,310 Total	Large - 5,723 PWR/3,734 BWR (includes 73 MOX) Small - 854 PWR/144 BWR 2,652 HLW including IPWF 1,349 HLW codisposed with DOE SNF 1,250 DOE SNF 15,706 Total

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