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Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, Fiscal Year 2007

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EXECUTIVE SUMMARY

The *Analysis of the Total System Life Cycle Cost (TSLCC) of the Civilian Radioactive Waste Management Program* presents the Office of Civilian Radioactive Waste Management's (OCRWM) May 2007 total system cost estimate for the disposal of the Nation's spent nuclear fuel (SNF) and high-level radioactive waste (HLW). The TSLCC analysis provides a basis for assessing the adequacy of the Nuclear Waste Fund (NWF) Fee as required by Section 302 of the Nuclear Waste Policy Act of 1982 (NWPA), as amended. In addition, the TSLCC analysis provides a basis for the calculation of the Government's share of disposal costs for government-owned and managed SNF and HLW. The TSLCC estimate includes both historical costs and costs projected through decommissioning of the Yucca MountFain Repository in 2133. This estimate updates the last published TSLCC, which was released in 2001. The 2001 estimate was reported in constant 2000 dollars and this estimate is in 2007 dollars. To provide comparison, summary level charts within the 2007 TSLCC are stated in both 2000 and 2007 dollars.

The TSLCC spans the period of 1983 to the assumed closure date of 2133, and totals $96.18 billion in constant 2007 dollars, as reflected in Table ES-1. For comparison purposes to the 2001 TSLCC, Table ES-2 states the 2007 TSLCC estimate as $79.34 billion in constant 2000 dollars. The difference of $16.84 billion is due to inflation from 2000 to 2007. Tables ES-3 and ES-4 summarize the 2001 TSLCC estimate in constant 2007 and 2000 dollars, respectively.

Assumptions used for the development of the 2007 TSLCC estimate were a snapshot in time, and program plans will continue to evolve. The schedules identified in this report are assumed for cost estimating purposes and reflect the previously assumed start of operations date of 2017. All of the schedules outlined in this estimate are currently being reevaluated and revised assumptions will be used in future cost estimates.

The TSLCC estimate is based on the acceptance, transport and permanent disposal in the Yucca Mountain Repository (Repository) of all currently projected civilian and defense wastes, estimated to be 122,100 Metric Tons Heavy Metal (MTHM) of SNF and HLW. The estimated total of civilian SNF is 109,300 MTHM, based on data that includes discharge projections from the 47 reactor license extensions granted by the Nuclear Regulatory Commission (NRC) as of January 2007. Any discharge from potential new reactors is not assumed. As more utilities receive reactor license extensions and additional reactors are built, the discharge projections will increase and be reflected in future TSLCC estimates. It is assumed that the Civilian Radioactive Waste Management Program (the Program) will dispose of the full inventory of approximately 12,800 MTHM of government-owned SNF and HLW.

The NWPA, as amended, set a statutory limit of 70,000 MTHM for the amount of SNF and HLW that can be emplaced in the first geologic repository before a second repository is in operation. The Administration has proposed legislation that would remove the current 70,000 MTHM statutory limit, and a recommendation on the need for a second repository will be issued in 2008. However, current cost information, designs, or authorization for a second repository do not exist. Therefore, for purposes of this cost estimate, a one-repository system, containing all waste, is assumed.

For the purposes of analyzing the cost changes between the 2001 and 2007 TSLCC estimates, the U.S. Department of Energy (DOE) used a recommendation made in the U.S. Government Accountability Office (GAO) Report GAO-05-182, "Defense Acquisitions: Information for Congress on Performance of Major Programs Can Be More Complete, Timely, and Accessible," March 2005. GAO recommended measuring change in the same year constant dollars because that removes the effects of inflation, which are beyond the control of individual programs, and measures real program cost growth. Additionally, showing cost variances in unit costs eliminates from the analysis the impacts of the growth in waste quantities requiring disposal (increased scope).

Table ES-1. Summary of the 2007 TSLCC Estimate – 2007 Dollars (in Millions of 2007$)

Cost Element	Historical Costs (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Repository	9,910	54,820	64,730
Transportation	780	19,480	20,250
Balance of Program	2,860	8,340	11,200
Total	**13,540**	**82,640**	**96,180**

NOTE: Row and column totals may not add due to rounding.

Table ES-2. Summary of the 2007 TSLCC Estimate – 2000 Dollars (in Millions of 2000$)

Cost Element	Historical Costs (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Repository	8,170	45,220	53,390
Transportation	640	16,070	16,710
Balance of Program	2,360	6,880	9,240
Total	**11,170**	**68,170**	**79,340**

NOTE: Row and column totals may not add due to rounding.

	2007 TSLCC Total Cost	2007 TSLCC MHTM	2007 TSLCC Cost/MTHM
Cost per MTHM (in 2000$)	$79,340	122,100	$0.650

Table ES-3. Summary of the 2001 TSLCC Estimate – 2007 Dollars (in Millions of 2007$)

Cost Element	Historical Costs (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Repository	8,170	43,810	51,980
Transportation	580	8,100	8,680
Balance of Program	2,250	6,810	9,070
Total	**11,000**	**58,720**	**69,730**

NOTE: Row and column totals may not add due to rounding. Historical costs are assumed to be Development and Evaluation costs for the 2001 TSLCC Estimate, see Table A-1.

Table ES-4. Summary of the 2001 TSLCC Estimate – 2000 Dollars (in Millions of 2000$)

Cost Element	Historical Costs (1983 – 2002)	Future Costs (2003 – 2119)	Total Costs (1983 – 2119)
Repository	6,740	36,140	42,880
Transportation	480	6,680	7,160
Balance of Program	1,860	5,620	7,480
Total	**9,080**	**48,440**	**57,520**

NOTE: Row and column totals may not add due to rounding. Historical costs are assumed to be Development and Evaluation costs for the 2001 TSLCC Estimate, see Table A-1.

	2001 TSLCC Total Cost	2001 TSLCC MHTM	2001 TSLCC Cost/MTHM
Cost per MTHM (in 2000$)	$57,520	97,000	$0.593

Tables ES-2 and ES-4 show that, excluding inflation, the unit cost per metric ton for disposal has increased by approximately 10% between the 2001 and 2007 TSLCC estimates.

Summary of Appendix A, Comparison of the 2007 and 2001 TSLCC Estimates

The 2007 TSLCC estimate represents a 38 percent cost increase (in constant dollars) from the comparable May 2001 TSLCC estimate, entitled *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, DOE/RW-0533*. The primary driver for the cost increase is the 26 percent increase in waste quantity (from 97,000 MTHM in FY2001 to 122,100 MTHM in FY2007). The larger quantity of MTHM captured in the 2007 TSLCC directly affects the duration or quantity of various key elements, resulting in cost increases. For example, the waste transportation period is extended by 16 years and the emplacement period by 25 years, there is an 18 percent increase in required waste packages, and there is a 35 percent increase in Transportation shipments.

The secondary cost driver is the further refinement and specificity in system designs since the 2001 estimate. For example, the 2001 TSLCC rail line estimate was an average of the multiple routes being considered at the time. Subsequently, the Department decided to study possible rail alignments in only two corridors, the Caliente and Mina Corridors. For budget projection purposes, detailed cost estimates have been provided based on costs associated with the Caliente

Corridor, since projected costs for the Caliente Corridor exceed those for the Mina Corridor. As a second example, more engineering design details for the surface facilities are now available than were available in 2001. In 2005, the Program adopted a canister-based system design which simplified design and operational requirements at the repository surface facilities, providing greater confidence in the licensing and construction of the surface facilities. The canister-based system saves significant construction and operational costs, but the costs for purchasing the canisters offset some of these savings.

Appendix A contains a detailed analysis of the cost and assumption changes between the 2001 and 2007 TSLCC estimates.

Commercial/Defense Share

The TSLCC estimate is used as the basis for the calculation of the Government's share of disposal costs for Department of Energy (DOE)-owned and managed SNF and HLW. The Program is funded on a full-cost recovery basis, with generators of waste funding their respective disposal costs. The cost allocation is based on the methodology published in the August 20, 1987, *Federal Register Notice* (52 FR 31508). The 2007 calculation indicates that approximately 80 percent (i.e., 80.4 percent) of the costs are due to the disposal of commercial SNF and HLW and are to be paid from the NWF. The Government is expected to make annual appropriations to pay for approximately 20 percent (i.e., 19.6 percent) of the Program's cost for disposal of Government wastes. This is a change from the 2001 TSLCC, where the commercial/defense share was approximately 73 percent commercial and 27 percent defense. The change in the percentage is primarily due to the increase in commercial SNF and HLW assumed to be brought into the system, while the defense SNF and HLW has remained relatively constant.

CONTENTS

Page

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FIGURES

Page

TABLES

Page

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ACRONYMS

AULG	Affected Units of Local Government
BWR	Boiling Water Reactor
CA	Construction Authorization
CFR	Code of Federal Regulations
CMF	Cask Maintenance Facility
CRCF	Canister Receipt and Closure Facility
CRD	Civilian Radioactive Waste Management System Requirements Document
CRWMS	Civilian Radioactive Waste Management System
CSNF	Commercial Spent Nuclear Fuel
DOE	U.S. Department of Energy
DPC	Dual-Purpose Canister
EIS	Environmental Impact Statement
EM	Office of Environmental Management
EPC	Engineer, Procure, and Construct
FOC	Full Operating Capability
FY	Fiscal Year
GAO	U.S. Government Accountability Office
GROA	Geologic Repository Operations Area
HH	Heavy Haul
HLW	High-Level Radioactive Waste
IHF	Initial Handling Facility
IOC	Initial Operating Capability
IPWF	Immobilized Plutonium Waste Form
LA	License Application
LWT	Legal Weight Truck
MCO	Multicanister Overpack
MR	Management Reserve
MTHM	Metric Ton(s) of Heavy Metal

ACRONYMS (Continued)

NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NRL	Nevada Rail Line
NWPA	Nuclear Waste Policy Act of 1982
NWF	Nuclear Waste Fund
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management
PETT	Payments Equal To Taxes
PWR	Pressurized Water Reactor
QA	Quality Assurance
REMY	Rail Equipment Maintenance Yard
RF	Receipt Facility
RSC	Regional Servicing Contractor
SNF	Spent Nuclear Fuel
TAD	Transportation, Aging, and Disposal
TEV	Transport and Emplacement Vehicle
TSLCC	Total System Life Cycle Cost
UCF	Uncanistered Fuel
WHF	Wet Handling Facility
WVDP	West Valley Demonstration Project
YOE	Year of Expenditure

1. INTRODUCTION

The Analysis of the Total System Life Cycle Cost (TSLCC) of the Civilian Radioactive Waste Management Program presents the Office of Civilian Radioactive Waste Management's (OCRWM) most recent total system cost estimate for disposal of the Nation's spent nuclear fuel (SNF) and high-level radioactive waste (HLW). The TSLCC analysis provides the basis for assessing the adequacy of the Nuclear Waste Fund Fee as required by the Nuclear Waste Policy Act (NWPA), as amended. In addition, the TSLCC analysis is the basis for the calculation of the Government's share of disposal costs for DOE-owned and managed SNF and HLW, and Naval SNF. This TSLCC estimate includes both historical costs and costs projected through the assumed decommissioning date of 2133 for a single permanent repository at Yucca Mountain. The cost estimates in the TSLCC analysis reflect the Department's best estimates – given the scope of the work identified and the planned schedule of required activities.

The design and emplacement concepts for the system used to develop the cost estimate are based on the canister-based system described in the *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, (DOE 2007, DOE/EIS-0250F-S1D). The canister-based system design will be used for the License Application (LA) to be submitted by the Department to the Nuclear Regulatory Commission (NRC) for authorization to construct the Repository. The design will continue to develop as more information becomes available and the engineering design progresses.

This TSLCC estimate is an update to the May 2001 *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program*, DOE/RW-0533, previously published by the Department. The update from the 2001 TSLCC estimate includes a 26 percent increase in the quantities of SNF and HLW entering the repository system, changes in design, refinements in cost estimates, and updates to unit costs for materials. The assumed waste stream for this estimate is 122,100 metric tons (MTHM) of defense SNF, defense and commercial HLW, and current and projected discharges of SNF from commercial utilities, including future discharges from 47 reactors that had received operating license extensions as of January 2007.

Assumptions used for the development of the 2007 TSLCC estimate were a snapshot in time, and program plans will continue to evolve. The schedules identified in this report are assumed for cost estimating purposes and reflect the previously assumed start of operations date of 2017. All of the schedules outlined in this estimate are currently being reevaluated and revised assumptions will be used in the next issues of future cost estimates.

The revised total life cycle cost estimate is $96.18 billion in constant 2007 dollars. Historical costs for the period from 1983 through the end of 2006 are $13.54 billion in constant 2007 dollars. The estimated future cost from FY2007 through permanent closure and decommissioning of the Repository is approximately $82.64 billion in constant 2007 dollars. Table 1-1 provides a summary of the major TSLCC cost categories, consisting of the Repository, Transportation, and the Balance of Program elements. Appendix B shows the annual life cycle cost for the Program by element in constant 2007 dollars. As the design and operations of the system continue to evolve, periodic reassessments of projected costs will be required.

For the purposes of analyzing the cost changes between the 2001 and 2007 TSLCC estimates, the Department used a recommendation made in the U.S. Government Accountability Office (GAO) Report GAO-05-182, "Defense Acquisitions: Information for Congress on Performance of Major Programs Can Be More Complete, Timely, and Accessible," March 2005. The report recommended measuring change in same year constant dollars because that removes the effects of inflation, which are beyond the control of individual programs, and measures real program cost growth. Additionally, showing cost variances in unit costs eliminates the impacts of the growth in waste quantities (increased scope) requiring disposal.

For comparison purposes to the 2001 TSLCC, Table 1-2 adjusts for the effects of inflation and converts the 2007 TSLCC estimate to $79.34 billion in constant 2000 dollars. Tables 1-3 and 1-4 summarize the 2001 TSLCC estimate in constant 2007 and 2000 dollars, respectively.

Table 1-1. Summary of the 2007 TSLCC Estimate – 2007 Dollars (in Millions of 2007$)

Cost Element	Historical Costs (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Repository	9,910	54,820	64,730
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Tables 1-2 and 1-4 show that, excluding inflation, the unit cost per metric ton for disposal has increased by approximately 10% between the 2001 and 2007 TSLCC estimates.

1.1 PURPOSE AND SCOPE

This TSLCC estimate aids in financial planning, provides policy makers with information for determining the course of the Program, and is an input for the assessment on the adequacy of the one mill ($0.001) per kilowatt-hour fee charged to generators of commercial spent nuclear fuel (CSNF). This TSLCC analysis provides an updated total system cost estimate consistent with the design described in the *Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, (DOE 2007, DOE/EIS-0250F-S1D). Since this estimate is for a system that will operate for over 100 years into the future, the concept upon which the estimate is based should be viewed only as representative of the system that may ultimately be developed.

The TSLCC estimate should not be interpreted as a final, definitive estimate. Numerous assumptions were required with respect to the waste management system design and operations where final decisions have not yet been made. Since these assumptions are critical to the resulting cost estimates, any changes in assumptions would influence the resulting estimate.

Assumptions used in these analyses are for cost analysis purposes and should not be interpreted as final DOE policy.

This TSLCC analysis is organized as follows:

Section 1. Introduction: This section introduces the reader to the overall purpose and scope of this analysis and summarizes the results and conclusions.

Section 2. Repository: This section discusses the Repository scope, assumptions, and costs included for each of five elements of the system life cycle including: Licensing; Surface & Subsurface Facilities; Waste Packages & Drip Shields; Performance Confirmation; and Regulatory, Infrastructure, & Management Support.

Section 3. Transportation: This section discusses the scope, assumptions, and costs for each of the Transportation system's two projects – National Transportation and Nevada Rail Infrastructure.

Section 4. Balance of Program: This section discusses Balance of Program scope. These activities include Quality Assurance (QA); Waste Management; Program Management; Benefits, Payments Equal To Taxes (PETT), Outreach, & Institutional; and costs associated with the NRC, Nuclear Waste Technical Review Board (NWTRB), and Nuclear Waste Negotiator that are funded from the NWF separately from the OCRWM budget.

Section 5. Commercial/Defense Cost Share Allocation: This section discusses calculation of the Government's share of disposal costs for DOE-owned SNF and HLW. The Program is funded on a full-cost recovery basis, with waste generators funding their respective disposal costs.

Appendices: In addition, there are three Appendices in this report. Appendix A provides some specific comparisons of the 2001 TSLCC to the 2007 TSLCC with a table that compares cost details and a table that compares the assumptions used for each estimate. Appendix B provides the annual total system life cycle cost profile of the Program. Appendix C provides a list of documents cited within the *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program*.

1.2 COMPARISON BETWEEN THE 2001 AND 2007 TSLCC

The 2007 TSLCC estimated cost represents a 38 percent increase (in constant dollars) from the May 2001 TSLCC estimate, entitled *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, DOE/RW-0533.* This cost estimate reflects a 26 percent increase in waste quantity (from 97,000 MTHM in FY2001 to 122,100 MTHM in FY2007), an 18 percent increase in required waste packages, and a 35 percent increase in transportation shipments. In addition to increases in other activities, materials, and durations due to the increased waste stream, this estimate also reflects updated material costs, more detailed cost estimates reflecting greater specificity in system designs, and the addition of the Transportation, Aging, and Disposal (TAD) canister-based system. An example of the greater specificity is the estimate for the Nevada rail line. The 2001 estimate was based on a nonspecific route, and the 2007 estimate is based on the detailed takeoffs for the Caliente Route.

The larger quantity of MTHM captured in the 2007 TSLCC directly affects the duration of various key projects, resulting in cost increases. Due to the increased waste quantities in the 2007 TSLCC, the waste transportation period is extended by 16 years and the emplacement period by 25 years. Furthermore, the estimate assumes a period of 50 years after the last emplacement to allow for additional monitoring and cooling before closure.

The adoption of a canister-based system design has lowered costs and simplified design and operational requirements at the repository surface facilities, but has increased costs for purchasing the TAD canisters. In the previous design, wastes were sealed into reusable transportation casks at the utilities and shipped to the repository. At the repository, the waste was repackaged into disposal canisters for emplacement. In the canister-based system, a single canister is used for transportation, aging, and disposal, minimizing waste handling at the Repository. For the first 70,000 MTHM, the cost savings offset the additional costs for the canisters. When estimating the full inventory, the canister purchases under current assumptions are somewhat higher than the surface facility savings offset.

The cost estimate presented in this TSLCC is parametric in nature. Variation in estimating assumptions can affect life cycle cost estimates. Examples include changes in the number of reactor license extensions, and variations in raw materials costs for high-volume items such as waste packages, TAD canisters, transportation casks, and transportation rolling stock.

1.3 MAJOR PROGRAMMATIC ASSUMPTIONS

The basis of the cost estimates used in the current analysis include costs for development, operation, monitoring, closure, and decommissioning of a canister-based waste management system for handling SNF and HLW. Under this system, the Department would accept most SNF in canisters sealed at commercial generators for transport to the Repository, provide temporary surface storage at the Repository, if necessary, and place the canisters in a waste package suitable for ultimate disposal underground at the Repository. Major programmatic assumptions are provided below. Later sections discussing the Repository, Transportation, and the Balance of Program identify specific assumptions used to achieve the cost estimating analysis for that area.

The major program-level assumptions that affect the TSLCC are as follows:

1. The waste management system is assumed to accept the following:

    a. Actual and projected CSNF discharges, including discharges from the 47 reactors with license extensions as of January 1, 2007.

    b. No new nuclear plants are included in this estimate.

    c. 2,788 canisters of DOE SNF and 400 canisters of Naval SNF (2,500 MTHM equivalent).

    d. 19,667 canisters (10,300 MTHM equivalent) of Defense HLW.

2. It is assumed for this estimate that CSNF fuel acceptance will follow the process in the Standard Contract using the Oldest Fuel First acceptance priority.

3. The TSLCC assumes the following near term milestones:

    a. Submittal of the License Application to the NRC in 2008

    b. Repository Construction Authorization by the NRC in 2011

    c. Receive and possess License Application submittal to the NRC in 2013

    d. Repository construction complete for initial operations in 2016

    e. Initial waste receipt at the repository is assumed for the purposes of this report to begin in 2017.

4. Funding is not constrained, providing consistent and sufficient funding for the Program as needed.

5. Potential schedule delays are not included in the estimate. The Program's schedule could be impacted by increased time for NRC license or license amendment reviews, delays in the issuance of other necessary regulatory permits or authorizations, litigation, new legislation, and constrained funding.

6. Costs for the siting and construction of a second repository are not included. The NWPA, as amended, limits the amount of SNF and HLW in Yucca Mountain to 70,000 MTHM prior to the start of operations at a second repository. For purposes of this estimate, it is assumed that all the SNF and HLW are disposed of in Yucca Mountain. OCRWM has not estimated costs for a second repository and expects the Department to report to the President and the Congress in 2008 on the need for such a repository.

7. It is assumed that approximately 90% of the CSNF will be accepted in TAD canisters. The remainder will be received as uncanistered (bare, intact) assemblies in rail or truck transportations casks.

8. SNF and HLW associated with the cleanup of the nuclear weapons complex managed by the Department's Office of Environmental Management (EM) and SNF from the U.S. Navy will be disposed in Yucca Mountain. These wastes and materials will be accepted consistent with existing agreements, the Memorandum of Agreement with the U.S. Navy, and the 2001 Integrated Acceptance Schedule in place with EM.

9. Defense HLW and SNF will be delivered to Yucca Mountain in sealed, disposable canisters, with the exception of 200 MTHM of intact commercial-origin DOE SNF that can be accepted bare.

10. Repository plans include disposal of only SNF or HLW that is not subject to regulations as hazardous waste under the Resource Conservation and Recovery Act Subtitle C.

11. Initial Operating Capability (IOC) is defined as the ability to receive and emplace HLW, Naval and DOE SNF, and standard CSNF as defined in the Standard Contract. The IOC includes Canister Receipt and Closure Facility (CRCF)-1, Wet Handling Facility (WHF), Initial Handling Facility (IHF), Aging Pad K, and supporting surface and subsurface facilities.

12. Full Operating Capability (FOC) is defined as all IOC facilities plus the Receipt Facility (RF), CRCF-2, CRCF-3, and the expansion of surface and subsurface facilities.

13. Added physical security systems to meet post-2001 security requirements are incorporated into Repository and Transportation Facility designs, systems, construction, and operations. Near-term security program cost estimates within the Balance of Program include protective forces; personnel, information, and operations security; material control and accountability; and security and contingency related training, risk analysis, and program management.

2. YUCCA MOUNTAIN REPOSITORY

2.1 YUCCA MOUNTAIN REPOSITORY SCOPE

The Yucca Mountain site is located on Federal land in a remote area of Nye County in southern Nevada, one of the most arid regions of the United States, approximately 90 miles northwest of Las Vegas. The Federal government controls nearly all of the land in the region. As shown in Figure 2-1, the area needed for the Repository encompasses land controlled by three Federal agencies: the U.S. Department of Defense (U.S. Air Force, Nevada Test and Training Range), the DOE (Nevada Test Site), and the U.S. Bureau of Land Management.

The conceptual repository design draws on extensive nuclear design-related experience, including: NRC regulations; NRC-approved industry codes and standards; and proven technology in use at NRC-licensed installations, international nuclear facilities, and mining operations worldwide. In addition, the NRC requires that systems, structures, and components important to safety be designed to withstand natural phenomena, including earthquakes, floods, and tornadoes (10 CFR Part 63, *Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada*).

Assumptions used for the development of the 2007 TSLCC estimate were a snapshot in time, and program plans will continue to evolve. The schedules identified in this report are assumed for cost estimating purposes and reflect the previously assumed start of operations date of 2017. All of the schedules outlined in this estimate are currently being reevaluated and revised assumptions will be used in the next issues of future cost estimates.

Although receipt and emplacement rates are expected to meet the requirements of the Civilian Radioactive Waste Management System Requirements Document (CRD), the actual emplacement rate can be adjusted based on such considerations as heat loads of the waste packages and the processing capabilities of the surface facilities. Surface staging will be provided at the Repository to compensate for any differences between receipt and emplacement rates.

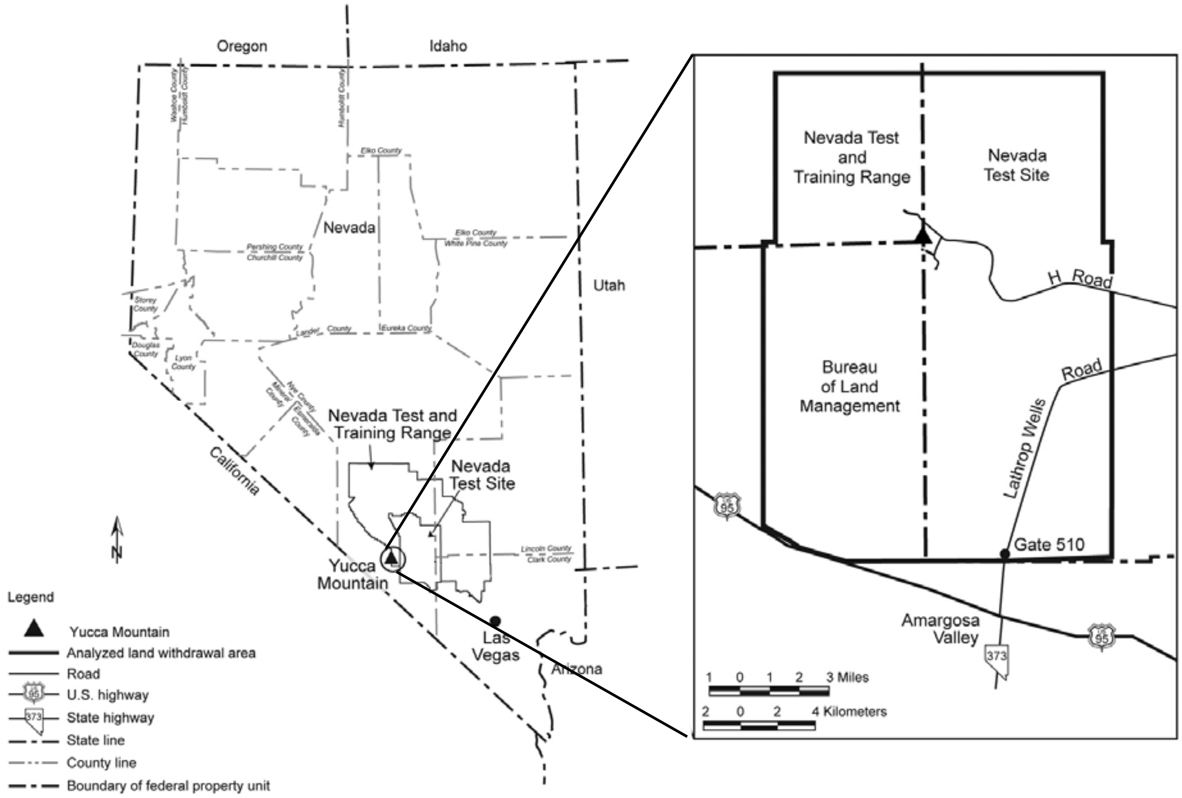


Figure 2-1. Yucca Mountain Site

After emplacement of the nuclear waste inventory has been completed and the monitoring and performance confirmation program has shown that the Repository will perform as expected, the Repository will be closed. Closure activities include sealing and backfilling all openings to the surface, dismantling the surface facilities, restoring the surface area as closely as possible to original conditions, preparing a postclosure monitoring plan, and protecting the Repository from unauthorized intrusion.

2.1.1 Licensing

The report assumes that the Department will submit a License Application (LA) to the NRC in 2008. The LA will provide the basis for an NRC decision on authorization for DOE to construct a repository at the Yucca Mountain site. Upon receipt, the NRC will conduct a preliminary review of the LA to determine whether it will be docketed.

The NRC and the Department conduct interactions on a variety of topics in order to facilitate timely review of the LA. These interactions will continue during the docketing and technical reviews of the application. The NRC will conduct a technical review and initiate licensing proceedings on the LA. The DOE will respond to technical questions and requests for additional information on design, science, and site work from the NRC in a timely fashion. Following completion of the NRC's review of the LA and issuance of its Safety Evaluation Report on the application, the Department will support discovery and all other activities associated with the licensing process.

2.1.2 Repository Surface & Subsurface Facilities

2.1.2.1 Repository Surface Facilities

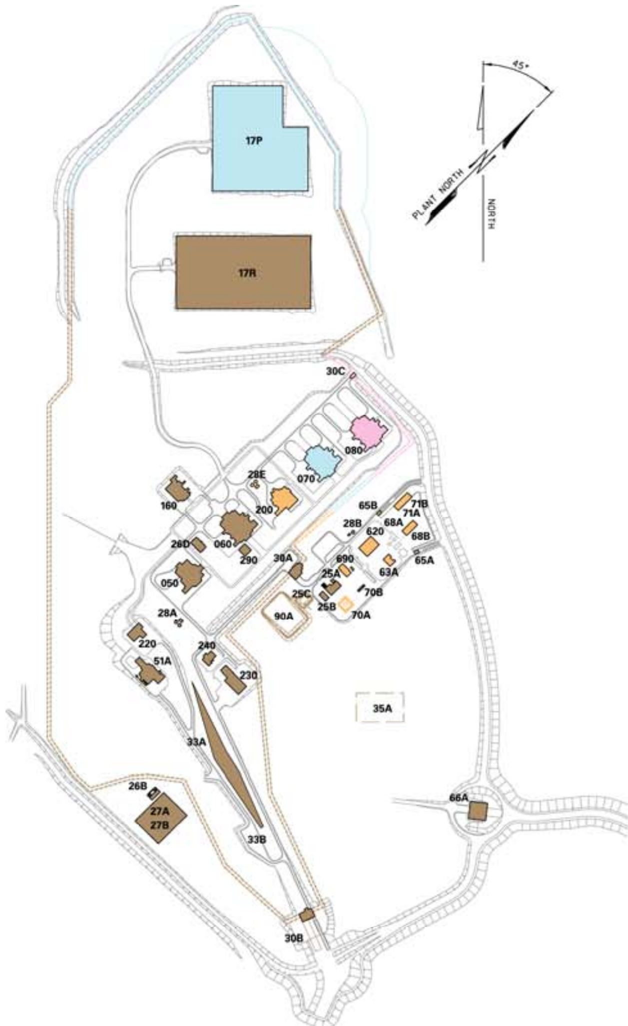
The Yucca Mountain surface facilities include the geologic repository operations area (GROA), the North Portal area, the South Portal development area, the North Construction Portal development area, the balance of plant area, and the surface shaft areas. The Repository operations areas and supporting areas (including utilities and roads) use as much as 1,500 acres (6 sq km) of land. Of this total, about 320 acres (1.3 sq km) have been disturbed by Repository activities since 1991. The surface portion of the Repository operations area includes the facilities necessary to receive, package, and support emplacement of waste in the Repository. Waste transfer operations are conducted inside reinforced concrete and metal frame buildings that are designed and constructed to withstand earthquakes and other natural phenomena. Workers, protected from radiation by shielded transfer equipment, shield walls, or both, use remotely controlled equipment to remove the waste forms from transportation casks and insert them into waste packages.

The primary facilities in the surface design are illustrated in Figure 2-2 and described below:

- **Initial Handling Facility (IHF)**—Rail transportation casks containing Naval SNF or HLW canisters are assumed to be received at the IHF. The canisters are transferred to waste packages, and the waste packages are closed and down-ended for transfer to the waste package transport and emplacement vehicle (TEV).

- **Receipt Facility (RF)—**Rail transportation casks containing TAD canisters or Dual Purpose Canisters (DPCs) are assumed to be received at the Receipt Facility. The material handling system in the Receipt Facility will provide the capability to receive and inspect transportation casks, remove casks from carriers, prepare casks for unloading, and unload casks into a shielded transfer cask for transfer to another waste handling facility or into an aging overpack for transfer to an aging pad. It is assumed that unloaded transportation casks will be prepared for return to the National Transportation System in the RF.

- **Wet Handling Facility (WHF)—**Loaded casks containing uncanistered CSNF assemblies (i.e., assemblies not loaded in TAD canisters) are assumed to be received in the WHF. Casks containing bare CSNF assemblies are unloaded in the WHF, and the CSNF assemblies are transferred to TAD canisters. It is assumed that DPCs are received at the Repository and cut open in the WHF to remove the CSNF assemblies inside and transfer them to a TAD canister. TAD canisters loaded in the WHF are then welded closed and transferred to a shielded transfer cask for transfer to a CRCF or an aging pad.



LEGEND			
Initial Operating Capability			
Phase 1			
050	Wet Handling Facility	26D	Emergency Diesel Generator Facility
060	Canister Receipt and Closure Facility 1	27A	Switchyard (138kV)
51A	Initial Handling Facility	27B	13.8kV Switchgear Facility
17R	Aging Pad R	28A	Fire Water Facility
160	Low-Level Waste Facility	28B	Fire Water Facility
220	Heavy Equipment Maintenance Facility	30A	Central Security Station
230	Warehouse and Non-Nuclear Receipt Facility	30B	Cask Receipt Security Station
240	Central Control Center Facility	33A	Rail Car Buffer Area
25A	Utility Facility	33B	Truck Buffer Area
25B	Cooling Tower	35A	Septic Tank and Leach Field
25C	Evaporation Pond	66A	Helicopter Pad
26B	Standby Diesel Generator Facility	290	Aging Overpack Staging Facility
90A	Storm Water Retention Pond		
Full Operating Capability			
Phase 2			
200	Receipt Facility	68B	Materials/Yard Storage
28E	Fire Water Facility	690	Vehicle Maintenance and Motor Pool
620	Administration Facility	70A	Diesel Fuel Oil Storage
63A	Fire, Rescue and Medical Facility	70B	Fueling Stations
65A	Administration Security Station	71A	Craft Shops
65B	Administration Security Station	71B	Equipment/Yard Storage
68A	Warehouse/Central Receiving		
Phase 3			
070	Canister Receipt and Closure Facility 2	17P	Aging Pad P
Phase 4			
080	Canister Receipt and Closure Facility 3	30C	North Perimeter Security Station

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Figure 2-2. Primary Repository Surface Facilities

- **Canister Receipt and Closure Facility (CRCF)—**The three CRCF facilities are assumed to receive rail transportation casks containing HLW, DOE SNF and TAD canisters, and shielded transfer casks from the WHF; load these canisters into waste packages, close the waste packages; and down-end the waste packages for transfer to the waste package TEV.

- **Aging Pads—**The aging pads will provide space for aging and staging waste. This aging capability enables CSNF to be aged as necessary to meet waste package thermal limits and the staging capability provides a surge capacity for additional flexibility in waste processing operations.

Other estimated surface facilities in the radiologically controlled area include the Central Control Center Facility, Heavy Equipment Maintenance Facility, and Warehouse and Non-Nuclear Receipt Facility. These facilities provide support to waste processing operations.

Surface transporters are planned to be used to move TAD canisters and DPCs between and among the waste handling facilities and aging pads. A waste package TEV is used to transport the waste packages from the CRCFs and IHF to the subsurface for emplacement.

The balance of plant area comprises the remaining general infrastructure facilities. The balance of plant area includes an administration building, a medical center, fire stations, a central warehouse, central shops, a motor pool service station, a visitor center, utility facilities, the North Portal Entrance Structure, a training facility, and security facilities.

The South Portal development area and the North Construction Portal development area will be used to support continuing construction of the Repository, even as the North Portal area accepts and prepares waste for underground emplacement in the first emplacement drifts.

2.1.2.2 Yucca Mountain Repository Subsurface Facilities

The system plans to dispose of waste packages in dedicated drifts, supported on emplacement pallets, and aligned end-to-end. Plans are to build the Repository emplacement drifts in a series of five panels, each comprising a set of emplacement drifts, and phased to match the planned throughput of the surface facilities. The total subsurface emplacement area required to accommodate 122,100 MTHM is approximately 2,400 acres. This includes approximately 333,346 feet of excavated emplacement drifts in five panels. About 17,450 waste packages and their engineered supports will be placed in these drifts. Panel 1 includes a single performance observation drift and eight emplacement drifts excavated to an 18-foot diameter at a center-to-center drift spacing of 266 feet. One of the eight emplacement drifts is used for performance confirmation testing.

The emplacement drifts are planned to be 18 feet in diameter and are excavated by tunnel boring machines consisting of mechanical excavators equipped with a rotating cutting head that uses hardened disc cutters to break the rock into small chips. Ground support is planned to be installed immediately behind the excavator to provide structural support and worker protection.

2.1.3 Drip Shields and Waste Packages

The drip shields and waste packages are primary elements that are designed to complement the natural barriers in isolating waste from the environment (Figure 2-3). Additional engineered barriers include pallets and supports and drift inverts.

- **Waste Packages (also called Disposal Overpacks when referring to the TAD canister system)—**The waste package designs assume two concentric cylinders. The inner cylinder is made of modified Stainless Steel Type 316. The outer cylinder is made of a corrosion-resistant, nickel-based alloy (Alloy 22). The Alloy 22 cylinder protects the internal components of the waste package, including the stainless steel inner cylinder, from corrosion due to contact with water. The Stainless Steel Type 316 cylinder provides structural support for the thinner Alloy 22 cylinder. Each waste package is being designed to have an outer lid and an inner lid on the top of the waste package. The outer (closure) lid would be made of Alloy 22 and the inner lid would be made of Stainless Steel Type 316. The basic waste package design is the same for the various waste forms. However, the sizes and internal configurations vary to accommodate the different waste forms to include commercial SNF in TAD canisters, HLW, DOE SNF, and Naval SNF.

- **Drip Shields—**Drip shields are assumed to be procured and installed during the last 10 years of the monitoring period. Drip shields are designed to be installed over the waste packages. The drip shields divert moisture that might drip from the drift walls, as well as condensed water vapor, around the waste packages to the drift floor, further extending the long life of the waste packages. The drip shields are also being designed to protect the waste packages from rockfall. All drip shields are being designed to be the same size, allowing one design to be used with the various waste packages.

- **Pallets and Supports—**Each waste package is designed to have a pallet for structural support. The pallet is used to support the waste package in a horizontal position within the emplacement drift. Pallets would be fabricated from Alloy 22 and Stainless Steel Type 316.

- **Drift Invert—**The invert includes structures and materials at the bottom of the emplacement drifts that support the pallet and waste package, drift rail system, and drip shield and backfill, if used. It is composed of two parts: the steel invert structure and ballast (or fill), which consists of granular material. Following repository closure, the granular material in the invert will provide a layer of material below the waste packages that will slow the movement of radionuclides into the host rock and will provide support if the steel invert corrodes.

2.1.4 Monitoring and Closure

Information concerning the Repository and the surrounding environment is being collected and compiled to provide a performance confirmation baseline against which to compare what occurs after the Repository is built and waste is emplaced. When repository operations begin, remote sensors will monitor the waste packages, emplacement drifts, and surrounding rock. The observed effects will be compared with the pre-emplacement repository characteristics and model predictions. These performance confirmation activities 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 will be accomplished using remotely operated equipment. The NRC currently requires that the Repository be designed to allow for the retrieval of waste at any time up to 50 years after waste emplacement operations begin. Any retrieval of waste will follow, in reverse order, the same steps taken to emplace the waste and, for the most part, will use the same systems and equipment. For the purpose of this cost estimate, the cost for retrieval is not included.

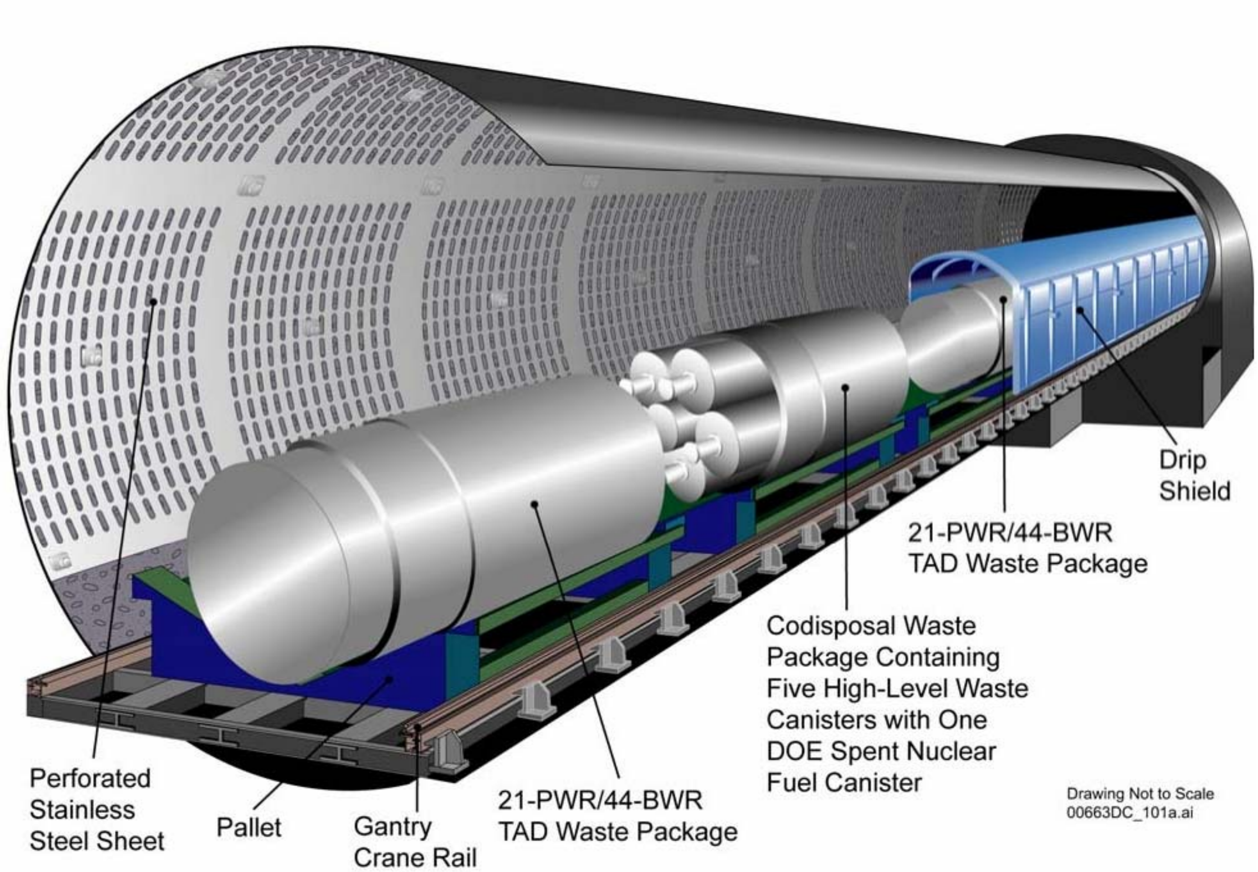

Figure 2-3. Waste Packages and Drip Shields

After the last waste package is placed underground, the Repository can be monitored for many decades, perhaps even centuries. Permanently installed sensors will monitor waste packages, emplacement drifts, and the surrounding rock, providing the data required to confirm performance. It is planned that a remotely operated inspection gantry will track conditions in the waste emplacement drifts. For the purpose of this cost estimate, it is assumed that monitoring will last for 50 years after emplacement of the last waste package. Drip shields will be installed during the last 10 years of monitoring.

Closure activities include sealing and backfilling all openings to the surface, dismantling the surface facilities, restoring the surface area as closely as possible to original conditions, preparing a post closure monitoring plan, and finally, ensuring the protection of the Repository from unauthorized intrusion.

2.2 YUCCA MOUNTAIN REPOSITORY ASSUMPTIONS

In addition to the assumptions in the description of the system in the previous section, the major Repository assumptions that affect the TSLCC are as follows:

1. For the purposes of this report, the Yucca Mountain repository surface and subsurface facility operations are assumed to begin in 2017 and end when all waste has been emplaced in the Repository by 2073. It is assumed that the Repository will be licensed by the NRC and that licenses to construct the facility and to receive and possess waste will be obtained in a timely manner to support the assumed start of operations in 2017.

2. The basis for the TSLCC estimate is the scope as described in the Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, (DOE 2007, DOE/EIS-0250F-S1D). Repository construction costs include preoperational testing and start up activities prior to turnover of the facilities for operations.

3. Costs for design of new facilities required for the canistered approach were developed based on parametric evaluations of deliverables (drawings, specifications, calculations, etc.) and relative complexity as compared to existing facility design.

4. Construction work for the GROA begins after receipt of the NRC CA. Work necessary to support requirements for the construction phase will be conducted in advance of the CA. This could include, for example: site safety upgrades for the existing Exploratory Studies Facility, sample drilling for siting of future aggregate borrow pits, geotechnical characterization of repository facilities, design of construction facilities, long-lead procurement, constructability assessments, and construction process development.

5. All infrastructure activities not in the GROA that are required for the onset of repository construction will be completed prior to CA.

6. The GROA design for the LA is based on receipt of approximately 90% of CSNF in TAD canisters, with the remainder arriving uncanistered (bare SNF in truck transportation casks and DPCs in rail transportation overpacks). The capacity of a standard TAD canister will be approximately 9 MTHM and will include either 21 Pressurized Water Reactor (PWR) or 44 Boiling Water Reactor (BWR) assemblies.

7. HLW and DOE SNF will be accepted in accordance with the 2001 DOE EM Integrated Acceptance Schedule. Naval SNF will be accepted in accordance with the schedule in the CRD.

8. The 57 year emplacement period is followed by 50 years of monitoring with drift ventilation. A 10-year period is anticipated to perform closure operations.

9 Site rail access will be available to meet the receipt ramp-up rate consistent with Tables 3-1 through 3-3 of this document.

10. Construction, testing and monitoring, and infrastructure support will be available for science activities related to the licensing review and Performance Confirmation program, as well as the long-term testing and monitoring program. This support will be in compliance with applicable QA procedures.

11. The provision of oversight funding to Affected Units of Local Government (AULG) will continue throughout repository operations per the NWPA Section 116(c).

12. PETT will continue throughout repository operations per the NWPA Section 116(c).

13. Impact assistance will be provided, if required, to the State of Nevada and any AULG as stated in the NWPA Section 116(c).

14. Monitoring will take place following the end of emplacement activities. Closure and decommissioning activities will take approximately ten years and will follow monitoring. Annual costs during the monitoring period are significantly lower than during the emplacement period.

2.3 REPOSITORY COSTS

Major cost drivers for the Repository cost estimate include the cost of surface facility construction, repository facility operations, drip shields and waste package costs. The major repository surface facilities included in this estimate are described in Section 2.1.2.1. For the purpose of this analysis, they are assumed to process wastes as follows:

- Initial Handling Facility—Naval SNF and HLW canister receipt and waste package loading/closure;
- Wet Handling Facility—uncanistered commercial SNF receipt and TAD canister loading/closure;
- Canister Receipt and Closure Facility 1—HLW, DOE SNF and TAD canister receipt and waste package loading/closure;
- Canister Receipt and Closure Facility 2—TAD canister receipt and waste package loading/closure;
- Canister Receipt and Closure Facility 3—TAD canister receipt and waste package loading/closure; and
- Receipt Facility—Receive rail transportation casks with TAD canister or DPC and transfer to aging pads or another waste handling facility.

In addition to these facilities, the estimate also includes costs for site infrastructure and balance of plant facilities, including offsite access roads, onsite and offsite utilities, equipment maintenance facilities, a central control center and administration building, security and emergency (fire, rescue and medical) facilities and systems, and aging pads to allow for proper cooling of waste prior to emplacement. The Repository estimate includes costs for underground emplacement panels for disposal of waste.

For the purposes of the TSLCC estimate, the Repository cost estimate is comprised of integrated costs from five time phases with estimated periods to include:

- Development & Evaluation (1983 – 2002)
- Engineering Procurement & Construction (2003 – 2053)
- Emplacement Operations (2017 – 2073)
- Monitoring (2074 – 2123)
- Closure (2124 – 2133)

A summary of Repository costs broken out by major cost components is provided in Table 2-1 below.

Table 2-1. Repository Costs by Phase (in Millions of 2007$)

Cost Element	Historical (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Development & Evaluation (1983 – 2002)	8,330	0	8,330
Engineering, Procurement & Construction (2003 – 2053)	1,580	16,550	18,130
Emplacement Operations (2017 – 2073)	0	26,730	26,730
Monitoring (2074 – 2123)	0	10,150	10,150
Closure (2124 – 2133)	0	1,390	1,390
Total	**9,910**	**54,820**	**64,730**

NOTE: Row and column totals may not add due to rounding.

2.3.1 Repository Development & Evaluation

Repository development and evaluation costs were incurred for activities associated with evaluating multiple geologic repository candidate sites in the 1980s and in conceptual design and site characterization activities in the 1990s through the approval by Congress of the Yucca Mountain Repository Site Recommendation in 2002. During the 1980s, the Program evaluated nine sites in six states for their suitability for a repository, including sites in basalt rock formations in the Pacific Northwest and salt dome formations in the West and South. Activities during this time included establishing field offices to conduct technical evaluations, conducting field work, drilling test boreholes to gather samples, and developing repository conceptual designs.

During the 1990s, following passage of the Nuclear Waste Policy Amendments Act of 1987 through which Congress directed the federal government to focus on Yucca Mountain, the Department conducted in depth site characterization activities of Yucca Mountain to determine its suitability for a geologic repository. This work included the boring of the Exploratory Studies

Facility, a five mile long tunnel through Yucca Mountain, in which scientific studies could be conducted on the long-term performance of the repository environment. An additional 1.7 mile tunnel was bored to study the rock at the Repository level. Work also included conceptual design of, and materials testing on, spent fuel waste packages and drip shields. The Development and Evaluation phase culminated in the Presidential recommendation of Yucca Mountain as the site for a geologic repository and the approval of that recommendation by Congress in 2002. Details of costs during this period are included in Table 2-2 below.

Table 2-2. Repository Development & Evaluation Costs (in Millions of 2007$)

Cost Element	Historical Costs (1983 – 2002)
Development & Evaluation at Yucca Mountain	6,270
Other Repository Development & Evaluation	2,060
Total	**8,330**

NOTE: Other Repository Development & Evaluation includes other First Repository Sites and Second Repository Sites.

2.3.2 Repository Engineering, Procurement, and Construction

The Engineering, Procurement, and Construction (EPC) phase began in 2003, following the approval of the Site Recommendation by Congress. It includes all activities necessary to design, license, and construct the geologic repository at Yucca Mountain. Licensing activities (license application preparation and interactions with the NRC), surface facility construction (infrastructure, waste handling buildings, and balance of plant), and subsurface construction (emplacement drifts) are the major cost categories during this phase. Procurement of disposal waste packages (or TAD disposal overpacks) are primarily included as part of the repository operations estimate, with only the initial procurements included in the engineering, procurement and construction estimate. Table 2-3 details the costs for the EPC phase.

Table 2-3. Repository Engineering, Procurement, and Construction Costs (in Millions of 2007$)

Cost Element	Historical Costs (2003 – 2006)	Future Costs (2007 – 2053)	Total Costs (2003 – 2053)
Licensing	670	1,660	2,340
Surface & Subsurface Facilities	880	14,670	15,550
Waste Package & Drip Shield Fabrication	20	220	240
Performance Confirmation	0	0	0
Regulatory, Infrastructure, & Management Support	0	0	0
Total	**1,580**	**16,550**	**18,130**

NOTE: Row and column totals may not add due to rounding.

2.3.3 Repository Emplacement Operations

For the purposes of this report, emplacement operations are assumed to extend through 2073. The primary cost drivers during this phase are operations of the surface facilities and the fabrication of approximately 17,450 waste packages. Activities at the surface facilities will include waste receipt and unloading, placement of waste canisters in disposal overpacks, and limited surface aging activities for thermal blending purposes. Performance confirmation, site management, and safeguards and security activities will also take place during this period. Table 2-4 details the costs for the emplacement operations phase.

Table 2-4. Repository Operations Costs (in Millions of 2007$)

Cost Element	Future Costs (2017 – 2073)
Licensing	0
Surface & Subsurface Facilities	9,580
Waste Package & Drip Shield Fabrication	12,580
Performance Confirmation	1,680
Regulatory, Infrastructure, and Management Support	2,890
Total	**26,730**

NOTE: Column totals may not add due to rounding.

2.3.4 Repository Monitoring

The Repository monitoring phase is assumed to cover the period from 2074 through 2123 and includes activities to gather and analyze data on repository performance as well as perform maintenance activities on the facilities. Costs for staffing, spare parts and consumable supplies, utilities, and ventilation of the repository are included. Drip shields are emplaced during the last 10 years of this phase. Table 2-5 details the costs for the monitoring phase.

Table 2-5. Repository Monitoring Costs (in Millions of 2007$)

Cost Element	Future Costs (2074 – 2123)
Licensing	0
Surface & Subsurface Facilities	1,030
Waste Package & Drip Shield Fabrication	7,630
Performance Confirmation	1,040
Regulatory, Infrastructure, and Management Support	440
Total	**10,150**

NOTE: Column totals may not add due to rounding.

2.3.5 Repository Closure

The Repository closure phase covers the last ten years of repository operations, and is assumed for the purposes of this report to be from 2124 through 2133. It includes costs to decontaminate and decommission surface facilities, backfill shafts and ramps, permanently seal the repository, and construct monuments. Table 2-6 details the costs for the closure phase.

Table 2-6. Repository Closure Costs (in Millions of 2007$)

Cost Element	Future Costs (2124 – 2133)
Licensing	0
Surface & Subsurface Facilities	970
Waste Package & Drip Shield Fabrication	0
Performance Confirmation	300
Regulatory, Infrastructure, and Management Support	120
Total	**1,390**

NOTE: Column totals may not add due to rounding.

3. TRANSPORTATION

3.1 TRANSPORTATION SCOPE

The mission of the Transportation Program is to develop and manage a safe, secure, and efficient Transportation System for shipping SNF and HLW from specified locations throughout the United States to the Repository. The Transportation System focuses on developing transportation assets, operational strategies, and policies that will support shipment training exercises and shipments. The OCRWM is collaborating with stakeholders and interested parties as it develops this Transportation System. The Transportation System consists of two capital projects – the National Transportation Project and the Nevada Rail Infrastructure Project. The Transportation System estimate consists of the technical scope, schedule and cost to execute both of these projects.

The Department is responsible for transporting all HLW and SNF (except Naval SNF) to the Repository via a national transportation system and a regional transportation system in Nevada. The Navy is responsible for the transportation of Naval SNF to the Repository. Pursuant to a Record of Decision in April 2004, the Department selected "mostly rail" as its preferred mode of transportation to the Repository.

3.2 TRANSPORTATION ASSUMPTIONS

For purposes of this analysis, it is assumed the Department will purchase equipment, including TAD canisters and any necessary DPC transportation overpacks, casks, and rolling stock and will contract out for planning, acquisition, and operations services.[1] For this analysis, the

[1] In addition, it is assumed that locomotives will be leased.

transportation infrastructure will include the Cask Maintenance Facility (CMF), Rail Equipment Maintenance Yard (REMY), and the Transportation Operations Center that will conduct maintenance activities on equipment and coordinate transportation logistics. It is assumed the NWPA Section 180(c) planning and training grants to state and local governments for emergency preparedness and response will be awarded three to five years prior to the start of operations and will continue during the transportation operations period.

Additional major Transportation assumptions used to develop the TSLCC are as follows:

1. For the purposes of this estimate, it is assumed that CSNF and DOE SNF and HLW pickup is to begin in 2017, using the Oldest Fuel First acceptance priority in the Standard Contract for CSNF acceptance.

2. Tables 3-1 through 3-3 show the assumed nominal acceptance rates for CSNF and DOE SNF and HLW, respectively.

3. CSNF acceptance rates are based on the CRD.

Table 3-1. Assumed Acceptance Rates for Commercial Spent Nuclear Fuel

Calendar Year	Acceptance (MTHM/calendar year)
2017	400
2018	600
2019	1,200
2020	2,000
2021	3,000
2022	3,000
2023	3,000
2024	3,000
2025	3,000
2026 – 2055	3,000 each year
2056 – 2063	Total of 877*

NOTE: Because of heat restrictions in shipping wastes, it has been estimated that the last shipment cannot be made until 2063.

Table 3-2. Assumed Acceptance Rates for DOE Spent Nuclear Fuel

Year	DOE SNF (Canisters)	Naval SNF (Canisters)
2017	72	10
2018	45	15
2019	81	18
2020	126	21
2021	63	24
2022	54	24
2023	90	24
2024	81	24
2025	90	24
2026	108	24
2027	126	24
2028	135	24
2029	162	24
2030	153	24
2031	108	24
2032	90	24
2033	171	24
2034	171	24
2035	137	—
2036	90	—
2037	86	—
2038	50	—
2039	66	—
2040	88	—
2041	87	—
2042	61	—
2043	48	—
2044	52	—
2045	48	—
2046	49	—

Table 3-3. Assumed Acceptance Rates for High-Level Radioactive Waste

Year	Acceptance (Canisters)
2017	195
2018	380
2019	380
2020	380
2021	380
2022	385
2023	380
2024	380
2025	425
2026	650
2027	650
2028	650
2029	695
2030	710
2031	740
2032	800
2033	830
2034	825
2035	825
2036	792
2037	745
2038	745
2039	745
2040	740
2041	745
2042	746
2043	650
2044	650
2045	645
2046	471
2047	445
2048	445
2049	443

4. For cost estimating purposes, the Department is basing this TSLCC estimate on rail alignments within the Caliente Corridor, although the Department has not yet completed its National Environmental Policy Act (NEPA) review and has not yet made a decision whether to utilize the Caliente or the Mina Corridor.

5. The preferred mode of transportation will be mostly rail, using dedicated trains.

6. Contingency and management reserve for Transportation were estimated at 15% to 30%.

7. Rail transportation of SNF and HLW will be performed by dedicated trains with up to five casks per train for DOE waste and three casks per train for commercial waste. Buffer cars will be provided as necessary to meet specific loading restrictions and a security escort car will complete the consist (i.e., locomotive, buffer car, cask cars, buffer car, and escort car).

8. Locomotives will be leased.

9. The TSLCC estimate includes the capital costs associated with developing and fabricating the rail cars.

10. Naval Reactors is responsible for procurement of its own rolling stock and casks and for the transport of Naval SNF to the Repository. These costs are not included in the TSLCC estimate.

11. The Navy will pay 1/3 of the cost of the design, fabrication, and testing of the prototype escort car and the Department will pay 2/3 of the cost. The cost sharing for development reflects the number of escort cars each program will ultimately need. OCRWM's share of costs is included in this estimate.

12. All cask and basic rolling stock maintenance facilities are assumed to be located at Yucca Mountain outside the GROA, and will be constructed by the Department.

13. Institutional funding will support resolution of key issues with states, tribes and carriers and funding of cooperative agreement groups. It is assumed that institutional funding and Section 180(c) funding will continue throughout the period of transportation operations.

14. The TSLCC estimate includes development of contingency plans for transportation to assure the highest level of security and safety, while mitigating impacts on shipping schedules and GROA receipt operations.

3.3 TRANSPORTATION COSTS

Major cost drivers for the Transportation system element include the purchase of casks and TAD canisters, construction of the rail line, and transportation system support and operations. A summary of the transportation cost estimate is included in Table 3-4. This estimate includes Transportation Development & Evaluation costs through 2002. It also includes historical and future costs for the National Transportation and Nevada Rail Infrastructure Projects. The estimate assumes that TAD canisters will be purchased by the Department and delivered to commercial waste sites for loading and then transported to the Repository. Some TAD canisters will be delivered to the Repository for loading of bare fuel in preparation for disposal. Major cost drivers for construction of the branch rail line through Nevada include earthwork (e.g., clearing and grading, cut and fill of terrain) and the purchase and laying of the track itself.

Transportation system operations include conducting shipments from the DOE facilities and utilities to the Repository and operation of maintenance facilities for casks and rolling stock.

Table 3-4. Transportation Cost Summary (in Millions of 2007$)

Cost Element	Historical (1983 – 2006)	Future Costs (2007 – 2073)	Total Costs (1983 – 2073)
Development & Evaluation (1983 – 2002)	640	0	640
National Transportation Project (2003 – 2073)	100	16,830	16,930
Nevada Rail Infrastructure Project (2003 – 2017)	40	2,650	2,690
Transportation Total	**780**	**19,480**	**20,250**

NOTES: Row and column totals may not add due to rounding. Future costs for the Nevada Rail Infrastructure Project extend through 2017.

3.3.1 National Transportation Project

The National Transportation Project scope includes: the acquisition of rail and truck cask systems; design, acquisition, manufacture, testing and acceptance of rolling stock; national institutional activities, including implementation of Section 180(c) provisions; systems engineering and operations development; acquisition of physical security systems; and project management. In addition, the acquisition cost of TAD canisters (excluding the initial 35 canisters to support IOC) is accounted for under the National Transportation Project.

The Department is developing the TAD canister-based system to simplify and standardize operations throughout the Civilian Radioactive Waste Management System (CRWMS). The TAD canister will be the key interface component that facilitates various TAD system functions. Separate overpacks will be needed for transportation, aging, and disposal. The transportation overpack is used when transporting fuel from the utilities to Yucca Mountain. The aging overpack is used when fuel is sent to the Surface Aging Facility at the Repository. The disposal overpack (waste package) is used when a TAD canister is prepared for final emplacement. As such, all components of a TAD canister-based system will comply with the regulatory requirements of Titles 10 CFR Part 71, 10 CFR Part 72, and 10 CFR Part 63, as applicable.

TAD canisters are loaded with CSNF and sealed at the utility reactor sites. The Department will take title and deliver the loaded TAD canisters to the Repository using a transportation overpack. At the Repository, a TAD canister may also be handled using a shielded transfer cask or aged in an aging overpack, and will be disposed of in a waste package. These three Repository functions will be covered by the Repository license granted under 10 CFR Part 63.

Storage and maintenance of the entire transportation fleet are planned to be performed at two locations. The CMF will service and maintain the transportation cask fleet. A physical location for the CMF has not been designated, but for the purpose of this analysis it is assumed to be located on the repository site adjacent to the GROA. For rail shipments, the REMY will serve as the physical location where rail cars are separated, so that only the cask cars are delivered to the Repository. The REMY could provide temporary storage of the entire rolling stock fleet. The REMY will be located along the Nevada Rail Line near the Repository. These two maintenance facility designs supersede the previous one Fleet Management Facility design to allow for enhanced operational efficiency.

Long lead times may be required between the initial procurement of the transportation capital assets, including casks, TAD canisters, and rolling stock, and the actual delivery of such items. For estimating purposes, casks and rolling stock are assumed to be procured two to three years before their needed operations date.

The National Transportation Project encompasses the acquisition of the necessary capital assets to safely transport the SNF and HLW from commercial and DOE sites to the Repository, with shipping operations commencing in 2017. The shipping operations phase concludes in 2063 when all SNF and HLW have been transported to the Repository. These transportation operations will be handled mostly by rail, using dedicated trains. Transportation costs are assumed to continue through 2073, while new TAD canisters are acquired and sent to Yucca Mountain. The National Transportation Project costs are summarized in Table 3-5 below.

Table 3-5. National Transportation Project Costs (in Millions of 2007$)

Cost Element	**Historical Costs (2003 – 2006)**	**Future Costs (2007 – 2073)**	**Total Costs (2003 – 2073)**
National Transportation Project	100	16,830	16,930
Total	**100**	**16,830**	**16,930**

NOTE: Row totals may not add due to rounding.

The National Transportation Project estimate includes costs for the acquisition of DOE SNF and HLW casks, CSNF casks, and BWR and PWR TAD canisters; the acquisition of rolling stock including escort, cask, and buffer cars; and the design and construction of support and maintenance facilities, including the Transportation Operations Center, CMF, and REMY. Costs for System Support and Operations Execution are also accounted for within the National Transportation Project estimate.

System Support encompasses the costs related to crosscutting elements necessary to support the Transportation System such as System Design, Operations Systems Development, Institutional Planning, Stakeholder Relations, 180(c) Development/Funding, Safeguards and Security and Emergency Response, and Program Management. Operations Execution includes the costs for shipping the SNF and HLW from the waste generator sites to the Repository, the transportation operations contractor, Nevada Rail operations and maintenance, and cask and rolling stock maintenance.

The National Transportation Project future costs are summarized in Table 3-6 below.

Table 3-6. National Transportation Project Future Costs (in Millions of 2007$)

Cost Element	**Future Costs (2007 – 2073)**
National Transportation Project	—
Cask Systems	10,870
Rolling Stock	280
Support/Maintenance Facilities	100
System Support	2,450
Operations Execution	3,120
Total	**16,830**

NOTE: Column totals may not add due to rounding.

The cask and rolling stock fleet size for the National Transportation Project, in terms of quantities and unit costs are summarized in Tables 3-7 and 3-8 below.

Table 3-7. Transportation Cask Fleet

Cask Type	**Quantity (each)**	**Unit Cost (in Millions of 2007$)**
DOE Casks	—	—
HLW Rail	25	4.5
SNF Rail	5	4.5
Commercial SNF Casks	—	—
Truck Casks	30	4.4
Transportation Overpacks	42	4.5
BWR TAD Canisters	4,983	0.8
PWR TAD Canisters	7,965	0.7
Medium/Small Casks	31	4.5

NOTE: The costs for the first 22 BWR TAD Canisters and 13 PWR TAD Canisters are included in the Waste Management estimate under the Balance of Program costs.

Table 3-8. Transportation Rolling Stock Fleet

Rolling Stock Type	**Quantity (each)**	**Unit Cost (in Millions of 2007$)**
Rolling Stock	—	—
Escort Car	18	3.7
Cask Car	100	0.7
Buffer Car	37	0.5

NOTE: Unit costs reflect Rolling Stock acquisition costs only and do not include design, testing and inspection costs. In addition, one prototype for each rolling stock car type will be fabricated.

3.3.2 Nevada Rail Infrastructure Project

The Nevada Rail Infrastructure Project scope provides for the design and construction of a new branch rail line and associated support facilities within the State of Nevada. It includes the development of a Nevada Rail Infrastructure system interface from the National Transportation System to the Repository. It also encompasses the design, acquisition of materials and equipment, construction, testing, and certification of a Nevada rail line for the transportation of SNF and HLW. Work scope includes National Environmental Policy Act (NEPA) analyses, land acquisition, and supporting field investigations and analyses.

The Caliente Corridor is the current planning basis for budget projections for the Nevada rail line, although the Department currently is in the process of considering potential alternative alignments within both the Caliente and Mina Corridors. For this cost estimate, it is assumed that the rail line will be completed by 2014 to facilitate Repository construction.

The rail line will be designed, constructed, tested and certified in accordance with applicable DOE requirements and federal regulations.

The rail line designs include mainly a single track with a number of sidings to facilitate passing of opposing movements and storage of maintenance and train equipment. The rail line design includes the following:

- Numerous structures to traverse washes, as well as cuts and fills to minimize grades encountered along the alignment;
- Train control systems to assure train separation;
- Grade crossing equipment and traffic control devices to warn highway traffic of the passage of trains;
- A right of way access road for railroad construction and maintenance along the majority of the track; and
- Communications equipment to supervise, control and transmit the status of various equipment along the alignment, as well as to provide basic communications with the trains and maintenance personnel.

The rail line will be designed to provide transfer to and from the connecting railroad and to and from the Yucca Mountain site. It is assumed that connections to the CMF and REMY and other supporting facilities will be incorporated, as necessary. The rail line must support all train movements required in the operations plan including the capability to dispatch empty casks to the utilities and DOE sites and deliver loaded casks to the Repository. The rail line connection is planned to support operational testing of the railcar fleet; training of operating and maintenance personnel; and testing of interfaces with the Repository site and the connecting railroad in time for the planned operational startup date.

For the cost estimate, it is assumed that the construction for the Nevada Rail Infrastructure Project begins in 2009 and concludes when the Nevada Rail Line (NRL) is placed in service, assumed to be in 2014. Operations and maintenance start-up costs extend through the beginning of repository operations. These planned dates are consistent with achieving initial repository operations in 2017. The TSLCC Nevada Rail Infrastructure estimate is summarized in Table 3-9 below.

Table 3-9. Nevada Rail Infrastructure Project Costs (in Millions of 2007$)

Cost Element	Historical Costs (2003 – 2006)	Future Costs (2007 – 2017)	Total Costs (2003 – 2017)
Nevada Rail Infrastructure Project	40	2,650	2,690
Total	**40**	**2,650**	**2,690**

NOTE: Row totals may not add due to rounding.

The NRL is the main cost component within the TSLCC Nevada Rail Infrastructure estimate. The NRL element includes the development; design; construction, management, and operations; and maintenance planning for the NRL and its associated bridges and drainage structures. Systems costs, such as signals and communications, as well as testing and certification costs are also included.

Other cost elements within Nevada Rail Infrastructure estimate are the EIS, Design Supporting Field Investigations, and Rail Support Facilities. The EIS costs include NEPA and regulatory compliance costs. The Design Supporting Field Investigations element accounts for the costs of evaluations supporting rail design, such as aerial mapping, geotechnical investigations, hydraulic analyses, and route optimization studies. The Rail Support Facilities includes the design and construction costs for ancillary facilities, such as the Union Pacific Railroad Interchange Yard, NRL Staging Yard, REMY, Maintenance of Way Facilities, and Train Control Center.

The Nevada Rail Infrastructure Project future costs are summarized in Table 3-10 below.

Table 3-10. Nevada Rail Infrastructure Project Future Costs (in Millions of 2007$)

Cost Element	Future Costs (2007 – 2017)
Nevada Rail Infrastructure Project	—
Nevada Rail Line	2,400
Environmental Impact Statement	30
Design Supporting Field Investigations	50
Rail Support Facilities	180
Total	**2,650**

NOTE: Column totals may not add due to rounding.

4. BALANCE OF PROGRAM

4.1 BALANCE OF PROGRAM SCOPE

The cost component for the Balance of the Program encompasses areas such as: QA; Waste Management; Program Management; Benefits, PETT, Outreach, and Institutional; and costs outside the OCRWM budget funded from the NWF. A brief description of each of the areas is provided below. The cost estimate for the years to construction reflects assumptions that are consistent with the conceptual design cost estimates and the budget projections through 2023. During construction, operations, monitoring and decommissioning, the Balance of Program estimates are expected to fluctuate according to the activities under way at that phase of the Program. Future estimates will improve upon the fidelity of the current estimates as more detail is developed.

4.1.1 Quality Assurance

The QA estimate includes funds for independent contractor staff dedicated to ensuring that the OCRWM Program and its contractors implement requirements mandated by the NRC for nuclear QA. Applicable tasks include OCRWM program activities related to public radiological health, safety and waste isolation. Activities associated with QA are performed independent of the organizational functions associated with work products, and are directly related to the acceptability of the technical products and services provided by the performing organization. Included in this element are cost estimates for surveillance and audits to verify the quality of work, identification of conditions adverse to quality, and corrective action oversight. Near-term costs are assumed to be at current budget planning levels during the initial construction phase through FY2053.

Costs for the operations phase after the conclusion of surface construction are somewhat lower to reflect ongoing oversight of repository activities. Costs during the monitoring phase are reduced to reflect the low level of activity at the repository during this period. When activities for decommissioning increase, costs for QA rise accordingly.

4.1.2 Waste Management

The Waste Management estimate includes costs for staff to conduct all activities necessary to plan for, integrate, and manage the administrative aspects of accepting waste from utility sites and DOE sites. This includes maintenance of the Standard Contract with utilities governing the acceptance of waste by the Department, planning and negotiation with other governmental entities regarding the acceptance of defense wastes, and establishment of high-level Program requirements and configuration control documents that address the rates and timing of the handling of wastes. Costs are also included to conduct the annual fee adequacy assessment. Waste Management costs are anticipated to continue through the end of acceptance and transportation activities.

Near-term Waste Management costs also support the design and licensing of the TAD canister-based system by commercial vendors, which includes the cost of developing and issuing a performance specification for the TAD canister and support to vendors to develop licensable system designs. Also included in this area is the cost to procure the first 35 TAD canisters to be used by the Department in accepting SNF from utilities.

4.1.3 Program Management

The cost estimate for program management includes the administrative costs associated with implementing the Program. This includes the human resources and information technology functions currently managed by the OCRWM Office of Government Services, as well as the

Program Direction budget category within which all Program federal salaries and other administrative costs are included. Integrated program costs for safeguards and security and the emergency management program are also contained in this estimate. The federal salary estimate includes the direct and overhead costs of Federal staff working on the program. Federal staffing levels vary with the overall level of costs over the Program's phases. In addition, general administrative costs such as building maintenance, computer equipment, communications, utilities, computer/video support, training, printing and graphics, photocopying, postage, and supplies are included in this estimate. Costs of management and technical support services contractors are also included in this element.

4.1.4 Benefits, Payments Equal to Taxes, Outreach, and Institutional

The Benefits, PETT, Outreach, and Institutional estimate includes funding to external parties as prescribed by the NWPA. 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 that they would receive if authorized to tax DOE activities at the same rate as commercial activities. States and units of local government are entitled to PETT for real property and industrial activities, including site characterization activities and development and operation of a potential repository. The NWPA authorizes the Secretary to enter into benefit agreements with the State of Nevada or affected Indian tribes pertaining to a potential repository for the acceptance of HLW or SNF. The NWPA states that the State or Indian tribe in which the potential repository is located is eligible to receive annual payments through decommissioning of the Repository.

4.1.5 Other Agencies

Those costs outside of the OCRWM budget funded from the NWF are included in the TSLCC analysis. These costs include NRC costs, NWTRB costs, and costs for the no longer active Office of the Nuclear Waste Negotiator.

NRC costs cover that agency's operating costs for regulatory oversight of the Yucca Mountain Project. NRC funding is assumed to be paid through operations and again at decommissioning. Funds for NRC activities that support the Program are appropriated separately by Congress as part of the NRC budget rather than the Department's budget. 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 OCRWM. The NWTRB's activities began in 1990 and are assumed for the purposes of this report to cease one year after receipt of the first waste in 2017. 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 attempted to find a state or Indian tribe willing to host an interim storage facility at a technically qualified site. The Negotiator's activities began in 1990 and were terminated in 1995.

4.2 BALANCE OF PROGRAM ASSUMPTIONS

The major Balance of Program assumptions that affect the TSLCC are as follows:

1. Program Direction costs are included in the Program Management estimate. Program Direction costs include salaries and benefits for Federal employees and costs for technical support service contractors. It is assumed that the Program does not use support service contractors after the start of operations.

2. Federal staffing levels are expected to increase through the construction and initial operations period and then gradually decline through the rest of the operations period to account for efficiencies in operations and oversight during this period. It is also assumed that the Program employees are reduced significantly during the 50-year monitoring period and staffing levels are then increased to oversee closure and decommissioning activities.

3. Some of the costs for PETT, Financial and Technical Assistance and funding for other agencies (U.S. Geological Survey, Bureau of Land Management, and others) and funding for oversight activities by the state and local governments are initially included in the Yucca Mountain Project cost estimate through 2023. The remaining costs for these areas are included in the Balance of Program estimate.

4. Current PETT costs are based on a negotiated amount between the Department, the State of Nevada and local governments. It is assumed that PETT costs will increase during the construction period to reflect expenditures at Yucca Mountain, then will level off at a flat rate throughout the operations period.

5. As stated in the NWPA, the State or Indian tribe in which the potential repository is located is eligible to receive annual payments through the decommissioning of the repository.

6. NWPA Section 180(c) benefits payments for transportation corridor states are included in the Transportation Institutional estimate.

7. It is assumed that the NRC will be the regulator for the Yucca Mountain Repository throughout its lifecycle and that future associated NWF costs will be consistent with NRC budget estimates and reflect varied staffing levels. As with the Department's Program staffing, NRC staffing is assumed to fluctuate based on the level and type of ongoing activity at the Repository.

8. The NWTRB is assumed to be funded through the first year after the beginning of waste receipt, at a level of approximately $3 million per year.

9. Costs for the initial purchase of 35 TADs are included in the Waste Management cost estimate under this element. For the purposes of the report, it is assumed that costs for these TADs will be incurred between FY2015 and FY2017 in order to support initial Transportation and Repository operations.

4.3 BALANCE OF PROGRAM COSTS

This Balance of Program estimate includes Development & Evaluation costs through 2002. It also includes historical (2003 – 2006) and future (2007 – 2133) costs for Quality Assurance; Waste Management; Program Management; Benefits, PETT, Outreach and Institutional; and Other Agencies. Major cost drivers for the Balance of Program estimate are PETT, benefits, and financial assistance to be paid to state and local entities over the life of the Program. A summary of program costs is included in Table 4-1 below.

Table 4-1. Balance of Program Cost Summary (in Millions of 2007$)

Cost Element	Historical (1983 – 2006)	Future Costs (2007 – 2133)	Total Costs (1983 – 2133)
Development & Evaluation (1983 – 2002)	2,300	0	2,300
Quality Assurance (2003 – 2133)	60	670	730
Waste Management (2003 – 2133)	30	330	360
Program Management (2003 – 2133)	270	3,020	3,280
Benefits, PETT, Outreach and Institutional (2003 – 2133)	0	3,150	3,150
Other Agencies (2003 – 2133)	200	1,170	1,370
Total	**2,860**	**8,340**	**11,200**

NOTE: Row and column totals may not add due to rounding.

5. COMMERCIAL/DEFENSE COST SHARE ALLOCATION

The CRWMS is funded on a full-cost recovery basis, with waste generators paying their respective disposal costs. Allocation of costs between commercial and defense waste generators are recalculated when the TSLCC is reestimated and the percentage shares are applied to both historical and future costs. Cost allocation is based on the methodology published in the August 20, 1987, Federal Register Notice (52 FR 31508). In accordance with that methodology, the costs of activities related to the disposal of a specific type of waste, whether civilian or government-managed, are assigned to that waste generator. Remaining Program costs are then shared in the same proportion as assigned direct and common variable costs. This prevents cross-subsidization between waste generators and ensures that each bears the full cost of disposal of its wastes.

Each cost account (line item) in the TSLCC is assigned to one of three cost-sharing categories. Costs in each category are then assigned to the appropriate waste generator. Cost accounts are grouped into the following categories:

1. Assignable direct costs are incurred solely for the disposal of DOE SNF and HLW or of commercial SNF and HLW. One hundred percent of the costs in directly assignable categories are allocated to the appropriate waste generator.

2. Assignable common variable costs are allocated to civilian and government purchasers by applying various cost sharing factors, such as piece count and areal dispersion, to the specific cost accounts. Sharing costs by a piece-count factor is based on the

number of waste packages emplaced, number of waste shipments, etc. Sharing costs by areal dispersion is based on the repository disposal area required for government-managed or civilian waste divided by the total disposal area. Sharing factors vary depending on the basis used for cost sharing.

3. All costs that cannot be included in one of the previous categories are called common unassigned costs. Unassigned costs are allocated in the same percentage as total assigned costs. Using this TSLCC as an example, because 19.6% of total assigned costs were allocated to defense, 19.6% of unassigned costs were also allocated to defense.

The allocation of estimated costs and percentages to civilian and government purchasers is shown on Table 5-1. Table 5-2 shows detailed cost share allocations and provides insight into how the overall percentages and dollar amounts are derived.

Table 5-1. Commercial and Defense Shares (in Billions of 2007$)

Entity Responsible	Percentage	Total Life Cycle Costs
Commercial – Nuclear Waste Fund	80.4%	77.38
Defense – Annual Appropriations	19.6%	18.80
TOTAL TSLCC	**100%**	**96.18**

Table 5-2. Detailed Civilian Radioactive Waste Management Cost Share Allocations (in Millions of 2007$)

Category	Cost Share Allocation		
	Government-Managed Nuclear Material	Civilian	Total
Repository	14,130	50,610	64,740
Assigned	10,410	35,310	45,720
Unassigned	3,720	15,300	19,020
Allocation Percent	21.8%	78.2%	100%
Transportation	2,490	17,800	20,290
Assigned	2,280	16,940	19,220
Unassigned	210	860	1,070
Allocation Percent	12.3%	87.7%	100%
Balance of Program – Unassigned	2,180	8,970	11,150
Allocation Percent	19.6%	80.4%	100%
Total	18,800	77,380	96,180
Aggregate Allocation Percent	19.6%	80.4%	100%

NOTE: Totals may not add or compare with other totals due to independent rounding.

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APPENDIX A

COMPARISON WITH 2001 TOTAL SYSTEM LIFE CYCLE COST

A1. COMPARISON WITH 2001 TOTAL SYSTEM LIFE CYCLE COST

This appendix provides a comparison of the results of the current TSLCC estimate with the 2001 TSLCC estimate. All estimates are in constant 2000 dollars to remove the effects of inflation. The current estimate of $79.4 Billion, in constant 2000 dollars, compares with the 2001 TSLCC estimate of $57.5 Billion, in constant 2000 dollars. Table A-1 provides a comparison of the 2001 TSLCC with the 2007 TSLCC. Table A-2 provides a summary comparison of the assumptions between the 2001 and 2007 TSLCC estimates.

Table A-1. Comparison of 2001 and 2007 TSLCC Costs (in Millions of 2000$)

Cost Element	2001 TSLCC	2007 TSLCC	Variance	% Variance
Repository Costs	**42,880**	**53,390**	**10,510**	**25%**
Licensing	**1,290**	**1,930**	**640**	**50%**
Development & Evaluation	0	0	0	—
Engineering, Procurement, Construction	1,290	1,930	640	50%
Operations	0	0	0	—
Monitoring	0	0	0	—
Closure	0	0	0	—
Surface & Subsurface Facilities	**16,830**	**22,380**	**5,550**	**33%**
Development & Evaluation	0	0	0	—
Engineering, Procurement, Construction	3,630	12,830	9,200	253%
Operations	9,630	7,900	−1,730	−18%
Monitoring	2,890	850	−2,040	−71%
Closure	680	800	120	18%
Waste Packages & Drip Shields	**13,240**	**16,870**	**3,630**	**27%**
Development & Evaluation	0	0	0	—
Engineering, Procurement, Construction	200	200	0	0%
Operations	8,270	10,380	2,110	26%
Monitoring	1,550	6,290	4,740	306%
Closure	3,220	0	−3,220	−100%
Performance Confirmation	**2,060**	**2,490**	**430**	**21%**
Development & Evaluation	0	0	0	—
Engineering, Procurement, Construction	330	0	−330	−100%
Operations	870	1,390	520	60%
Monitoring	860	860	0	0%
Closure	0	250	250	—
Regulatory, Infrastructure, & Management Support	**9,460**	**9,720**	**260**	**3%**
Development & Evaluation	6,740	6,870	130	2%
Engineering, Procurement, Construction	940	0	−940	−100%
Operations	940	2,380	1,440	153%
Monitoring	700	370	−330	−47%
Closure	140	100	−40	−29%

Table A-1. Comparison of 2001 and 2007 TSLCC Costs (in Millions of 2000$) (Continued)

Cost Element	2001 TSLCC	2007 TSLCC	Variance	% Variance
Transportation	**7,160**	**16,710**	**9,550**	**133%**
Development & Evaluation	480	530	50	10%
National Transportation	5,840	13,960	8,120	139%
Nevada Rail Infrastructure	840	2,220	1,380	164%
Balance of Program	**7,480**	**9,240**	**1,760**	**24%**
Development & Evaluation	1,860	1,900	40	2%
Quality Assurance	540	600	60	11%
Waste Acceptance	70	300	230	329%
Program Management	1,420	2,710	1,290	91%
Benefits, PETT, Outreach & Institutional	3,310	2,600	−710	−21%
Other Agencies	280	1,130	850	304%
TOTAL CRWMS COST	**57,520**	**79,340**	**21,820**	**38%**

NOTE: Totals may not add or compare to other totals due to rounding.

1. All Costs in Table A-1 and in the notes below are in millions of fiscal year 2000 dollars.
2. Some cost items reported in the 2001 TSLCC have been reallocated to conform to the way costs are currently tracked. This allows for a more accurate comparison between the 2001 and 2007 estimates. Specifically, the 2001 TSLCC adjustments and/or re allocations are as follows:
   a. Payments Equal To Taxes costs of $368 million through 2010 were transferred from Balance of Program to Repository;
   b. Benefit costs of $89 million through 2010 were transferred from Balance of Program to Repository;
   c. Financial Assistance costs of $352 million through 2010 were transferred from Balance of Program to Repository;
   d. Waste Acceptance costs of $100 million were transferred from Transportation to Balance of Program; and
   e. 180(c) Assistance costs of $460 million were transferred from Balance of Program to Transportation.
3. The 2001 TSLCC total of $57,520 (in millions of 2000$) has not changed.
4. The “Variance” and “% Variance” are calculated on costs rounded to the nearest ten million.

Table A-2. Comparison of 2001 and 2007 TSLCC Assumptions

TOPIC	2001 TSLCC	2007 TSLCC
Waste Management		
Total Amount Accepted	CSNF: 83,800 MTHM DOE: ~13,200 MTHM 21,847 defense HLW canisters 300 canisters West Valley HLW 3,841 DOE SNF canisters 300 Navy canisters	CSNF: 109,300 MTHM CSNF DOE: 12,800 MTHM 19,390 defense HLW canisters 277 WVDP HLW canisters 2,788 DOE SNF canisters 400 Navy canisters
License Extensions	N/A	47
Start Waste Pickup	6/2010	4/2017
Last Waste Pickup Last TAD Delivery	2040 2040	2063 2073
Transportation		
Cask Capacities	Commercial Rail UCF: 26 PWR/68 BWR; 12 PWR/32 BWR DPCs: 24/68, 26/56, 21/44 PWR/BWR HH: 12/32, 7/17 PWR/BWR LWT: 1–4 PWR/2–9 BWR, various specialty casks HLW: 5 canisters (small and large) DOE SNF: 9 canisters, 4 MCOs, 1 Naval canister	Commercial Rail TAD overpacks: 21 PWR/44 BWR DPCs: 24 PWR, 26 PWR, 32 PWR, 36 PWR (Yankee Rowe only), 52 BWR, 56 BWR, 61 BWR, 68 BWR, 80 BWR (Humboldt Bay only) LWT: 1–4 PWR/2–9 BWR, various specialty casks HLW: 5 canisters (small and large) DOE SNF: 9 canisters, 4 MCOs, 1 Naval canister
Transportation Modal Split	8 reactor pool facilities and 2 DOE storage sites ship by commercial LWT 46 pool facilities ship by Small Rail 46 pool facilities ship by Large Rail	8 reactor pool facilities and 2 DOE storage sites ship by commercial LWT 24 sites intermodal 74 direct rail, 9 truck, 19 heavy haul/rail, 17 barge/rail sites
Rail Shipping	General freight for all rail shipments	All rail shipments by dedicated train
Cask Maintenance Facility	Limited maintenance integrated with repository facilities; responsibility of RSCs	Independent facility to service and warehouse transportation casks and ancillary equipment
Rail Equipment Maintenance Yard	N/A	Integrated facilities at end of Nevada Rail Line to service and stage rail car fleet
Repository		
Monitoring Phase	From end of emplacement to 100 years after the beginning of emplacement	From 50 years beyond the last waste package emplacement
Monitoring End	2110	2123
Closure Phase	10 years	10 years
Closure	2119	2133

Table A-2. Comparison of 2001 and 2007 TSLCC Assumptions (Continued)

TOPIC	2001 TSLCC		2007 TSLCC	
Number of Cask Shipments	Rail UCF	5,645	Truck	4,239
	Rail DPC	3,583	DPCs	920
	Truck	1,039	TADs	10,989
	HLW	4,430	DOE Rail	4,710
	DOE SNF	784		
	Total	15,481	Total	20,858
Number of Waste Packages	Large – 5,800 PWR/3,732 BWR		TADs – 7,978 PWR/5,005 BWR	
	Small – 293 PWR/94 BWR		Codisp – 1,493	
	HLW including IPWF – 906		CodispLong – 2,352	
	HLW codisposed with DOE SNF – 3,643		CodispMCO – 220	
	Naval SNF – 300		Navy – 90	
	Total – 14,768		NavyLong – 310	
			Total – 17,448	

APPENDIX B

ANNUAL COST PROFILE

B1. ANNUAL COST PROFILE

Figure B-1 shows the annual life cycle cost profile that has been decomposed into four categories. The costs are in 2007 dollars. For a comparison with the 2001 TSLCC, please see the *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program* (May 2001), cited in Appendix C.

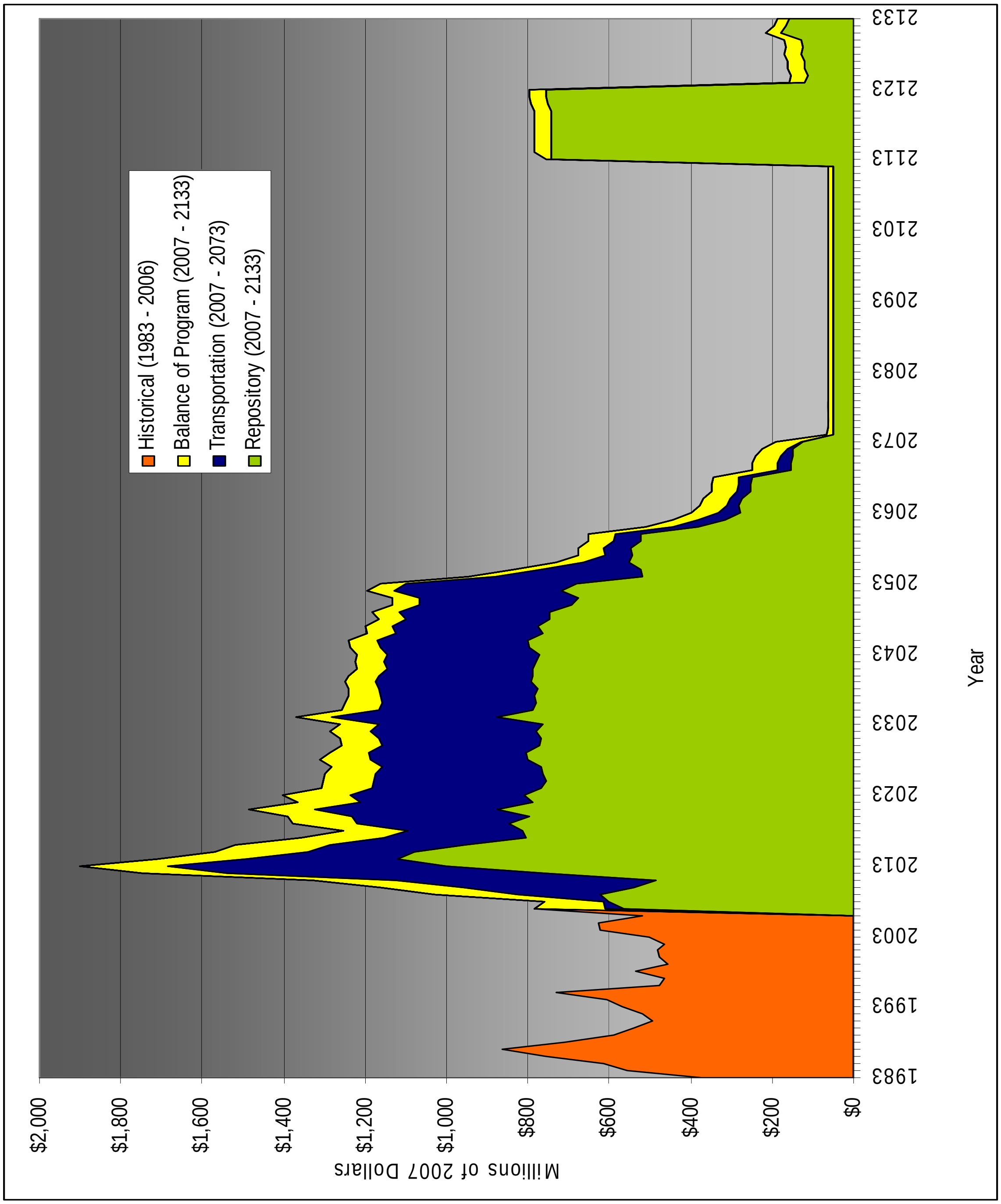

Figure B-1. Annual Total System Life Cycle Cost Profile

Table B-1 presents the annual life cycle cost of the Program. The Historical costs are shaded. The annual estimate is in constant 2007 dollars. Budget requests for the OCRWM program are in year-of-expenditure dollars, and will not be the same as these charts. Additionally, the estimate for 2007 and 2008 do not reflect any appropriation decisions since the cost estimate was developed.

Table B-1. Annual Cost Profile (in Millions of 2007$)

Year	Repository	Transportation	Balance of Program	Total
1983	$ 347	$ 8	$ 18	$ 374
1984	$ 456	$ 24	$ 75	$ 555
1985	$ 473	$ 34	$ 107	$ 614
1986	$ 603	$ 28	$ 124	$ 755
1987	$ 720	$ 42	$ 102	$ 864
1988	$ 539	$ 44	$ 128	$ 711
1989	$ 399	$ 55	$ 136	$ 590
1990	$ 329	$ 55	$ 158	$ 541
1991	$ 289	$ 53	$ 152	$ 493
1992	$ 299	$ 66	$ 154	$ 520
1993	$ 333	$ 60	$ 175	$ 568
1994	$ 393	$ 49	$ 163	$ 605
1995	$ 517	$ 48	$ 164	$ 729
1996	$ 331	$ 42	$ 103	$ 476
1997	$ 356	$ 12	$ 95	$ 463
1998	$ 435	$ 8	$ 92	$ 535
1999	$ 371	$ 2	$ 84	$ 457
2000	$ 389	$ 3	$ 87	$ 479
2001	$ 386	$ 3	$ 92	$ 480
2002	$ 368	$ 4	$ 93	$ 464
2003	$ 395	$ 9	$ 100	$ 504
2004	$ 465	$ 32	$ 124	$ 621
2005	$ 392	$ 57	$ 179	$ 627
2006	$ 324	$ 41	$ 153	$ 517
2007	$ 566	$ 42	$ 178	$ 786
2008	$ 601	$ 15	$ 144	$ 759
2009	$ 624	$ 202	$ 204	$ 1,030
2010	$ 540	$ 418	$ 204	$ 1,162
2011	$ 483	$ 641	$ 204	$ 1,328
2012	$ 758	$ 782	$ 207	$ 1,746
2013	$ 1,002	$ 683	$ 217	$ 1,902
2014	$ 1,120	$ 374	$ 217	$ 1,710
2015	$ 1,081	$ 260	$ 229	$ 1,569
2016	$ 956	$ 329	$ 233	$ 1,518

Table B-1. Annual Cost Profile (in Millions of 2007$) (Continued)

Year	Repository	Transportation	Balance of Program	Total
2017	$ 807	$ 348	$ 202	$ 1,356
2018	$ 811	$ 285	$ 156	$ 1,253
2019	$ 847	$ 374	$ 157	$ 1,378
2020	$ 795	$ 438	$ 157	$ 1,390
2021	$ 875	$ 449	$ 159	$ 1,484
2022	$ 787	$ 424	$ 156	$ 1,367
2023	$ 809	$ 429	$ 162	$ 1,401
2024	$ 770	$ 414	$ 125	$ 1,308
2025	$ 756	$ 422	$ 125	$ 1,302
2026	$ 765	$ 408	$ 125	$ 1,297
2027	$ 770	$ 388	$ 125	$ 1,282
2028	$ 800	$ 386	$ 125	$ 1,310
2029	$ 806	$ 384	$ 97	$ 1,288
2030	$ 771	$ 387	$ 97	$ 1,256
2031	$ 769	$ 396	$ 97	$ 1,262
2032	$ 781	$ 407	$ 97	$ 1,286
2033	$ 764	$ 402	$ 97	$ 1,263
2034	$ 877	$ 403	$ 90	$ 1,371
2035	$ 790	$ 378	$ 90	$ 1,258
2036	$ 780	$ 377	$ 90	$ 1,247
2037	$ 783	$ 378	$ 78	$ 1,239
2038	$ 777	$ 387	$ 78	$ 1,243
2039	$ 794	$ 382	$ 74	$ 1,250
2040	$ 789	$ 376	$ 74	$ 1,239
2041	$ 789	$ 357	$ 74	$ 1,220
2042	$ 782	$ 370	$ 74	$ 1,226
2043	$ 770	$ 374	$ 74	$ 1,218
2044	$ 798	$ 365	$ 72	$ 1,235
2045	$ 800	$ 370	$ 72	$ 1,242
2046	$ 763	$ 361	$ 72	$ 1,196
2047	$ 776	$ 355	$ 66	$ 1,197
2048	$ 748	$ 353	$ 66	$ 1,167
2049	$ 745	$ 370	$ 66	$ 1,181
2050	$ 691	$ 374	$ 66	$ 1,131
2051	$ 677	$ 391	$ 66	$ 1,134
2052	$ 719	$ 412	$ 66	$ 1,197
2053	$ 679	$ 418	$ 66	$ 1,164
2054	$ 518	$ 360	$ 66	$ 945

Table B-1. Annual Cost Profile (in Millions of 2007$) (Continued)

Year	Repository	Transportation	Balance of Program	Total
2055	$ 523	$ 244	$ 66	$ 834
2056	$ 554	$ 112	$ 66	$ 732
2057	$ 543	$ 69	$ 63	$ 674
2058	$ 546	$ 67	$ 63	$ 676
2059	$ 523	$ 66	$ 63	$ 651
2060	$ 521	$ 66	$ 63	$ 649
2061	$ 380	$ 65	$ 63	$ 509
2062	$ 317	$ 65	$ 63	$ 445
2063	$ 277	$ 57	$ 63	$ 397
2064	$ 282	$ 31	$ 63	$ 376
2065	$ 273	$ 31	$ 63	$ 368
2066	$ 255	$ 31	$ 63	$ 349
2067	$ 252	$ 31	$ 63	$ 347
2068	$ 249	$ 32	$ 63	$ 344
2069	$ 153	$ 33	$ 63	$ 250
2070	$ 152	$ 35	$ 63	$ 250
2071	$ 150	$ 27	$ 63	$ 240
2072	$ 149	$ 13	$ 63	$ 226
2073	$ 125	$ 2	$ 63	$ 190
2074	$ 50	$ —	$ 14	$ 65
2075	$ 50	$ —	$ 13	$ 63
2076	$ 50	$ —	$ 13	$ 63
2077	$ 50	$ —	$ 13	$ 63
2078	$ 50	$ —	$ 13	$ 63
2079	$ 50	$ —	$ 13	$ 63
2080	$ 50	$ —	$ 13	$ 63
2081	$ 50	$ —	$ 13	$ 63
2082	$ 50	$ —	$ 13	$ 63
2083	$ 50	$ —	$ 13	$ 63
2084	$ 50	$ —	$ 13	$ 63
2085	$ 50	$ —	$ 13	$ 63
2086	$ 50	$ —	$ 13	$ 63
2087	$ 50	$ —	$ 13	$ 63
2088	$ 50	$ —	$ 13	$ 63
2089	$ 50	$ —	$ 13	$ 63
2090	$ 50	$ —	$ 13	$ 63
2091	$ 50	$ —	$ 13	$ 63
2092	$ 50	$ —	$ 13	$ 63
2093	$ 50	$ —	$ 13	$ 63

Table B-1. Annual Cost Profile (in Millions of 2007$) (Continued)

Year	Repository	Transportation	Balance of Program	Total
2094	$ 50	$ —	$ 13	$ 63
2095	$ 50	$ —	$ 13	$ 63
2096	$ 50	$ —	$ 13	$ 63
2097	$ 50	$ —	$ 13	$ 63
2098	$ 50	$ —	$ 13	$ 63
2099	$ 50	$ —	$ 13	$ 63
2100	$ 50	$ —	$ 13	$ 63
2101	$ 50	$ —	$ 13	$ 63
2102	$ 50	$ —	$ 13	$ 63
2103	$ 50	$ —	$ 13	$ 63
2104	$ 50	$ —	$ 13	$ 63
2105	$ 50	$ —	$ 13	$ 63
2106	$ 50	$ —	$ 13	$ 63
2107	$ 50	$ —	$ 13	$ 63
2108	$ 50	$ —	$ 13	$ 63
2109	$ 50	$ —	$ 13	$ 63
2110	$ 50	$ —	$ 13	$ 63
2111	$ 50	$ —	$ 13	$ 63
2112	$ 50	$ —	$ 13	$ 63
2113	$ 744	$ —	$ 13	$ 756
2114	$ 744	$ —	$ 41	$ 785
2115	$ 744	$ —	$ 41	$ 785
2116	$ 744	$ —	$ 41	$ 785
2117	$ 744	$ —	$ 41	$ 785
2118	$ 744	$ —	$ 41	$ 785
2119	$ 744	$ —	$ 41	$ 785
2120	$ 744	$ —	$ 41	$ 785
2121	$ 750	$ —	$ 41	$ 791
2122	$ 757	$ —	$ 41	$ 798
2123	$ 757	$ —	$ 41	$ 798
2124	$ 119	$ —	$ 40	$ 159
2125	$ 113	$ —	$ 40	$ 154
2126	$ 121	$ —	$ 40	$ 161
2127	$ 122	$ —	$ 40	$ 162
2128	$ 129	$ —	$ 40	$ 169
2129	$ 126	$ —	$ 40	$ 166
2130	$ 129	$ —	$ 40	$ 169
2131	$ 178	$ —	$ 37	$ 215
2132	$ 165	$ —	$ 30	$ 195

Table B-1. Annual Cost Profile (in Millions of 2007$) (Continued)

Year	Repository	Transportation	Balance of Program	Total
2133	$ 159	$ —	$ 27	$ 186
TOTAL	**$ 64,728**	**$ 20,252**	**$ 11,201**	**$ 96,181**

NOTE: Columns totals may not add due to rounding.

APPENDIX C

REFERENCES

C1. REFERENCES

C1.1 DOCUMENTS CITED

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