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NUCLEAR WASTE

A Look at Current Use of Funds and Cost Estimates for the Future

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The Honorable J. Bennett Johnston
Chairman, Committee on Energy
and Natural Resources
United States Senate

The Honorable James A. McClure
Ranking Minority Member
Committee on Energy and Natural Resources
United States Senate

As requested, this report discusses the results of our review of program costs within the Department of Energy's nuclear waste program.

We are sending copies to the Secretary of Energy, other committees and Members of the Congress, and other interested parties. Copies will be made available to others upon request.

This work was performed under the direction of Mr. Keith O. Fultz, Associate Director. Other major contributors are listed in appendix V.

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Executive Summary

Purpose

Since 1983, when the Department of Energy (DOE) began its current program to dispose of spent (used) nuclear fuel and other highly radioactive waste, the Department has revised its long-range cost estimates from about $20 billion to between $21 billion and $41 billion, depending on various schedule and technical assumptions. Delays in meeting some program milestones have also added to the costs of the program, and DOE has proposed a 5-year delay in the program for the first repository to come on-line. Concerned over cost growth and the effects of program delays on costs, the Senate Committee on Energy and Natural Resources asked GAO to (1) compare the use of fiscal year 1985 program funds with the approved budget, (2) assess the effects of schedule delays on program costs, and (3) assess DOE's long-range cost estimates and reasons for substantial increases in the estimates. This report addresses the first two issues, and also addresses the third issue on a broad, total-program basis. In subsequent reviews, GAO intends to assess reasons for cost increases in specific cost components.

Background

The Nuclear Waste Policy Act of 1982 established a comprehensive national program for developing deep underground repositories to safely isolate nuclear waste. The act established a step-by-step process for siting two geologic repositories. For the first repository, it required the Secretary of Energy to nominate at least five sites suitable for detailed testing (called site characterization), prepare an environmental assessment for each nominated site, and recommend three sites for such testing to the President by January 1985. DOE completed the environmental assessments and recommended sites for testing in May 1986. DOE is also required to identify candidate second repository sites by following essentially the same procedures.

The act requires owners and generators of nuclear waste to finance the program by paying disposal fees into the Nuclear Waste Fund. The Secretary must evaluate the amount of the fee annually to determine if total revenues will offset total costs. As part of this determination, DOE estimates the long-range cost (life cycle) of disposing of the waste generated through 2020. Estimating the volume of waste that will be generated is key to fee adequacy analyses and waste system planning.

Results in Brief

Changes in the scope, content, and schedule for completing environmental assessments delayed the recommendation of three candidate sites for the first repository. As a result,

- some activities planned for fiscal year 1985 were not accomplished that year, and funds were used for other program purposes;
- near-term program costs increased by an amount that has not been measured precisely but is estimated by DOE officials to be in the millions of dollars; and
- the time available to meet future milestones was compressed significantly, and DOE subsequently delayed the operational date for the first repository by 5 years.

Life cycle cost estimates have changed each year because of uncertainty in the final design and operation of the waste disposal system. Although DOE's cost estimating methodology has improved, program uncertainties will limit confidence in the estimates for the next several years. One such uncertainty is the estimated quantity of spent fuel for disposal. By all present indicators, DOE's estimating approach overstates the amount of spent fuel that utilities will generate and the fees that they will pay into the Nuclear Waste Fund. As a result, DOE may not be collecting fees at a rate that will cover total program costs and may be overbuilding the waste system.

Principal Findings

Delays Affect Use of Funds

Some activities planned for fiscal year 1985 had not been started or completed because of delays in issuing the environmental assessments. For example, site characterization plans were not started or completed as planned. Because activities such as these were delayed, DOE used the related funds to cover the increased costs of other activities. (See ch. 2.)

Expanded Assessments and Delays Increase Costs

DOE expanded the initial scope and content of the environmental assessments. Therefore, additional funds were needed to complete these documents. For example, DOE originally planned to spend $92,000 on the environmental assessment of the Hanford, Washington, site in fiscal year 1985. Actual costs were $1 million. Moreover, DOE continued to incur costs for activities that should have ended had the environmental assessments been completed as originally scheduled. For example, the management costs (planning and scheduling, contract administration and purchasing, records management, etc.) related to studying candidate locations continued longer than planned. These activities cost an additional $140,000 over the budgeted cost in fiscal year 1985, and had cost an additional $1.3 million by the time DOE completed the environmental assessments. (See ch. 2.)

Milestones Compressed

Delays in the schedule for the first repository have moved remaining milestones closer to January 31, 1998—DOE's original target for completing the repository. As a result of this compression, in June 1987 DOE rescheduled startup of the first repository from 1998 to 2003. Prior to this extension, DOE field officials, scientists working for DOE contractors, and the Nuclear Regulatory Commission had expressed concern over the effect of schedule delays on DOE's ability to meet the original milestones without sacrificing quality. (See ch. 2.)

Life Cycle Cost Estimates Uncertain

DOE's life cycle cost analyses show a range of costs for transporting, packaging, and disposing of nuclear waste in two repositories. Cost estimates have changed significantly from one year to the next. Since 1983, for example, development and evaluation cost estimates (essentially, costs incurred up to repository construction) have increased about $4 billion while transportation cost estimates have decreased $2 billion to $3 billion. Repository cost estimates increased $0.6 billion to $8.5 billion from 1983 to 1986. (GAO has adjusted these numbers to constant 1986 dollars.) DOE attributes these changes to changes in the type of waste disposal system to be implemented, revised engineering designs, and use of different estimating methods. Underlying these reasons is uncertainty over the final design, construction, and operation of the waste system. (See ch. 3.)

Optimistic Spent Fuel Estimates

DOE's spent fuel projections and revenue estimates are based on long-range forecasts of economic activity and energy demand, and the assumption that nuclear power will grow and provide a material portion of electricity demand. However, utilities have not ordered new nuclear plants for a decade and no orders are expected in the next few years. Overestimating the future growth of the industry creates a danger that an unnecessarily large waste disposal system may be built and that current fees may be set too low to produce revenues at the rate needed to cover total program costs.

DOE could reduce the uncertainty inherent in projecting spent fuel inventories and revenues by basing these projections on actual nuclear power plants operating and under active construction. Because 16 or more years are required to build new nuclear plants and allow for the initial batch of spent fuel to cool sufficiently for disposal in a repository. DOE has ample time to incorporate new plants into its waste program plans. (See ch. 3.)

Recommendation

For waste system planning, including life cycle cost analyses and fee adequacy determination, GAO recommends that the Secretary of Energy project spent fuel inventories on the basis of nuclear plants operating and under active construction.

Agency Comments

DOE agreed with the GAO budget and expenditure analysis, and the conclusion that schedule delays have increased program costs.

DOE did not agree that spent fuel inventories should be projected on the basis of existing nuclear power plants. DOE believes that prudent planning includes designing a system that will dispose of the maximum amount of reasonably projected waste. DOE added that its projection represents the maximum amount of spent fuel that can be reasonably projected, and that it is based on positive developments in the nuclear power industry. GAO does not agree that DOE's forecasting approach provides "reasonable" estimates of spent fuel inventories because the approach does not take existing conditions within the nuclear power industry into account.

Finally, DOE stated that geologic disposal needs may be understated if only existing nuclear plants are used to project spent fuel inventories. GAO recognizes that this is a possibility if utilities eventually begin ordering new nuclear plants. GAO believes, however, that DOE would have adequate lead time, following new plant orders, to appropriately adjust its waste disposal system plans.

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Abbreviations

DOE	Department of Energy
EIA	Energy Information Administration
MRS	Monitored Retrievable Storage
MTU	metric tons uranium
NAS	National Academy of Sciences
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982
OCRWM	Office of Civilian Radioactive Waste Management
OMB	Office of Management and Budget
TSLCC	total system life cycle cost

Introduction

The safe disposal of spent nuclear fuel and other high-level radioactive wastes has been a national concern for almost 3 decades.[1] Nuclear waste is difficult to dispose of because of its high toxicity, heat production, and long-lived nature. Because nuclear waste can remain hazardous for hundreds to thousands of years, it must be isolated from the environment until its radioactivity declines to levels that will not threaten people or the environment.

The Nuclear Waste Policy Act of 1982 (NWPA) (Public Law 97-425) established a comprehensive national program directed toward (1) siting, constructing, and operating geologic repositories for the permanent disposal of nuclear waste and (2) developing means to safely store such waste until its ultimate disposal. The act authorized the Department of Energy (DOE) to enter into contracts to begin accepting nuclear waste by January 31, 1998. NWPA also established the Office of Civilian Radioactive Waste Management (OCRWM) within DOE to carry out the provisions of the act and established the Nuclear Waste Fund to finance the program.

NWPA required that the cost of providing disposal and/or storage services be fully recovered from the generators and owners of nuclear waste through fees paid into the Nuclear Waste Fund. NWPA requires the Secretary of Energy to review annually the amount of the fee established to determine whether it will provide sufficient revenues to offset the costs of the program and if not, to propose an adjustment of the fee to the Congress. As part of this annual fee adequacy determination, DOE develops total system life cycle cost (TSLCC) estimates for disposing of waste generated through December 31, 2020, the date specified by the act.

Key Requirements of the Act

NWPA, among other things, established a step-by-step process for the siting and testing of two geologic repositories and the licensing, construction, and operation of the first repository. For construction of a second repository, congressional authorization would be required. The act also requires DOE to complete a study of the need for and feasibility of a monitored retrievable storage (MRS) facility and to submit a proposal to

[1] Spent nuclear fuel is the used uranium fuel that has been removed from a nuclear reactor and used to the extent that it can no longer be useful in the production of electricity.

the Congress for the construction of one or more MRS facilities.[2] To finance the program, NWPA requires nuclear utilities, through contracts with DOE, to pay annually into the Nuclear Waste Fund a user fee of 1 mill (one-tenth of a cent) per killowatt hour of electricity generated from their nuclear power plants since 1983 and to pay a one-time user fee for disposal of their spent nuclear fuel generated before April 7, 1983.

The First Repository Subprogram

NWPA requires the Secretary of Energy to nominate as first repository candidates at least five sites that he determines are suitable for more detailed geologic testing, called site characterization, and to recommend three of the five sites for such testing to the President. According to NWPA, DOE's recommendation of the three sites for site characterization will be accompanied by an environmental assessment for each site that must explain the basis for DOE's recommendation and the probable impacts of investigation activities at each site on public health and safety and the environment.

After the Secretary prepares environmental assessments and recommends candidate sites, NWPA requires the President to review each candidate site recommendation and accompanying environmental assessment to either approve or disapprove the candidate site for further detailed testing. NWPA implies that the environmental assessments be completed no later than January 1, 1985, when the Secretary was to have recommended to the President three potential first repository sites for site characterization.[3] In May 1986 DOE recommended and the President approved three potentially acceptable first repository sites for site characterization—Hanford, Washington; Yucca Mountain, Nevada; and Deaf Smith County, Texas.

The Second Repository Subprogram

NWPA requires the Secretary of Energy to recommend to the President by July 1, 1989, three candidate second repository sites for site characterization. DOE's second repository efforts have focused primarily on the study of crystalline rock formations in 17 states in the north central, northeastern, and southeastern regions of the United States. Although

[2]MRS facilities are generally thought of as ground-level or slightly below ground-level storage facilities that will permit continuous monitoring, management, and maintenance of radioactive waste. These facilities also are to provide for the ready retrieval of radioactive waste for either further processing or permanent disposal

[3]Site characterization includes activities undertaken to establish the geological condition and the ranges of the parameters of a candidate site relevant to the location of a repository.

site-specific work on a second repository was postponed by the Secretary of Energy in May 1986, DOE plans, with Congressional approval, to continue studies that will focus on technical issues and alternate siting strategies until 1995, when it plans to start a national survey leading to the identification of candidate sites in 2007. If affirmative congressional action on DOE's plans is not taken, DOE plans to immediately resume its efforts to identify potentially acceptable second repository sites.

Monitored Retrievable Storage

NWPA required DOE to complete by June 1, 1985, a detailed study of the need for and feasibility of one or more MRS facilities where radioactive waste can be packaged, monitored, stored, and subsequently retrieved for disposal in a permanent repository. NWPA also required DOE to submit by June 1, 1985, a proposal to the Congress for its approval to construct one or more of these facilities. DOE's proposal was ready for submittal to the Congress in February 1986, but litigation delayed the submittal for more than a year. On March 31, 1987, DOE submitted its MRS proposal to the Congress.

Financing the Program Through User Fees

As required by section 302 of NWPA, as of December 31, 1986, nuclear utilities had paid about $1.2 billion in annual fees and over $1.4 billion in one-time user fees into the Nuclear Waste Fund. The fund finances repository development activities, including preparation of the environmental assessments and site characterization plans, MRS activities, and construction of test and evaluation facilities. It also finances nongeneric research, program administrative costs, and other related costs. As of December 31, 1986, the fund had a balance of about $1.5 billion.

The Congress makes annual appropriations from the fund that remain available to DOE until expended. Table 1.1 shows DOE's budget requests and appropriations from the Nuclear Waste Fund for fiscal years 1983 through 1988. DOE obligates money from the fund by awarding contracts and grants, and also disburses funds for its civil service payroll and other program needs. DOE can obligate amounts only as appropriated, regardless of the balance of the fund. Since inception of the fund, DOE has obligated about $1.4 billion for over 140 contracts.

Table 1.1: DOE's Budget Requests and Appropriations From the Nuclear Waste Fund—Fiscal Years 1983 Through 1988

Dollars in thousands

Fiscal year	Budget request	Appropriation
1983	$ •	$218,600
1984	306,675	319,621
1985	327,669	327,669
1986	571,460	521,460[b]
1987	769,349[a]	499,000
1988	500,000[c]	•

[a]After DOE's announcement to postpone site-specific activities for a second repository a budget amendment was submitted reducing this amount by $58.9 million to $710.449 million

[b]This appropriation was subsequently reduced by $22.423 million in compliance with the Balanced Budget and Emergency Deficit Control Act of 1985, Public Law 99-177

[c]Reflects a $225 million reduction in the amount of funding DOE estimated was needed to carry out the program in fiscal year 1987 pending satisfactory resolution with the Congress on issues pertaining to consultation and cooperation with states and Indian tribes affected by sites selected for characterization Upon satisfactory resolution, an amendment to the fiscal year 1988 budget will be submitted to provide the required funding to carry out the program

As required by NWPA DOE has reviewed annually the amount of the fee paid into the Nuclear Waste Fund Since inception of the program, DOE has not proposed any adjustments to the fee because its fee-adequacy determination has shown that fees collected are sufficient to cover the costs of the program. In July 1983 DOE estimated that its program would cost between $19.3 billion and $19.8 billion (in constant 1982 dollars). In April 1986 DOE estimated that its program will operate over 100 years and cost between $21.3 billion and $40.5 billion (in constant 1985 dollars) depending on assumptions such as repository operating dates and waste quantities. One assumption DOE made in determining fee-adequacy analyses and waste system planning is the volume of waste that will be generated through 2020 (See ch. 3.)

DOE's TSLCC estimates prepared through April 1986 were comprised of three major cost categories—development and evaluation, transportation, and repository construction and operation The development and evaluation category includes costs for siting, design development, testing, and regulatory and institutional activities associated with the repositories and transportation. The costs of building and operating repositories and transporting wastes are not included in this category. As DOE has defined the development and evaluation category, it encompasses all program expenditures both currently and for the next several years as well as the life cycle federal administrative costs of the waste management program.

The transportation category includes costs for the purchase of shipping casks and for carrying out the actual transportation of waste once the system is operational. The repository category includes costs for engineering, construction, operation, and closure and decommissioning of both surface and underground facilities. Within this category are costs for surface support facilities for security, fire protection, food service, administration, maintenance, and laboratories; waste-handling buildings; and underground shafts and ramps. Also included are costs for staffing, supplies, and utilities over the waste preparation and emplacement phase, the caretaker phase, and any subsequent period through the decommissioning phase. The latter phase involves permanently sealing the boreholes, decontaminating surface facilities, and returning the site to its natural state. In its 1987 TSLCC estimates, DOE added another category covering the cost of adding an MRS facility to the waste system.

OCRWM Responsibilities

OCRWM is directly responsible to the Secretary of Energy for conducting the Civilian Radioactive Waste Management Program in implementing NWPA. OCRWM consists of four suboffices that are responsible for the key activities in the program. The Office of Geologic Repositories is the suboffice primarily responsible for repository siting activities. This suboffice is responsible for, among other activities, coordinating the preparation and review of the required documents in support of repository site nominations and recommendations, such as the environmental assessments.

DOE's field operations offices support OCRWM in its activities. As part of the field operations offices, DOE project offices are responsible for the work on the nine sites that DOE formally identified as potentially acceptable first repository sites in February 1983. (See table 1.2.) DOE's Chicago Operations Office is conducting OCRWM's second repository project.

Table 1.2: DOE Project Offices Responsible for the Potentially Acceptable First Repository Sites

DOE project office	Host rock[a]	Potentially acceptable first repository sites
Richland, Washington	Basalt	Hanford, Washington[b]
Las Vegas, Nevada	Tuff	Yucca Mountain, Nevada[b]
Columbus, Ohio	Salt	Gulf Interior Salt Basin—Richton Dome, Mississippi, Cypress Creek Dome Mississippi Vacherie Dome, Louisiana Palo Duro Basin—Deaf Smith, Texas;[b] Swisher County, Texas Paradox Basin—Davis Canyon, Utah, Lavender Canyon, Utah

[a]The rock formations being considered are basalt a material formed from molten rock from volcanoes or fissures; tuff, a hard, compacted ash from volcanoes; and rock salt a sedimentary rock formed by the evaporation of water from a saline solution

[b]Site has been approved by the President for site characterization

DOE's Budget and Planning Process

Section 302(e) of NWPA requires DOE to submit annually a triennial budget to the Congress for the Nuclear Waste Fund. The budget must consist of estimates of expenditures from the fund for the succeeding 3 fiscal years. Table 1.3 shows DOE's budget cycle for the Nuclear Waste Fund. As shown in table 1.3, preparation of the fiscal year 1985 budget began in fiscal year 1983.

Table 1.3: DOE's Budget Cycle for the Nuclear Waste Fund (Fiscal Year 1985 Budget)

	Fiscal year		
Month	**1983**	**1984**	**1985**
October	.	OMB review and analyze budget	Approved funding program based on appropriation issued
November	.	OMB budget markups and appeals	.
December	.	Budget submitted to controller	.
January	.	Budget submitted to Congress	.
February	.	Authorization hearings	.
March	Field budgets submitted to headquarters	Appropriation hearings	.
April	Field budgets analyzed	.	Midyear cost analysis
May	Receive internal review budget call	Receipt of appropriation marks	.
June	Internal review budget due to controller	.	.
July	Internal review budget hearings and appeals held	Receipt of authorization marks	.
August	Issue OMB budget call	Enactment of authorization/ appropriation bills	Last approved funding program change
September	OMB budget submission due to controller	Headquarters prepares initial approved funding program	.

DOE's Budget and Reporting Classification

Data for the Nuclear Waste Fund are recorded in DOE's financial information system and OCRWM's program management information system. At the start of fiscal year 1985, DOE project offices began reporting financial data into DOE's financial information system using revised budget and reporting program codes. Obligations, costs, and disbursements are reported using a work breakdown structure. (A work breakdown structure is a formalized method for subdividing activities into manageable segments and defining each segment.)

The work breakdown structure used in DOE's financial information system records data under six waste program activities or subprograms:

- first repository,
- second repository,
- MRS,
- program management and technical support,
- transportation and systems integration,[4] and
- debt service.

[4]In fiscal year 1985, this subprogram was included in program management and technical support

For example, obligations, costs, and disbursements for first repository activities, such as preparing the environmental assessments and site characterization plans, are recorded under the first repository subprogram. Also under this subprogram are repository design, equipment development, licensing, and quality assurance activities.

Within each of the six subprograms, obligations, costs, and disbursements are recorded by category and, within each category, under more detailed categories called tasks. To illustrate, the 11 tasks for each of the three possible host rocks (the three categories for the first repository subprogram) in fiscal year 1985 were systems, waste package, site, repository, regulatory and institutional, exploratory shaft, test facilities, land acquisition, program management, financial and technical assistance, and other. See appendix I for a definition of each task in the work breakdown structure.

OCRWM's program management information system builds on or obtains some data from DOE's financial information system. In addition to providing financial data, the data base provides management support in other areas such as tracking milestones and program status reports. In this system, a work breakdown structure is used to define technical scopes of work, allocate resources, develop schedules and budgets, and measure performance against the baseline. Its structure is similar to that used in DOE's financial information system.

In fiscal year 1985 the Basalt Waste Isolation Project in Hanford, Washington, and the Salt Repository Project in Columbus, Ohio, used an earned value system to measure performance. Performance measurement is one method used to provide information for cost control in the Nuclear Waste Fund. Earned value is the periodic consistent measurement of work performed in terms of the budget assigned to that work. Under an earned value system, activities within each task are divided into manageable segments or "work packages" (hereafter referred to as work activities) and defined so that work responsibility can be assigned to program participants. These work activities define a scope of work, are assigned to a specific performing organization or contractor, have definite start and completion dates, and are allocated a budget. Completion of a chapter of the site characterization plan is an example of a work activity.[5] The work activity is then monitored for performance and cost.

[5]The site characterization plan is the program document that will reflect expected site conditions for each of the three sites recommended for site characterization.

where appropriate. DOE's comments are reproduced in full in appendix IV of this report.

Analysis of Schedule Delays on Program Costs and Budget Variances

To address the first issue, we reviewed the program's first repository activities because 75 percent of the fiscal year 1985 funds were budgeted and 70 percent subsequently obligated for the first repository. We focused our efforts on the site and the regulatory and institutional tasks within the first repository subprogram because (1) the Committee expressed an interest in the site task and (2) these tasks had the highest obligations in fiscal year 1985 compared with other first repository tasks.

Specifically, we reviewed applicable legislation, implementing federal regulations, pertinent DOE policies and procedures, DOE's fiscal year 1985 budget submission to the Congress, project office budgets, project manager progress reports, major systems acquisition reports, and other pertinent documents related to costs and scheduling.

We interviewed DOE officials in Washington, D.C., and at all three first repository project offices, and contractor personnel. We obtained budget and financial data from DOE's financial information system and OCRWM's program management information system. Because cost data are generated in DOE's financial information system and OCRWM's program management information system at different times of the month, amounts may vary slightly. We did not attempt to reconcile any amounts obtained from OCRWM's program management information system with amounts shown in DOE's financial information system.

At the Basalt Waste Isolation Project and the Salt Repository Project, we selected nonstatistical samples of work activities in the first repository site and regulatory and institutional tasks. At the Basalt Waste Isolation Project, we selected a total of 30 work activities in the site and regulatory and institutional tasks that had the highest deviations from the budgeted cost and/or planned schedule. At the Salt Repository Project, we selected 30 work activities in the site task and 30 work activities in the regulatory and institutional task that had high deviations from the budgeted cost and/or planned schedule.

We obtained documentation and discussed these work activities with project office officials and/or two of DOE's prime contractors—Rockwell Hanford Operations and Battelle Memorial Institute. For each work activity, we determined (1) the fiscal year 1985 budgeted cost, (2) the contractor is responsible for the technical and management support services including reporting and scheduling.) We obtained documentation on the work activities completed and not completed by each contractor during fiscal year 1985.

Analysis of DOE's Total System Life Cycle Cost Estimates

To address this issue, we reviewed the 1984, 1985, and 1986 TSLCC analyses and related supporting documents. We discussed program cost estimates with DOE staff and with representatives of Roy F. Weston, Inc., the contractor that performed the cost studies. We also discussed program cost estimates with DOE officials in its Office of Independent Cost Estimating, Office of Project and Facilities Management, Assistant Secretary, Management and Administration.

In reviewing DOE's reasons for changes in the cost estimates from year to year, we focused on changes in individual engineering, construction, operations, and maintenance cost estimates in the repository construction and operation category. (As previously stated, the repository category is one of DOE's three major TSLCC categories.) We selected this category because it has had the highest estimated costs for each year the estimates have been prepared.

To assist in our review, DOE provided us with a detailed breakdown of its 1984, 1985, and 1986 cost estimates for the three first repository projects—basalt, salt, and tuff—and the second repository project—crystalline rock. For each of the four projects, we selected a nonstatistical sample of various cost components that had changed significantly from one year to another for further discussion with DOE and contractor staff. Generally, we selected and discussed cost components in which the estimates changed more than $25 million from one year to the next or changed more than $50 million over 2 years.

In addition to reviewing DOE's reasons for the changes in the cost estimates from year to year, we looked at the underlying assumptions, methodology, and cost-estimation methods used in the cost analyses. Because the nuclear waste repository is a "first of a kind" facility and the program is in its early years, the assumptions and methodology are subject to change from year to year as OCRWM's program definitions become more detailed. Predicting the costs of a program stretching out for almost 100 years, for example, presents an inherent uncertainty in cost estimating. Using the cost estimates in the repository category for the years 1984, 1985, and 1986, chapter 3 shows how uncertainty can

Schedule Delays Affect First Repository Subprogram Costs and Milestones

In fiscal year 1985 DOE requested and the Congress appropriated $327.7 million from the Nuclear Waste Fund. Based on DOE's budget submission to the Congress, this funding was to be used to accomplish certain major milestones in fiscal year 1985 including recommending three sites to the President for site characterization. However, primarily because of a change in the scope, content, and schedule for completing the environmental assessments, many of the milestones for the first repository subprogram were delayed. As a result, some fiscal year 1985 work activities were not accomplished as planned, and some program funds were not used as budgeted. The cost of the first repository subprogram increased because additional funds were needed to prepare the assessments, and DOE continued to incur costs for activities that should have ended had the assessments been completed as originally scheduled. In addition, the delay in completing the environmental assessments compressed the time available for DOE to meet first repository subprogram milestones. Therefore, in June 1987 DOE revised these milestones and delayed the operational date for the first repository 5 years.

Use of the Fiscal Year 1985 Appropriation

Of the $327.7 million appropriated by the Congress from the Nuclear Waste Fund for fiscal year 1985, $247.1 million was initially requested for the first repository subprogram. However, DOE moved about $12 million to other waste management subprograms. Of the $318.3 million incurred as obligations for the Nuclear Waste Fund, about $219.3 million was for the first repository subprogram.

DOE's Fiscal Year 1985 Budget Request and Appropriation

DOE's fiscal year 1985 budget submission to the Congress on the Nuclear Waste Fund was the first budget formulated by OCRWM. It provided information on the fund's revenue sources and repository activities, and separately described the budget request for the major subprograms and supporting activities. Table 2.1 shows DOE's fiscal year 1985 request for the Nuclear Waste Fund by the five subprograms and support activities.

Table 2.2: DOE's Budget Request for the First Repository Subprogram for Fiscal Year 1985 by Task

Dollars in millions

Task	Budget request
Systems	$17.9
Waste package	21.8
Site	58.2
Repository development	37.4
Exploratory shaft	56.2
Regulatory and institutional	15.5
Test facilities	3.5
Land acquisition	2.0
Program management	25.0
Federal/state assistance[a]	9.6
Total	**$247.1**

[a]In subsequent DOE budgets, the federal/state assistance task has been included in the regulatory and institutional task.

Movement of Fiscal Year 1985 Nuclear Waste Funds

As shown in table 2.3, about $12 million was moved from the first repository subprogram to other subprograms within the waste management program.

Table 2.3: Movement of Fiscal Year 1985 Nuclear Waste Funds

Dollars in thousands

Subprogram	Fiscal year 1985 financial plan	Revised fiscal year 1985 financial plan	Amount of increase (decrease)
First repository	$247,100	$235,246	($11,854)
Second repository	28,700	24,709	(3,991)
MRS	8,500	17,469	8,969
Transportation and systems integration[a]	2,400	2,875	475
Program management and technical support	37,669	44,070	6,401
Debt service	3,300	3,300	0
Total	**$327,669**	**$327,669**	

[a]In DOE's fiscal year 1985 budget submission to the Congress, $2.4 million in funding for transportation and systems integration was included in program management and technical support.

out technical support studies related to first repository activities. OCRWM is developing a category for technical support studies within its budgeting and reporting classification to minimize the need to move funds between subprograms.

Obligations in Fiscal Year 1985

As shown in table 2.4, DOE obligated about $318.3 million in the waste management program in fiscal year 1985.

Table 2.4: Nuclear Waste Fund Appropriations

Dollars in thousands

Carryover from prior year appropriations	$1,704
Fiscal year 1985 appropriation	327,669
Appropriation transfer[a]	6,521
Total for fiscal year 1985	$335,894
Total obligated during fiscal year 1985	318,298
Appropriations carried over to fiscal year 1986	$17,596

[a]The transfer resulted from a determination made by the Main Hurdman auditors that the unobligated balances transferred to the Nuclear Waste Fund at inception (Jan. 7, 1983) should have included an additional $6.521 million to cover contracts specifically identified with the Nuclear Waste Fund. (Main Hurdman is the contractor that provides professional audit services to OCRWM.)

Figure 2.1 shows the percentage of total obligations for each subprogram for fiscal year 1985. About 70 percent of the obligations incurred were for the first repository.

Of the $219.3 million incurred as obligations for the first repository subprogram, 96 percent ($211.4 million) was incurred as operating expenses and 4 percent ($7.9 million) as capital expenditures. Of the $211.4 million in obligations incurred as operating expenses, about $57.5 million was obligated in the site task—compared with $58.2 million requested in the fiscal year 1985 budget—and about $33.4 million in the regulatory and institutional task to 30 contractors. Obligations for the latter task were more than double the $15.5 million contained in DOE's fiscal year 1985 budget request. For the site and regulatory and institutional tasks, appendixes II and III give a detailed analysis of funds obligated to each contractor, total funds each contractor had available, and each contractor's budget.

OCRWM needed more time to ensure consistency among the nine assessments. As a result, OCRWM revised its schedule to delay issuing the final environmental assessments until December 1984.

In September 1984 OCRWM decided to (1) publish the environmental assessments in draft in December 1984, (2) allow 90 days for public comment (until Mar. 20, 1985), (3) address all comments in about 3 months, and (4) issue the final environmental assessments in June 1985. OCRWM issued the draft environmental assessments on December 20, 1984. During the 90-day comment period, DOE received over 21,000 comments on the draft assessments from more than 2,600 commenters, including the 6 states containing potential first repository sites, Indian tribes, federal agencies, and other interested parties.

Because of the level of interest in the environmental assessments, DOE informally extended the comment period through June 1985 and revised the issuance date for the final assessments to August 1985. About 2,000 additional comments were received through the extended period. As a result of the number and complexity of the comments received, the issuance date for the final assessments was further delayed from August 1985 to December 1985. (DOE had planned to issue final environmental assessments for five nominated sites on December 20, 1985. OCRWM officials stated that the environmental assessments for the other four sites would be completed at a later date to allow them to be considered in the second repository site selection process.)

According to OCRWM officials, the final assessments were not issued in December 1985 largely because of OCRWM's desire to obtain a NAS review of the methodology for ranking the potential repository sites. The Director, OCRWM, then requested that the NAS Board review the actual application of the revised methodology proposed by NAS to the data that were collected on each site. As a result of these NAS reviews, the final environmental assessments were not issued until May 28, 1986.

Likewise, the scheduled dates for the Secretary to recommend three sites to the President for site characterization changed as the issue dates for the environmental assessments changed. The recommendation could not be made until the environmental assessments were complete. The recommendation was initially scheduled for January 1985 but was made on May 28, 1986.

showed that 10 work activities budgeted at $914,000 had been completed in fiscal year 1985. Five activities budgeted at $434,000 had not been started, and 13 activities budgeted at $3.433 million had not been completed as planned. The status of two activities budgeted at $149,700 could not be determined from the information available at the time of our review.

The following are examples of activities that were not started or not completed during fiscal year 1985.

- A contractor was to drill three boreholes at different places around the potential repository site to evaluate the salt content at the repository level. (At the time of our review, the contractor had not been selected.) The information to be obtained would be used in the site characterization plan and license application report. This activity was scheduled to start in September 1985, following the original milestone date for recommending three sites for site characterization on September 6, 1985. Because sites could not be recommended and approved for characterization until the environmental assessments were complete, work did not begin on this activity in fiscal year 1985. The fiscal year 1985 budgeted cost for this activity was $100,000.
- Woodward and Clyde Consultants was responsible for the installation, operation, and maintenance of a seismographic network in the Paradox Basin. (The seismographic network consists of 16 stations that measure earth movement. The data were analyzed to establish a history of earthquakes.) The network was scheduled to operate from December 1984 to August 1985 at a fiscal year 1985 budgeted cost of $300,700. Because the environmental assessments were delayed and specific sites were not selected for characterization, the network's operation continued through the end of fiscal year 1985 at an additional cost of about $25,000; as further discussed in a subsequent section of this chapter, this activity also extended well into fiscal year 1986. The network's operation continued to avoid interrupting the flow of data collected should a site in the Paradox Basin be selected for site characterization.
- Woodward and Clyde Consultants was to provide staff support to the U.S. Geological Survey and maintain and operate the Denver core facility during the period December 1984 to August 1985. (The U.S. Geological Survey did research on core samples from the Paradox Basin at this facility.) Because the environmental assessments delayed approval of sites for characterization, the facility's operation continued through September 1985 and, as further discussed in a subsequent section of this chapter, was also extended well into fiscal year 1986.

- Battelle was to review and evaluate preliminary information and data, and then prepare the geologic input to chapter 8 of the site characterization plan. Chapter 8 will provide information on the site characterization program, including planned tests, analyses, and studies; and milestones, decision points, and schedules. Although the fiscal year 1985 budgeted cost for this activity was $157,800, the actual cost was $1,000. This activity was continued in fiscal year 1986 because the final environmental assessments were not issued in fiscal year 1985.
- A contractor was to provide reviews of site characterization plan documents and provide site characterization plan-related support at a budgeted cost of $100,000 in fiscal year 1985. (At the time of our review, a contractor had not been selected.) This activity was planned but not started in fiscal year 1985 because of the delay in the environmental assessments.

Although we do not have summary information for the Basalt Waste Isolation Project similar to that for the Salt Repository Project, we found activities that had been started but not completed in fiscal year 1985 as planned. Examples of these activities follow:

- Rockwell was to prepare the site characterization plan, including photography and graphics support, technical editing, report coordination, and printing, and issuing the final site characterization plan to DOE. The fiscal year 1985 budgeted cost for this activity was $677,000, and the actual cost was $464,300. Rockwell was also to provide support for the site characterization plan. Actual support costs totaled $654,900, or $51,900 under the budgeted cost. According to the Rockwell official in charge of these activities, they were not completed because the same staff had to work on both the site characterization plan and the environmental assessment, and the environmental assessment received higher priority.
- Rockwell was to provide peer review of the site characterization plan document. The fiscal year 1985 budgeted cost for this activity was $111,000. According to the Rockwell official in charge of this activity, it was not completed in fiscal year 1985 as planned because delays in preparing the environmental assessment delayed preparation of the site characterization plan.

According to officials at the Nevada Nuclear Waste Storage Investigations Project, the regulatory and institutional activities at the tuff site were prioritized in order to make staff and funds available to complete the environmental assessment. For example, on the basis of information provided by the DOE project office, a contractor (Science Applications

The draft report received numerous review comments as it went through the peer review process. Each of the comments had to be addressed, which took a considerable amount of time.

- Also at the Salt Repository Project, Stone and Webster provided support as needed to the Texas Bureau of Economic Geology, which was studying salt-dissolution water-well activities. The specific task involved disposal of brine from pumping activities. The fiscal year 1985 budgeted cost for this work was $9,000; however, the actual cost was $88,000 The budgeted cost did not include the cost to plug the wells because the pumping activities were not scheduled to be completed in fiscal year 1985. Because the pumping ended in fiscal year 1985, Stone and Webster plugged the wells.
- At the Basalt Waste Isolation Project, Rockwell was responsible for completing chapter 8 of the site characterization plan. The actual cost for that portion of the work completed in fiscal year 1985 totaled $338,100, or $121,000 more than the budgeted cost of $217,100. According to a Rockwell official, the overrun was due to a change in OCRWM guidance on what should be contained in the chapter. He said that the guidance changed on the basis of discussions DOE had held with the Nuclear Regulatory Commission (NRC).

Schedule Delays Increased First Repository Subprogram Costs

In fiscal year 1985 DOE requested $247.1 million to perform specific activities in the first repository subprogram including completing the environmental assessments. Because of a change in the scope and content of the assessments, however, additional funds were needed to prepare these documents. Moreover, funds were needed for other activities that continued while OCRWM completed the environmental assessments.

Although DOE and contractor officials agree that considerable additional costs have been incurred because of schedule delays, project office officials expressed concern that DOE might be asked to determine the costs of these delays on the program. According to a Salt Repository Project official, these costs would be difficult to determine since delays have increased the cost of some activities while they have precluded the start of others.

The costs for preparing the environmental assessments have been higher than anticipated. For example, in April 1984 Rockwell estimated that work on the Hanford site environmental assessment would cost $92,000 in fiscal year 1985. This estimate assumed that the environmental assessment would be issued in November 1984 to the Basalt Waste cost of this activity in fiscal year 1985 was $434,500, or $295,600 more than had been budgeted.

- Battelle was to manage and support the preparation of draft and final environmental assessments and address review comments for each draft and final assessment in a written document. The fiscal year 1985 budgeted cost for this activity was $90,200. The actual cost was $236,300, or $146,100 more than had been budgeted. Under this activity, the level of effort needed to prepare modifications to the draft environmental assessments and address comments received after the 90-day comment period was unanticipated. In addition, the number of review cycles necessary to prepare final documents for three sites was unanticipated.

In addition to the added cost to prepare the environmental assessments, several activities originally scheduled for completion in fiscal year 1985 were extended within fiscal year 1985 and/or into fiscal year 1986 while awaiting completion of the environmental assessments. The following examples show that in some cases, additional costs amounting to hundreds of thousands of dollars were associated with these activities

- The management and administrative activities[3] at the three salt areas—Paradox Basin, Palo Duro Basin, and Gulf Coast Basin—cost an additional $142,300 over the fiscal year 1985 budgeted cost. In addition, these activities were extended into fiscal year 1986 at a total estimated cost of about $1.6 million. As of May 1986, the additional cost was $202,900 for the Paradox Basin, $566,000 for the Palo Duro Basin, and $488,000 for the Gulf Interior Salt Basin, or a total of about $1.3 million.
- The installation, operation, and maintenance of the seismographic network at the Paradox Basin has continued. Fiscal year 1986 costs as of March 1986 totaled about $140,500. The network was originally scheduled to operate from December 1984 to August 1985.
- The quality assurance functions at the Paradox Basin continued in fiscal year 1986 because these functions were needed until sites were selected for site characterization. As of March 1986, this activity had incurred $144,400 in costs for fiscal year 1986.
- The maintenance and operation of the Denver core facility, a facility used by the U.S. Geological Survey to conduct research on core samples from the Paradox Basin, continued through the end of fiscal year 1985 and into fiscal year 1986. The facility was scheduled to operate from

[3]Management and administrative activities include (1) estimates, forecasts, and cost maintenance functions, (2) planning and scheduling, (3) contract administration and purchasing, (4) records management, (5) project management, and (6) clerical and staff services

Battelle official estimated that the increased cost of conducting program activities at the three salt basins longer than planned was $1 million for the Paradox Basin, $1.5 million for the Gulf Interior Salt Basin, and $2.5 million for the Palo Duro Basin.

Schedule Delays Compressed First Repository Subprogram Milestones

As required by NWPA, DOE developed milestones for the first repository subprogram. By meeting these milestones, DOE would begin operation of the first repository by January 31, 1998. However, schedule delays, such as the delay in completing the environmental assessments, compressed the time available to meet the milestones. In June 1987 DOE revised its milestones and delayed the operational date for the first repository 5 years.

Section 301(a) of NWPA required DOE to prepare a comprehensive report, known as the mission plan, that would be an informational basis for making informed decisions in carrying out the repository program. The mission plan was to include, among other things, an estimated schedule for constructing a repository. In addition, section 114(e) of NWPA required DOE to prepare a project decision schedule that included a description of objectives and a sequence of deadlines for all federal agencies.

As shown in table 2.7, first repository operations were to begin in January 1998; however, some of the milestones identified in the mission plan and project decision schedule for the first repository subprogram continued to slip. For example, DOE's milestone date for the draft environmental assessments was August 1984 in the draft mission plan, and December 1984 in the final mission plan and project decision schedule. As previously discussed, the environmental assessments were completed on May 28, 1986.

Until June 1987, however, DOE did not change the 1998 date for accepting radioactive waste at the first repository. Therefore, the amount of time available for work between some of the milestones was reduced. For example, the April 1984 draft mission plan provided for 3 years between submission of the license application to NRC and receiving construction authorization. The June 1985 final mission plan and the March 1986 project decision schedule provided for 27 months.

Table 2.8: First Repository Subprogram Milestones as Shown in DOE's Amendment to Its Mission Plan

Milestone	Current schedule
Start of exploratory shaft construction	
tuff	Fourth quarter 1988
basalt	Second quarter 1989
salt	Fourth quarter 1989
Start of in situ testing	
tuff	Second quarter 1990
basalt	Fourth quarter 1991
salt	Fourth quarter 1991
Draft environmental impact statement	1993
Final environmental impact statement	1994
Submittal of the site-selection report to the President	1994
Submittal of the license application to NRC	1995
Receipt of a construction authorization from NRC	1998
Start of construction	1998
Start of phase I operations	2003
Start of phase II operations	2006

Before DOE's recent extension of the first repository timetable, DOE's project offices, scientists that work for DOE contractors, and NRC had all expressed concern over the impact of recent schedule delays on subprogram milestones. For example, a Nevada project office official had indicated that although the project office staff was working hard toward meeting originally scheduled 1987 milestones, they were concerned about doing the necessary work in the time allowed. Based on knowledge gained from slippage in prior milestones such as the environmental assessments, Nevada project office officials prepared an internal project analysis of additional time needed to complete future program milestones. These milestones, as shown in figure 2.2, added over 4 years to the schedule for the first geologic repository when compared with milestones in OCRWM's March 1986 project decision schedule.

"How do you plan milestone dates based on the site characterization plan when the schedule assumptions used are unrealistic to begin with?"

"One of the major concerns I have is the difficulty in expressing differences in scientific opinion between the scientists and . . . management. The normal give and take which one would normally expect when major differences of scientific opinion occur is not allowed."

In one case, management told scientists that their recommendations on a particular issue might jeopardize the technical program. These scientists are among those who will be held accountable for the work on the groundwater, hydrology, and geochemistry aspects of site characterization.

NRC raised concerns that the time DOE had allowed between submittal of the license application and receipt of a construction authorization may not have been adequate. In its September 13, 1985, testimony before the Committee on Interior and Insular Affairs, the Chairman, NRC, stated that NRC believes the 3 years provided by NWPA is a very optimistic estimate for the time required to reach a licensing decision on repository construction. He further stated that (1) the time required depends on the submittal by DOE of an acceptable, complete, high-quality application and on the ability of DOE to present its case forcefully and effectively before the adjudicatory hearing held by the NRC licensing board and (2) NRC had not identified specific actions that could permit the license review period to be reduced from the statutory 3 years. DOE's June 1987 revised timetable now provides 3 years for NRC licensing of first repository construction, as allowed by NWPA.

Conclusions

In fiscal year 1985 the Congress appropriated $327.7 million from the Nuclear Waste Fund. According to DOE's fiscal year 1985 budget submission to the Congress, about $247.1 million (75 percent) of this appropriation was to be used to carry out activities for the first repository. Primarily because of the delay in completing the environmental assessments and selecting sites for site characterization, however, (1) DOE's first repository project offices could not accomplish many activities planned during fiscal year 1985, (2) the additional cost required to complete the environmental assessments and several other activities that should have ended had the environmental assessments been completed as originally scheduled, such as the management of three salt basins, substantially increased the cost of the first repository subprogram, and

Total System Life Cycle Cost and Revenue Estimates

Each year DOE analyzes the total system life cycle cost (TSLCC) of the nuclear waste program. Since DOE's first TSLCC estimate in 1983, estimates in each of the three broad cost categories—development and evaluation, transportation, and repository construction and operation—have changed significantly from year to year. Uncertainty about the final design and operation of the waste system has led to the large cost changes in various waste system categories.

Although large cost uncertainties appear reasonable this early in the program, DOE's approach to establishing one key assumption used in waste program planning, and in estimating program costs and revenues, unnecessarily compounds the current life cycle cost uncertainties. Specifically, DOE projects spent fuel quantities on the basis of long-range (35-year) forecasts of U.S. economic activity, energy demand, electricity's share of energy demand, and nuclear power's estimated share of projected electricity production. This approach has led to spent fuel projections that are too large in view of the current outlook for nuclear power. Realistic projections are important because they help shape the size of the planned waste system and determine the fees that utilities pay to fund the waste program. DOE could minimize uncertainty in waste system planning, and in life cycle costs and revenue estimates, by basing its projections only on plants currently in operation and under active construction.

TSLCC Analyses Provide a Range of Cost Estimates

DOE's annual TSLCC analyses have presented a range of costs for activities spanning a period of about 100 years, although most activities would be completed and most costs incurred over the next 45 years. The TSLCC analyses are based on reference and sensitivity cases that are distinguished by repository-site combinations and an assumed quantity of waste to be disposed. Because the specific host rocks for the first and second nuclear waste repositories are not yet known, the TSLCC analyses use different combinations of host rocks (tuff-crystalline rock, basalt-crystalline rock, etc.) for the first and second repositories. The analyses also assume

- the quantity of spent fuel generated through 2020,
- the startup dates for first (1998) and second (2008) repository operations, and
- construction and operation of the first repository in two phases.

DOE's 1986 TSLCC analysis contains reference and sensitivity cases for the waste system authorized by the NWPA (no MRS facility) and an "improved

Table 3.1: 1986 Total System Life Cycle Cost Estimates

Dollars in billions

Repository-site combination	Authorized system	Improved performance system
Reference cases		
Basalt/crystalline rock (high)	$32 3	$34.0
Basalt/salt	29 9	31 6
Basalt/tuff	28.8	30 4
Basalt/crystalline rock (low)	29.0	30 8
Salt/crystalline rock (high)	28 5	30.6
Salt/salt	26 0	27.9
Salt/crystalline rock (low)	25 3	27 4
Tuff/crystalline rock (high)	26.9	29 4
Tuff/salt	24.3	26 7
Tuff/crystalline rock (low)	23 6	26 2
Sensitivity cases		
Decreased spent fuel generation		
Basalt/crystalline rock (high)	28 4	30 9
Tuff/crystalline rock (low)	21 3	24 2
5-year repository delay		
Basalt/crystalline rock (high)	35 7	37 2
Tuff/crystalline rock (low)	27 0	29.4
10-year repository delay		
Basalt/crystalline rock (high)	38 9	40.5
Tuff/crystalline rock (low)	30 4	32.6

Note Costs are in constant 1985 dollars

Because DOE's crystalline rock siting program has not advanced to the point of identifying specific potentially acceptable second repository sites, and the program encompassed 17 states in the north central, northeastern, and southeastern regions of the United States, DOE stated in its 1986 TSLCC analysis that a wide range of possibilities could be associated with the second repository. The 1986 analysis attempted to quantify the cost impacts resulting from this uncertainty by assuming two alternative generic sites in crystalline rock. DOE assumed that the differences in geologic conditions would affect the costs of the second repository, and therefore the cases in table 3.1 reflect both a generic high-cost and low-cost crystalline rock repository.

In May 1986 the Secretary of Energy announced an indefinite postponement of site-specific work on a second geologic repository, citing as justification the progress on the first repository program and uncertainty over when a second repository may be needed. Although funding for the second repository program has been reduced for fiscal year 1987, it is and low-cost crystalline rock repository while earlier TSLCC analyses did not distinguish between a high- and low-cost repository.

- Different engineering designs or assumptions about the same case are employed. For example, improved transportation cask technology is now used.
- Different estimation methods are used. For example, transportation cost methods are now based on movements of spent fuel from 21 regional reactor locations in contrast with a single average reactor location.
- Different quantitative information for the same cost-estimating factor is used. For example, DOE has used different labor rates for repository construction and operation, depending on the location of the site and the required labor skills.

Although DOE indicated that the reasons for changes in TSLCC estimates from year to year generally fall into one of these categories, the 1986 TSLCC analysis also contained more detailed information regarding the specific reasons for the changes occurring between the annual estimates.

The following sections show how uncertainty about the final design and operation of the waste system leads to both increases and decreases in various cost components in the repository category for each of the four potential host rocks. As discussed earlier, the 1984 to 1986 cost estimates in tables 3.3 through 3.6 have been converted to constant 1986 dollars for ease in comparison. The cost estimates discussed in connection with these tables have also been converted to constant 1986 dollars.

Basalt

Table 3.3 shows DOE's estimated costs as summarized in its 1984, 1985, and 1986 TSLCC analyses for engineering and construction, and operations and maintenance for a repository in basalt. Decommissioning, which is not shown in the table, is also part of the repository costs, but a comparatively small part of the overall repository cost estimates. Life cycle decommissioning costs (constant 1986 dollars) were estimated at $198.2 million in 1984, $152.9 million in 1985, and $273.9 million in 1986.

Although the overall repository cost estimates for basalt increased about $144 million from 1985 to 1986, the estimates for the underground development component decreased by about $1.3 billion. As shown in table 3.3, cost increases in other categories, such as surface facilities, shafts and ramps, and waste package fabrication, more than offset the cost decrease from 1985 to 1986 in underground development.

One of the cost components we selected for further discussion with DOE was in the underground development category. This component, called "other drift development," had cost estimates for operation and maintenance of $478.8 million in 1984, $1.4 billion in 1985, and $326.4 million in 1986. DOE staff explained that the large increase and subsequent major decrease was due to the change in the site design from the old site-specific estimate in 1984 to the estimate based on a tuff design in 1985, and then to a new site-specific design in 1986. As DOE had described in its TSLCC analyses, the estimating methodology had changed basically.

Salt

Although the overall cost estimates for a repository in the salt medium increased each year through 1986, the individual cost components in which the increases and decreases occurred differed somewhat from the basalt estimates. Table 3.4 shows the estimated costs from DOE's 1984, 1985, and 1986 TSLCC analyses for a repository in salt, without regard to a specific site. Estimated decommissioning costs were $218 million in 1984, $267.2 million in 1985, and $251.2 million in 1986.

Table 3.4: Repository Cost Comparison—Salt

Dollars in millions

	Engineering and construction			Operations and maintenance		
Cost category	**1984**	**1985**	**1986**	**1984**	**1985**	**1986**
Land acquisition	$20.9	$2.2	$33.1	$0.0	$0.0	$0.0
Site preparation	76.0	163.0	108.8	38.5	209.0	144.1
Surface facilities	865.4	756.3	1,055.4	2,394.7	2,895.2	2,629.0
Shafts/ramps	373.2	602.1	687.1	0.0	0.0	30.9
Underground development	448.1	181.6	178.6	1,077.9	1,274.7	1,973.8
Waste package fabrication	0.0	0.0	0.0	663.9	776.1	1,060.6
Total[a]	**$1,783.6**	**$1,704.9**	**$2,063.1**	**$4,175.0**	**$5,154.9**	**$5,838.4**

Note: Costs are in constant 1986 dollars

[a]Totals may not add because of rounding

method, which based costs on the design layout for a tuff repository, resulted in higher underground development costs. Cost differences were also due to different requirements for caretaker operations and backfilling.

From 1985 to 1986 the greatest increase in the estimates—about $0.62 billion—was in the category called "shafts/ramps." DOE explained that different shaft requirements, such as number, diameter, depths, and use of exploratory shafts, led to increased costs for all repositories except tuff. The 1986 cost increase in shafts/ramps, however, was more than offset by changes in other cost components, including cost decreases in underground development and surface facilities, resulting in an overall decrease of about $0.57 billion in the cost estimates.

DOE's Spent Fuel Projection Method Leads to Planning, Cost, and Revenue Uncertainty

According to DOE, the quantity and schedule of waste generation are critical assumptions in its annual TSLCC analysis. For waste system planning and for cost, revenue, and fee adequacy analyses, DOE projects long-range nuclear generating capacity—and from that, spent fuel inventories—on the basis of an assumed nuclear power share of total estimated electrical energy generation. However, DOE's approach adds uncertainty to the results and, in view of the unfavorable environment for nuclear power, appears to overestimate future generating capacity. In turn, DOE's overly optimistic projections of nuclear generating capacity raise questions about whether future revenue collections, which depend on the actual amount of electricity generated by nuclear power, will be adequate to recover waste program costs without increases in fees. Put another way, by overestimating the volume of spent fuel that DOE will dispose of, it risks planning and implementing a waste system that is larger and more costly than what will eventually be required.

An alternative approach that would reduce the uncertainty in long-range spent fuel projections is to base projections on actual plants operating or under active construction. This approach would increase confidence that revenues collected over the life of the program will be sufficient to cover life cycle costs. The nature of the nuclear waste disposal program provides DOE with ample time to revise its waste system plans and related cost and revenue projections to reflect any future utility nuclear plant orders.

assumes that utilities will not build any new nuclear plants, but will operate existing plants until the end of their useful lives.[2]

EIA notes that any projection for 15 to 40 years into the future is "fraught with uncertainty," and that many unforeseen factors are likely to affect the commercial nuclear power program in the period. Nevertheless, in making its projections based on long-range forecasts of economic activity, EIA assumes that U.S. utilities will continue to rely on both coal and nuclear fuels to reduce reliance on oil and gas and meet projected growth in electricity demand.

In its April 1986 TSLCC analysis, DOE used the EIA middle case (moderate growth) and "no new orders" spent fuel projections to estimate the quantity and generating rate of spent fuel for its reference and sensitivity cases. The life cycle costs for the reference cases, shown in table 3.1, are based on the EIA middle case spent fuel projection.[3] The sensitivity cases (see table 3.1), however, assume decreased spent fuel generation using the EIA "no new orders" projection. Table 3.7 compares the DOE reference and decreased spent fuel projections through 2020.

Table 3.7: Comparison of Projected Spent Fuel Inventories

	DOE reference case		Decreased spent fuel case	
Year	Nuclear generating capacity (gigawatts-electric)[a]	Cumulative spent fuel discharges (thousands of MTU)[b]	Nuclear generating capacity (gigawatts-electric)	Cumulative spent fuel discharges (thousands of MTU)
1985	80	12 7	77	12 7
1990	110	21 8	105	21 6
1995	117	33 5	108	32 5
2000	116	46 1	106	44 3
2005	149	59.7	106	55 7
2010	182	77 4	104	67 7
2015	216	101 2	59	80.9
2020	248	126 6	46	87.4

[a]a unit equal to 1 billion watts of electric power

[b]metric tons uranium

[2]Commercial Nuclear Power: Prospects for the United States and the World (DOE EIA-0438(85), Sept. 1985).

[3]World Nuclear Fuel Cycle Requirements 1985 (DOE EIA-0436(85), Dec. 1985)

line after the year 2020 is outside the scope of DOE's current waste program plans at this early stage in the nuclear waste disposal program. Thus, if the forecast that DOE is using for waste-planning purposes materializes, DOE will eventually need to begin planning for substantial waste repository space beyond its current plans for the first and second repositories.

The uncertainty inherent in DOE's spent fuel forecasting approach is of particular concern in view of past events and the current outlook for the nation's commercial nuclear power program. From 1955 through 1978 utilities ordered 247 commercial nuclear power plants, but 121 were subsequently cancelled, retired, or are no longer under active construction, including all 39 plants ordered since 1974. As of December 31, 1986, NRC expected that only 120 of the 247 plants ordered would be completed and placed into operation. Beyond these 120 plants, no other plants are now under active construction or NRC construction permit review. Further, according to the Edison Electric Institute, an association of investor-owned utilities, there is no evidence that utilities will order new nuclear power plants in the next few years.

Since the early 1970s many problems have plagued the nuclear industry that continue today. These include changes in electricity demand patterns, a changing utility financial environment, regulatory and safety issues, construction cost increases, and construction delays. Events such as the March 1979 accident at the Three Mile Island nuclear plant and the April 1986 accident at the Soviet Union's Chernobyl nuclear plant have heightened public concern over the safety of nuclear power. This concern is being highlighted by the controversy over emergency planning around the Shoreham (Long Island, New York) and Seabrook (New Hampshire) nuclear plants. Both plants have been constructed, but the issuance of full-power operating licenses is opposed by the state of New York (for Shoreham's) and the neighboring state of Massachusetts (for Seabrook's). In addition, the disposal of nuclear waste from commercial nuclear power plants—DOE's mission under the Nuclear Waste Policy Act—has itself become a controversial nuclear power issue that may affect growth in nuclear power.

One cannot rule out the possibility that future events will change this pessimistic outlook for nuclear power and that utilities will once again build new nuclear power plants. Until such events occur, however, the weight of evidence points to a domestic nuclear power program comprised of the current generation of plants.

Table 3.5: Repository Cost Comparison—Tuff

Dollars in millions

Cost category	Engineering and construction 1984	1985	1986	Operations and maintenance 1984	1985	1986
Land acquisition	$0 0	$1 4	$1 6	$0 0	$0 0	$0 0
Site preparation	406 3	189.3	175 3	91 4	244 2	232.2
Surface facilities	994 2	576 2	674 3	2,283.5	2,819 5	2,878 2
Shafts/ramps	247.7	80 8	71.4	0 0	0 0	3 1
Underground development	377.6	325 1	335.3	690.3	1,858 4	1,197 6
Waste package fabrication	0 0	0 0	0 0	437.1	1,200 9	480.1
Total[a]	**$2,025.8**	**$1,172.8**	**$1,257.9**	**$3,502.3**	**$6,123.0**	**$4,791.2**

Note Costs are in constant 1986 dollars

[a]Totals may not add because of rounding

The total cost estimates for the three annual analyses, including engineering and construction, operations and maintenance, and decommissioning costs, for a repository in the tuff medium are $5.727 billion in 1984, $7.427 billion in 1985, and $6.164 billion in 1986. As in the basalt estimates, the greatest cost increase from 1984 to 1985 was in underground development—about $1.1 billion (65 percent) of the $1.7-billion increase between 1984 and 1985. DOE's 1985 TSLCC analysis indicated that some of the increase in costs for underground development was due to additional mining requirements, and caretaker and backfilling requirements.

Another category, called "waste package fabrication," also had a substantial increase in its cost estimates from 1984 to 1985, but had a corresponding decrease in 1986. The cost estimates in this category increased by $763.8 million in 1985, and decreased by $720 8 million in 1986. The 1985 TSLCC analysis generally attributed the increase to a redesigned waste package and increased quality assurance requirements.

We discussed one cost component, which fell within the waste package fabrication category, with DOE officials. The component, called "spent fuel," had cost estimates for operations and maintenance of $336.9 million in 1984, $1.042 billion in 1985, and $378.5 million in 1986. This component includes the costs associated with the stainless steel canisters designed to hold spent nuclear fuel in a tuff medium. Our discussions with DOE confirmed that the cost changes were due mainly to changes in the design of the waste package, although part of the 1985-

Treasury during periods of high expenditures. All figures are expressed in 1985 dollars and all calculations assume a constant fee rate of the present 1 mill per kilowatt hour.

Table 3.8: Comparison of Reference and Decreased Spent Fuel Cases for Fee-Adequacy Purposes

Dollars in billions

Assumptions	Cumulative fee revenues[a]	Life cycle costs[b]	Difference
Reference case			
Authorized system (no MRS):			
Highest cost	$34 5	$32 3	$2.2
Lowest cost	34 5	23 6	10 9
Improved performance system (with MRS)			
Highest cost	34 5	34.0	0 5
Lowest cost	34 5	26.2	8 3
Decreased spent fuel case			
Authorized system (no MRS):			
Highest cost	23 9	28 4	(4 5)
Lowest cost	23 9	21 3	2 6
Improved performance system (with MRS)			
Highest cost	23 9	30.9	(7 0)
Lowest cost	23 9	24 2	(0 3)

[a]Does not include interest earned on investment of waste program funds

[b]Does not include interest expense incurred from borrowing funds

Note Costs are in constant 1985 dollars

As table 3.8 shows, at 1 mill per kilowatt hour, revenues from the decreased spent fuel case would cover life cycle costs for the lowest cost repository combination without an MRS facility, but would be insufficient in the other cases. The drop in total revenues from $34.5 billion to $23.9 billion is $10.6 billion, or a 31-percent drop. This is essentially the same rate of reduction in the annual quantities of spent fuel for the two cases. According to DOE's April 1986 TSLCC analysis, however, depending on the assumed repository host rocks and system configuration, costs would decrease from $2 billion to $3.9 billion, or about 8 to 12 percent. From this analysis, DOE concluded that the relatively small cost reduction compared with the 30-percent reduction in waste is indicative of the large fixed cost of the waste management program.

Furthermore, depending on when this occurred, a number of currently operating plants, whose owners are now paying fees into the Nuclear Waste Fund, may have been retired. According to EIA, for example, such retirements may begin by the end of the century. Thus, any significant downward adjustment in DOE's spent fuel and revenue projections, after utilities begin to retire plants that are operating now, would require that DOE increase its fees enough so that revenues from fees collected (and interest earned) thereafter from fewer remaining operating plants would be sufficient to recover estimated life cycle costs.

In an August 1984 special study,[5] CBO also noted that projecting future Nuclear Waste Fund revenues on nuclear plants that are not operational involves some risk to the solvency of the fund. CBO stated:

> "In light of the current status of the nuclear utility industry, it might be prudent for OCRWM to base its revenue projections on the low or no nuclear-growth scenarios, which at this time seem more probable than the medium-growth case. Underestimating future revenue collections involves little financial risk, since it is quite probable that the program cost estimates will increase significantly, more than accounting for unforeseen revenues that might accrue."

Estimating Spent Fuel Inventories on the Basis of Actual Plants Reduces Uncertainty

Given the uncertainty associated with the future of nuclear power, a prudent approach to waste program planning would be for DOE to use the actual number of nuclear power plants in operation and under active construction—essentially, the EIA "no new orders" case. As DOE annually updates its fee adequacy and TSLCC reports, new reactor orders could be factored into the reference cases, and the waste program plans could be more accurately adjusted to reflect the actual amount of spent fuel anticipated.

Spent fuel projections based on actual plants would provide a higher level of confidence in the amount of electricity to be generated from nuclear power plants—the basis on which DOE collects waste disposal fees. For this reason, this approach provides a sound basis for DOE's annual fee adequacy determinations. In addition, it would ensure that DOE does not plan waste program facilities and transportation requirements on the basis of optimistic projections that do not materialize.

Use of the "no new orders" projections in DOE's reference cases is a feasible alternative because of the long lead time to build and operate a

[5] Nuclear Waste Disposal: Achieving Adequate Financing (CBO, Aug. 1984)

project, the uncertainty may not be unreasonable. Until the program matures beyond the conceptual design stage, it is unlikely that program cost catagories, such as construction of repositories, can be accurately estimated.

DOE could, however, reduce one major source of uncertainty in its life cycle cost analyses as well as its waste system planning and revenue estimates. Specifically, DOE could base spent fuel and revenue projections on nuclear plants in operation and under active construction rather than on economic forecasts 30 or more years into the future. DOE's current approach has led to spent fuel and revenue projections that can only be achieved through dramatic and sustained renewed growth in the commercial nuclear power industry beginning in the very near future. If such growth does not occur, DOE will eventually have to lower its spent fuel—and cumulative revenue—projections. Thus, by relying now on relatively optimistic projections, DOE increases the risk that in the future—perhaps after some plants have been retired—it will have to raise the waste fee to ensure recovery of all waste program costs. On the other hand, by basing current spent fuel projections on actual plants—and appropriately adjusting the estimates when utilities order new plants—DOE would have much greater assurance that, over the life of the waste program, cumulative revenues from fee collections and interest earnings will be sufficient to recover life cycle program costs. This would also help ensure that DOE does not plan a waste system on the basis of optimistic projections that do not materialize.

Recommendation to the Secretary of Energy

For waste system planning, including life cycle cost analyses and fee adequacy determination, we recommend that the Secretary of Energy base long-range projections of spent fuel inventories for commercial nuclear power plants on the nuclear generating capacity of operating commercial nuclear plants and plants that are actively progressing through NRC licensing and construction.

Agency Comments and Our Evaluation

DOE commented that basing waste system planning and cost and revenue analyses on actual nuclear power plants oversimplifies the task of projecting system requirements and fee adequacy. This approach, said DOE, would increase, rather than decrease, uncertainty regarding the waste system and fee adequacy. Of particular concern to DOE is that acting on our recommendation may understate the need for geologic disposal. In while the state of the nuclear power industry did not undergo dramatic changes over this 3-year period, EIA's projections first increased 36 gigawatts-electric and then dropped 29 gigawatts-electric in those years.

Further, when one examines the condition of the domestic nuclear power industry over the last 10 years, as discussed earlier in this chapter, we believe it is not realistic to expect that nuclear generating capacity will increase from a peak of about 108 gigawatts-electric in 1995—on the basis of existing plants in operation and under active construction—to EIA's most recent projection of 219 gigawatts for the year 2020. Achieving this level of capacity would require construction of about 170 new nuclear power plants by 2020 to replace retired plants and add new generating capacity. This would require utilities to order new plants at a rate of about seven per year through 2010—a period of about 23 years—to have all of this capacity on line by 2020. Although this is not impossible, it is clearly not likely to occur. As discussed earlier in this chapter, from 1955 through 1978 utilities ordered 247 nuclear plants but subsequently cancelled or stopped construction on 127 of them, leaving a total active inventory of 120 plants.

We believe that the available evidence clearly shows that the EIA middle case projections of nuclear generating capacity and spent fuel inventories is not likely to be realized. Therefore, until the condition of the nuclear power industry strongly suggests additional growth, DOE should base its waste disposal program on estimates of spent fuel to be produced from the current generation of nuclear plants. Such estimates represent the most realistic projections of future electrical generation from nuclear power, spent fuel inventories, and revenues collected from fees assessed to utilities. With regard to the latter point, this approach for projecting nuclear generating capacity would also, as discussed earlier in this chapter, help to ensure that DOE has not overestimated future revenues in the early years of the program only to find in later years that, absent increases in the current fee rate, revenues will not be sufficient to recover all waste program costs.

Finally, regarding DOE's concern that adopting our recommendation may understate geologic disposal needs, we recognize that this could occur if utilities eventually order, build, and operate new nuclear power plants. As discussed in this chapter, however, at least 16 years are available to DOE from the time that a utility orders a new nuclear plant until DOE must be prepared to take possession of the first batch of spent fuel that would be discharged from the new plant. In addition, although DOE projects spent fuel inventories through 2020, the useful lives of nuclear

The financial and technical assistance task includes grants and other payments to states and Indian tribes involved in nuclear waste disposal activities, pursuant to sections 116 and 118 of the act.

The other task includes all activities not included in the aforementioned tasks.

able II.3: Basalt Waste Isolation Project

Dollars in thousands

Contractor	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Fiscal year 1985 Total	Fiscal year 1985 Budget
Rockwell Hanford Operations	$340	$16,540	$16,880	$15,192
NORCUS	0	253	253	253
University of Washington	0	320	320	255
Department of Natural Resources	0	0	0	30
Bonneville Power Administration	0	0	0	45
U.S Geological Survey	0	227	227	227
Washington State University	0	33	33	45
Pacific Northwest Laboratory	12	874	886	822
Morrison Knudsen	1	27	28	25
Total	**$353**	**$18,274**	**$18,627**	**$16,894**

Comments From the Department of Energy

Department of Energy
Washington, DC 20585

[illegible]87

Mr. J. Dexter Peach
Assistant Comptroller General
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "Nuclear Waste: A Look at Current Use of Funds and Cost Estimates for the Future."

In general, the Department believes this report provides an accurate and useful evaluation of the two important topics covered--the use of funds in implementing the first repository subprogram and the projection of spent fuel inventories used for system planning and to determine the sufficiency of the disposal fee.

The Department agrees with the substance of the budget and expenditure analysis, and with the conclusion that delays in achieving major legislated or planned milestones have increased program costs. However, DOE believes it would improve the clarity of the report to add that most of these delays were unavoidable. The aggressive schedules in the Nuclear Waste Policy Act conflict with the mandated process that requires extensive public participation and cooperation with States and affected Indian Tribes. The Department believes that allowing adequate time for effective public participation and ensuring technical accuracy and quality of the products is essential and should take precedence over meeting scheduled dates in the Act, even though this entails an increase in program cost.

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Secretary's decision of May 28, 1986, to postpone site-specific work on the second repository. A major concern with using only EIA's "no new orders" case is that it may understate the need for geologic disposal. This year's EIA projections, and DOE's planning, reflect continuing trends of increased burnup of nuclear fuels, as compared with previous assumptions of constant burnup. Thus, this year's cost and fee projections are based on significantly lower projections of spent fuel generation through the year 2020 (106,300 MTU this year vs. 126,000 in last year's analyses).

The EIA projections assume the successful development and deployment of higher burnup fuels beyond current technology levels, which may or may not be achievable. Because of the large investment in existing nuclear plants and the cost of new generating capacity, there will be a strong incentive to extend reactor operations as long as it can be done safely and at reasonable cost. Thus, even if no new plants are built, extended operations could increase spent fuel generation beyond that projected by EIA in its "no new orders case." In summary, the middle case may turn out to be an overly optimistic spent fuel projection, but the "no new orders case" is probably too low. It should be noted that DOE is also considering an additional projection in this year's analyses. The "lower reference" (formerly low case) case projects nuclear capacity growth, but at a lower rate than in the "upper reference" case. DOE recognizes the importance of these assumptions in its analyses. It reviews the spent fuel projections each year and includes a range in assessing fee adequacy, but also feels that it is prudent to focus planning on the higher side of those projections to assure the development of an adequate system.

DOE does not concur with the GAO recommendation that civilian radioactive waste management program planning be based only on the reactors operating or under construction today. The conclusions appear to imply that any corrections to the fee based on possible revisions to SNF projections will occur too late. As noted above, the EIA projections reflect current nuclear industry conditions, as evidenced by the significant decrease in projected year 2020 capacity in the current projection. If present industry conditions do not improve, this will be reflected in future EIA projections. Therefore, assuming DOE continues to use the "upper reference" case as the upper bound of its SNF assumptions, that upper bound will continue to decline. If "positive" signs do not appear in the commercial nuclear industry over the next few years, it is

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:xploratory Shaft	A subsurface excavation composed of tunnels and rooms in the host rock in the immediate vicinity of the shafts and at the depth that a repository would be built. The shafts will be large enough to allow people and test equipment to be transported from the surface to the subsurface excavations and will allow detailed study of the host rock, including lateral exploratory drilling.
;eochemistry	The study of the distribution and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere.
n Situ Tests	Tests that are conducted with the subject material in its original place (i.e., at the repository site and depth).
Monitored Retrievable Storage Facilities (MRS)	Ground-level or slightly below ground-level storage facilities that will permit continuous monitoring, management, and maintenance of radioactive waste. In addition, these facilities are to provide for the ready retrieval of radioactive waste for either further processing or disposal.
)bligations	Amounts of orders placed, contracts awarded, services received, and similar transactions during a given period that will require payments during the same or a future period.
?eprogramming	The utilization of funds in an appropriation account for purposes other than those contemplated at the time of the appropriation.
;eismic	Anything that is pertaining to, characteristic of, or produced by earthquakes or earth vibrations.
;ite Characterization	Activities, whether in the laboratory or in the field, undertaken to establish the geologic condition and the ranges of the parameters of a candidate site relevant to the location of a repository, including borings, surface excavations, excavations of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing needed to evaluate the suitability of a candidate site for the location of a repository.

The Nevada Nuclear Waste Storage Investigations Project in Las Vegas, Nevada, did not have an earned value system in fiscal year 1985. The project office has subsequently developed such a system.

Objectives, Scope, and Methodology

By letter dated September 19, 1985, the Chairman and the Ranking Minority Member, Senate Committee on Energy and Natural Resources, expressed concern that costs in the waste management program are not being scrutinized by an independent group, and requested that GAO assist in the oversight of the large and rising outlays in the program. On the basis of this letter and subsequent discussions with the Committee staff, we agreed to review

- the use of fiscal year 1985 nuclear waste funds, compared with the budget approved by the Congress;
- the effect that schedule delays have had on costs in the waste management program; and
- potential problems involving the TSLCC estimates and reasons for substantial increases in the estimates since 1984.

Our review of the latter issue was limited to assessing the underlying reasons for changes in the major cost categories that make up DOE's TSLCC estimates. We did not, however, determine specific reasons why DOE increased its cost estimates for the many individual activities that, taken together, comprise its waste disposal program. In future reviews, we plan to assess in more detail the specific reasons for cost growth in selected waste program activities. For example, on the basis of additional discussions with the Committee staff, we are currently assessing the reasons for significant increases in DOE's estimates of the cost of characterizing the three potential first repository sites.

We made our review at DOE headquarters in Washington, D.C., and at DOE's first repository project offices in Richland, Washington; Las Vegas, Nevada; and Columbus, Ohio. We performed our review in accordance with generally accepted government auditing standards, except that because of time constraints, we did not verify the data obtained from DOE's financial information system or from OCRWM's program management information system.

We provided draft copies of this report to DOE for comment. Specific comments are summarized and addressed at the end of each chapter, and technical or editorial comments have been incorporated in the text fiscal year 1985 actual cost, (3) differences in the budgeted cost of work performed and its actual costs, (4) differences in the amount of work planned compared with the amount of work performed, and (5) reasons for these differences.

For each work activity, we obtained budget and cost data from OCRWM's program management information system. We did not perform a reliability assessment of the computer data. However, we discussed the data with project office and contractor officials. Our discussions did not disclose problems with the reliability of the fiscal year data in the program management information system for the Salt Repository Project. On the other hand, our discussions did reveal problems with the fiscal year 1985 data in the program management information system for the Basalt Waste Isolation Project. For example, the detailed cost data for one work activity—drilling of boreholes to test groundwater—were overstated by about $437,000. This error was discovered through our discussion with a Rockwell official. Rockwell officials subsequently indicated that other problems existed with the fiscal year 1985 data and that primarily because of budget constraints, Rockwell was unable to make all of the necessary corrections to the fiscal year 1985 computer data.[b]

Because we discussed each of our sample work activities with Rockwell officials at the Basalt Waste Isolation Project, we believe the data for those activities to be sufficiently reliable for the purpose of this review. However, because of problems noted with the data during our discussions, we did not develop overall statistics for activities at the Basalt Waste Isolation Project such as those compiled for the Salt Repository Project and discussed in chapter 2.

At the Nevada Nuclear Waste Storage Investigations Project, which did not have an earned value system in fiscal year 1985, we reviewed the project office budget for fiscal year 1985, the project management plan, and other pertinent documents. To review specific fiscal year 1985 work activities, we selected the three contractors in the site task and one contractor in the regulatory and institutional task that had the highest amount of obligations for fiscal year 1985. We discussed the work activities for each of these contractors with project office officials and contractor officials—Science Applications International Corporation (This

[b]According to Rockwell's project planning manager, the problems found in the fiscal year 1985 data do not exist in the fiscal year 1986 data. We did not, however, attempt to verify the accuracy of the fiscal year 1986 data.

affect various cost components resulting in both increases and decreases in estimates.

Table 2.1: DOE's Fiscal Year 1985 Budget Request for the Nuclear Waste Fund by Subprogram

Dollars in millions

Subprogram	Amount requested	Percentage of total
First repository	$247 1	75
Second repository	28 7	9
MRS	8.5	3
Program management and technical support	40 1	12
Debt service	3.3	1
Total	**$327.7**	**100**

The table shows that DOE intended to use $247.1 million, or 75 percent of the fiscal year 1985 appropriation, to carry out activities for the first repository subprogram. These activities, including completing the environmental assessments, were to achieve certain major milestones, including

- recommending three of five sites to the President for site characterization by January 1, 1985;
- issuing site characterization plans for the candidate sites in March 1985; and
- beginning construction of the first exploratory shaft in March 1985.

DOE's budget requested funds for 10 different tasks for the first repository subprogram. (See table 2.2.) Under the site task, DOE's budget stated that site characterization at the recommended salt site would be initiated in fiscal year 1985 and that two boreholes would be drilled for repository design data near the candidate site. It further stated that drilling and testing at the basalt and tuff sites would continue in fiscal year 1985. Under the regulatory and institutional task, the budget stated that site characterization plans would be issued in fiscal year 1985 for sites recommended for characterization and would be updated semiannually.

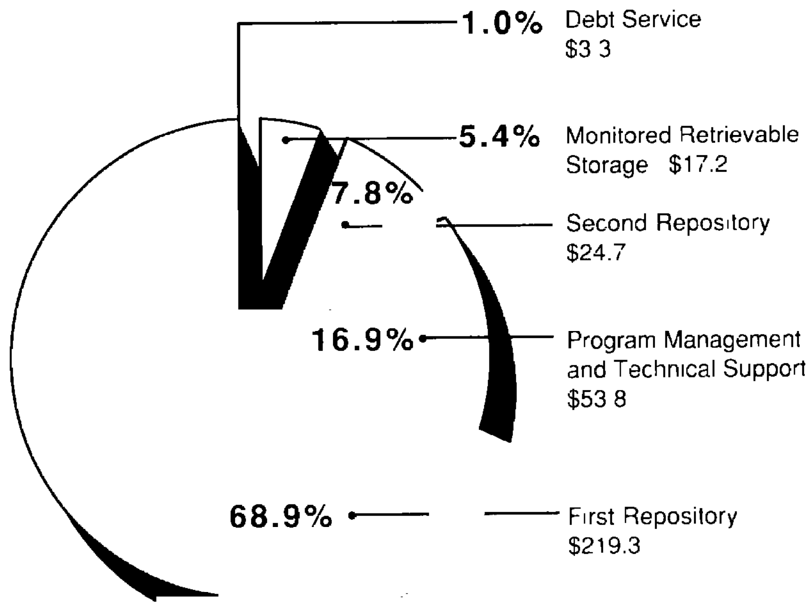
In fiscal year 1985 DOE had one major reprogramming of funds within the waste management program to MRS.[1] DOE's initial plan for an MRS facility was to provide backup storage capability should there be significant delays in the availability of a geologic repository. The facility would be built and operated until the repository was ready to receive spent nuclear fuel. Subsequently, DOE reevaluated the role of an MRS facility. As proposed by DOE, the facility would provide an early focus for developing and integrating the essential operational functions of waste acceptance, packaging, and transportation for disposal. Its primary purpose would be to receive and prepare spent nuclear fuel from commercial reactors for disposal in a geologic repository. (DOE's MRS proposal is discussed in more detail in our report, Nuclear Waste: DOE Should Provide More Information on Monitored Retrievable Storage (GAO RCED-87-92, June 1, 1987.))

As a result of the expanded role of MRS in the waste management system, DOE needed a significant amount of additional design and redesign work to meet the June 1, 1985, deadline to submit a proposal for constructing an MRS facility to the Congress. Therefore, more funds were needed for MRS than requested in the fiscal year 1985 budget. On March 1, 1985, DOE informed the Congress of its intent to reprogram $8.844 million from first repository activities and $150,000 from program management and technical support activities—a total of $8.994 million—to the MRS subprogram. Subsequently, $25,000 was transferred back to program management and technical support in order to fund travel activities related to MRS. This reprogramming action did not affect first repository activities because, as discussed in a subsequent section of this chapter, delays in the first repository subprogram made funds available for other waste program activities.

In addition to the one major reprogramming action, DOE administratively moved other funds from one subprogram to another. These movements were reported in the fiscal year 1986 and 1987 budget submissions to the Congress. In the first and second repository subprograms, $2.7 million and $4 million, respectively, were moved to program management and technical support. OCRWM then moved $9,000 back to the second repository. Another $310,000 and $165,000 was moved from first repository and program management and technical support, respectively, to transportation and systems integration. The funds were used to carry

[1]Reprogramming is the utilization of funds in an appropriation account for purposes other than those contemplated at the time of the appropriation. Reprogramming is generally preceded by consultation between the agency and the appropriate congressional committees.

Figure 2.1: Nuclear Waste Fund Obligations for Fiscal Year 1985 by Subprogram



Source GAO calculations using DOE data

Delay in Completing Environmental Assessments

Initially, DOE had planned to complete the final environmental assessments by September 1984, over 3 months in advance of the January 1, 1985, date by which NWPA specifies that the Secretary recommend sites to the President for site characterization. The final assessments, however, were issued 17 months later than set out in the act for the Secretary's recommendation because of (1) revisions needed to the environmental assessments, (2) OCRWM's decision to issue the environmental assessments in draft for public comment, and (3) OCRWM's decision to have the National Academy of Sciences (NAS) review its methodology for ranking potential repository sites and its application of the revised methodology proposed by NAS to the data that were collected on each site.

OCRWM had originally planned to issue nine draft assessments—one for each of the nine potential first repository sites—for comment in August 1984, and issue the final environmental assessments in September 1984. However, the draft environmental assessments were delayed because

Schedule Delays Affected the Use of Fiscal Year 1985 Nuclear Waste Funds

For the first repository subprogram, the project offices planned to accomplish many activities in the site and regulatory and institutional tasks in fiscal year 1985. Some activities were affected, however, by the delay in completing the environmental assessments and recommending and approving sites for site characterization. We analyzed the extent that the contractors were completing planned work in the site and the regulatory and institutional tasks at each of the three project offices. This analysis showed that in the site task the greatest impact of the delay in completing the environmental assessments was on the Salt Repository Project. In the regulatory and institutional task, all three project offices experienced delays and/or additional costs in accomplishing planned activities. As a result of some activities being delayed, the project offices had funds available to use for other activities that cost more than anticipated.

Site Task

Unlike the Basalt Waste Isolation Project, which has one basalt site (Hanford, Washington), and the Nevada Nuclear Waste Storage Investigations Project, which has one tuff site (Las Vegas, Nevada), the Salt Repository Project had to perform first repository subprogram activities in three areas—Paradox Basin, Palo Duro Basin, and Gulf Interior Salt Basin. These three salt basins included seven of the nine potentially acceptable first repository sites. Activities at each of these areas had to continue until three specific sites were selected for site characterization.

Table 2.5 shows the number of activities at the Salt Repository Project that were not started in the site task during fiscal year 1985 and the number that were over budget by $10,000 or more.

Table 2.5: Salt Repository Project Activities in the Site Task During Fiscal Year 1985

Dollars in millions

	Number of activities	Percentage of total	Budgeted cost[a]	Actual cost
Planned activities	496	100	$25 8	$21.9
Over budget by $10 000 to $24 999	29	6	1 6	2 1
Over budget by $25,000 or more	23	5	3.6	4 9
Activities not started	50	10	1.8	0 0

[a]Includes funds available from prior years

At the Salt Repository Project, we discussed and/or obtained documentation on 30 activities at a budgeted cost of $4.9 million. Our analysis

- The Earth Technology Corporation was to provide overall project management and administration for the Gulf Interior Salt Basin geotechnical studies. Management and administrative activities include (1) estimates, forecasts, and cost maintenance functions, (2) planning and scheduling, (3) contract administration and purchasing, (4) records management, (5) project management, and (6) clerical and staff services. The budgeted cost for fiscal year 1985 was $567,000 and the actual cost was $667,000 or $100,000 over the budgeted amount. As further discussed in a subsequent section of this chapter, this activity also continued into fiscal year 1986 because of the delay in completing the environmental assessments.

Regulatory and Institutional Task

Table 2.6 shows the number of activities at the Salt Repository Project that were not started in the regulatory and institutional task during fiscal year 1985 and the number that were over budget by $10,000 or more.

Table 2.6: Salt Repository Project Activities in the Regulatory and Institutional Task During Fiscal Year 1985

Dollars in millions

	Number of activities	Percentage of total	Budgeted cost[a]	Actual cost
Planned activities	364	100	$19.6	$17.7
Over budget by $10,000 to $24,999	25	7	1.0	1.4
Over budget by $25,000 or more	30	8	3.1	6.2
Activities not started	18	5	1.1	0.0

[a]Includes funds available from prior years

At the Salt Repository Project, we obtained documentation on 30 activities at a budgeted cost of $6.3 million. Our analysis showed that five work activities budgeted at $407,000 had been completed as planned in fiscal year 1985. Four activities budgeted at $558,000 had not been started, and 21 activities budgeted at $5.3 million had not been completed.

The following are several examples of the types of planned activities that were either not started or started but not completed at the Salt Repository Project:

International Corporation) had 31 planned activities in the regulatory and institutional task during fiscal year 1985. Eleven activities were not completed as planned.

Most of the uncompleted activities were related to preparing chapters 2, 4, or 8 of the site characterization plan. Chapters 2 and 4 of the site characterization plan will describe the site, waste package, and repository design in the geoengineering and geochemistry areas, respectively. We were unable to obtain budgeted and/or actual cost figures for these activities because, as indicated in chapter 1 of this report, the Nevada Nuclear Waste Storage Investigations Project did not have a detailed breakdown of these data by specific work activity in fiscal year 1985.

Schedule Delays Made Funds Available to Cover Unanticipated Costs

In addition to activities planned in the first repository site and regulatory and institutional tasks that were not started or completed as planned, activities in other tasks, such as exploratory shaft drilling, were not started, and funds were shifted from one task to another. The project offices, therefore, had funds available to cover the unanticipated cost of other activities.

At the Salt Repository Project, for example, 50 activities in the site task at a budgeted cost of $1.8 million were not started in fiscal year 1985. Likewise, 18 activities in the regulatory and institutional task at a budgeted cost of $1.1 million were not started in fiscal year 1985. These activities will be started in subsequent fiscal years.

In addition, more funds were used for some tasks than planned and less for other tasks. For example, although DOE requested $56.2 million and $15.5 million for the exploratory shaft and regulatory and institutional tasks, respectively, about $17.5 million in obligations were incurred as operating expenses in the exploratory shaft task and about $33.4 million in the regulatory and institutional task.

In effect, other activities with unanticipated costs could be funded. Examples follow:

- At the Salt Repository Project, Stone and Webster was to develop reports providing detailed information and maps on the potential for dissolution of salt in the Palo Duro Basin. The fiscal year 1985 budgeted cost for this activity was $42,000. The fiscal year 1985 actual cost was $109,000. According to a Battelle representative, the budgeted cost represented a bad estimate of the effort needed to perform this activity.

Isolation Project. For fiscal year 1985, actual costs for the environmental assessment totaled about $1 million. According to the Basalt Waste Isolation Project manager, the higher than anticipated costs were a result of changes in the scope of documents, which were required after interaction with NRC, states, and tribes.

For example, Rockwell was to prepare a final copy of the Hanford site environmental assessment, including photography support, technical editing, word processing, etc. Recognizing the increased cost associated with the environmental assessments, the activity was subsequently budgeted for $163,900. However, at the end of fiscal year 1985, the activity had incurred actual costs of $220,000 and not all of the planned work had been completed. The Rockwell official stated that Rockwell initially had no concept of the number of revisions that would subsequently be needed on the environmental assessment. He attributed the revisions to the lack of specific guidance on what was needed in the final environmental assessment.

In our second annual report on the waste management program, we stated that DOE officials at the Salt Repository Project estimated that the total cost for finalizing the environmental assessments increased from $7.7 million (October 1983) for three environmental assessments to over $23.2 million for seven environmental assessments.[2] In that same report, we stated that the cost of the contractor (Weston) that assisted OCRWM in reviewing the environmental assessments increased, according to Weston, from $350,000 (October 1983) for five environmental assessments to $875,000 for the nine drafts. According to DOE, these increases also reflect a larger job to finalize the environmental assessments than was originally estimated.

Examples of activities that increased costs as a result of completing the environmental assessments follow:

- Battelle was to provide all performance assessment activities relative to preparation of the environmental assessments including workshops and briefings. The fiscal year 1985 budgeted cost for this activity was $138,900. During fiscal year 1985, there were several changes in the environmental assessments regarding what sections were to be prepared and how many environmental assessments were to be prepared. Actual

[2]The Nuclear Waste Policy Act 1984 Implementation Status, Progress, and Problems (GAO RCED-85-100, Sept. 30, 1985)

December 1984 to August 1985. The fiscal year 1986 cost was $46,200 as of March 1986.

In addition, the delay in completing the environmental assessments has contributed to the delay in exploratory shaft drilling. DOE's overall objective for the first repository, prior to NWPA, was to have three sites characterized by surface technologies in 1983 and to have three exploratory shafts in some phase of construction.[4] Accordingly, at two sites DOE had begun preparing for site characterization. At the basalt site, DOE had finished drilling the principal borehole and was preparing to drill an exploratory shaft. Similarly, at the tuff site, DOE had begun to drill the principal borehole and was designing the exploratory shaft, which was scheduled for drilling in October 1983. For the salt site, DOE had planned to identify one salt site for characterization by mid-1983 and issue a site characterization report on the selected site. Exploratory shaft drilling was to follow in 1984.

With the passage of NWPA, this overall objective changed. Although DOE had selected tuff and basalt for detailed testing on the basis of their rock type and geohydrologic setting prior to NWPA, it needed to meet the requirements of NWPA using the new criteria specified in the siting guidelines. As a result, these sites became two of nine and subsequently two of five potential first repository sites. Consequently, exploratory shaft drilling was postponed pending issuance of the siting guidelines, environmental assessments, and site characterization plans as required by the act.

Morrison Knudsen, the contractor responsible for drilling the exploratory shaft at the basalt site, estimated that through fiscal year 1985, almost $3 million in costs were due to program delays such as the delay in completing the environmental assessments. These costs included about $2.53 million to lease the drill rig through fiscal year 1985, $175,000 to store the exploratory shaft liner, and about $251,000 for subcontract and labor costs.

DOE and contractor officials agree that schedule delays such as the delay in completing the environmental assessments have increased the cost of the first repository subprogram and that the additional cost, because of delays in fiscal year 1985, is in the millions of dollars. For example, a

[4]Before the act, the federal government had been developing a program to permanently dispose of radioactive waste in geologic repositories. For about 3 decades DOE and its predecessor agencies (Atomic Energy Commission and Energy Research and Development Administration) had primary responsibility for this program.

Table 2.7: Comparison of Milestones in DOE's Mission Plan and Project Decision Schedule

Milestone	Draft mission plan	Final mission plan	Project decision schedule
Issue final siting guidelines	6/84	12/84	12/84
Issue draft environmental assessments	8/84	12/84	12/84
Issue final environmental assessments and recommend 5 sites	12/84	11/85	4/86
President approves 3 sites for characterization	2/85	1/86	6/86
Issue initial site characterization plans	1/85–9/85	3/86–10/86	12/86–4/87
Begin exploratory shaft construction and testing	3/85	2/86	12/86
Complete exploratory shaft testing	3/89	12/89	9/90
Issue final environmental impact statement	3/90	12/90	7/91
President recommends site to the Congress	6/90	3/91	10/91
Submit license application to NRC	8/90	5/91	12/91
Receive NRC construction authorization	8/93	8/93	3/94
Complete phase I construction	7/97	7/97	7/97
Begin phase I operations	1/98	1/98	1/98

We have previously questioned DOE's ability to meet the January 31, 1998, date for first repository operations. In our third annual report on the waste management program, we said that schedule delays in the first repository siting process, problems with state and Indian tribe cooperation and consultation, and potential delays resulting from lawsuits had jeopardized DOE's ability to meet program milestones and ultimately its initial commitment to begin repository operations by January 31, 1998.[5] In a draft of the report, we proposed that the Secretary of Energy evaluate the impact of past schedule delays and determine whether DOE's January 31, 1998, target date was reasonable for beginning repository operations. However, in January 1987, prior to issuance of our third annual report, DOE proposed revisions to its milestones in a draft amendment to the mission plan. This amendment was submitted to the Congress on June 9, 1987.

As shown in table 2.8, exploratory shaft construction has been rescheduled for the fourth quarter of 1988 for the tuff site, the second quarter of 1989 for the basalt site, and the fourth quarter of 1989 for the salt site. First repository operations have been rescheduled for 2003.

[5] Status of DOE's Implementation of the Nuclear Waste Policy Act (GAO/RCED-87-17, Apr. 15, 1987).

Figure 2.2: Differences in Schedules for the First Repository Subprogram Effort
(Refer to table 2.9)

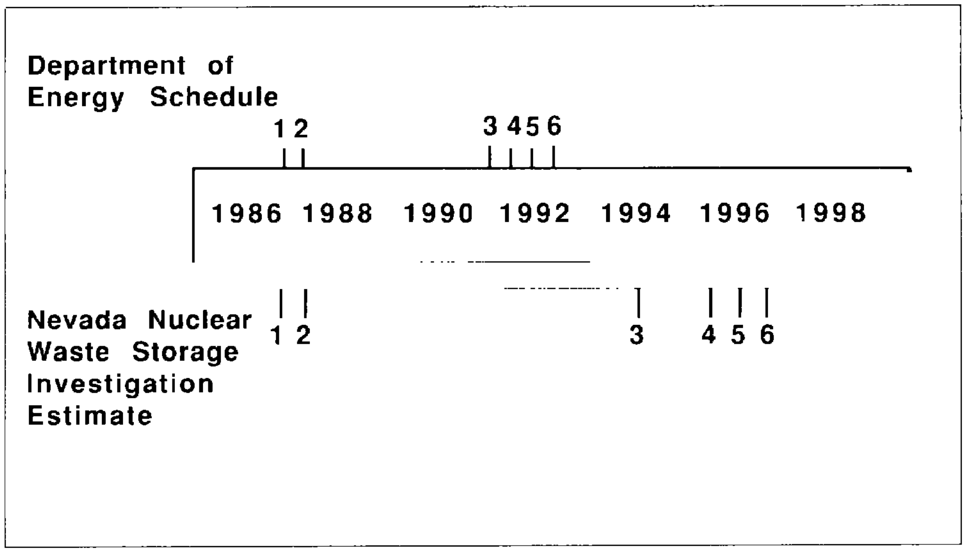


Table 2.9: DOE Milestones

Milestone		Department of Energy	Nevada Nuclear Waste Storage Investigations Project
1	Issue site characterization plan	12/86	12/86
2	Initiate exploratory shaft construction	5/87	5/87
3	Issue draft environmental impact statement	1/91	10/93
4	Issue final environmental impact statement	7/91	10/95
5	Presidential recommendation	10/91	1/96
6	Submit license application to NRC	12/91	4/96

Sources: DOE milestones are based on its March 1986 project decision schedule. The Nevada Nuclear Waste Storage Investigations Project milestones were developed based on an internal analysis of the schedule needed for exploratory shaft construction and prior experience in issuing program documents.

Scientists responsible for the technical work to accomplish subprogram milestones also expressed concern that schedule delays may affect the quality and quantity of the technical work. Some of their comments follow:

"My concern is that we have to plan our work in a continuing environment of flux. We can't carry out our tasks in this type of environment. The schedules we are working under are unrealistic and we have to make assumptions to squeeze things in."

(3) some subprogram milestones were moved closer to January 31, 1998, therefore, compressing the time available to meet them.

On the basis of our review of fiscal year 1985 work activities and discussions with DOE and contractor officials, the delays in fiscal year 1985 added millions of dollars to the first repository subprogram. According to a DOE project office official, the additional costs would be difficult to determine since delays have increased the cost of some activities while they have precluded the start of others. If DOE continues to incur higher than anticipated costs because of schedule delays or changes in scope, costs for the first repository subprogram could be substantially higher than DOE's current estimate.

In addition, in a June 1987 amendment to its mission plan, DOE revised its milestones for the first repository subprogram. These revised milestones will probably address some of the concerns expressed by DOE project office officials, scientists, and NRC. However, concerns may not be alleviated if schedules continue to slip as they have in recent years.

Agency Comments

DOE agreed with our budget and expenditure analysis, and our conclusion that delays in achieving major legislated or planned milestones have increased program costs. DOE stated that the aggressive schedules in the Nuclear Waste Policy Act conflict with the mandated process that requires extensive public participation and cooperation with states and affected Indian tribes. DOE believes that allowing adequate time for effective public participation and ensuring technical accuracy and quality of the products is essential and should take precedence over meeting scheduled dates in the act, even though program costs may increase.

performance" system (with an MRS facility).[1] Table 3.1 summarizes the cases for the 1986 analysis. For the authorized system, DOE analyzed 10 different reference cases using varying potential repository-site combinations. For these reference cases, the estimated cost for the waste disposal system ranged from $23.6 billion to $32.3 billion (1985 dollars).

In addition to the 10 reference cases, DOE analyzed 6 sensitivity cases involving variations in the repository host rock combinations coupled with (1) a decreased quantity of commercial spent fuel generated through the year 2020, (2) a 5-year delay in first and second repository operations, and (3) a 10-year repository delay. For these sensitivity cases, the estimated costs for the waste disposal system ranged from $21.3 billion to $38.9 billion (1985 dollars).

An additional factor that could affect the life cycle cost is the proposed MRS facility. The 1986 TSLCC analysis recognized DOE's intention to seek congressional authorization of an MRS facility and incorporated it into the case structure as an "improved performance" system. DOE's estimated total system cost with an MRS facility, including reference case and sensitivity case estimates, ranged from $24 billion to $41 billion (1985 dollars). In displaying the results of its sensitivity cases, DOE presented the highest and lowest cost host rock combinations.

In June 1987 DOE issued an amendment to its mission plan that delays the date for waste acceptance at the first repository 5 years (from 1998 to 2003), makes other adjustments to intermediate milestones, and proposes to defer the schedule for a second repository several years. With these schedule changes, the 1986 cost estimates shown in table 3.1 for the 5-year delay sensitivity case may now be more representative of DOE's current program plans than the reference case estimates that assume an operational repository in 1998. DOE is reevaluating the impact of a 5-year delay on the TSLCC. According to DOE's 1986 TSLCC analysis, life cycle costs increased $3.4 billion (1985 dollars) using the high (basalt/crystalline rock combination) and the low (tuff/crystalline rock combination) cost estimates in the event of a 5-year repository delay.

[1] Analysis of the Total System Life Cycle Cost for the Civilian Radioactive Waste Management Program (DOE RW-0047, Apr. 1986).

unclear what impact this decision will have on the program's long-term life cycle costs.

Changes in TSLCC Estimates Since 1983

The 1986 TSLCC analysis highlighted the changes in DOE cost estimates that have occurred since 1983. The cost estimates shown in tables 3.2 through 3.6 have been converted to constant 1986 dollars to eliminate the effects of general inflation and thus show how the "real" program costs have changed from year to year.[2]

The cost estimates in table 3.2 are for the "reference system"—the authorized system consisting of the two planned repositories and the waste transportation system—which does not contain an MRS facility. As shown in table 3.2, from 1983 to 1986, the range of total estimated costs for the authorized system increased by $2.1 billion to $10.4 billion. Development and evaluation cost estimates have increased by about $4 billion. Transportation cost estimates have fluctuated since 1983, and by 1986 they had actually decreased by $1.9 billion to $3 billion. The range of estimated repository costs increased by $0.6 billion to $8 5 billion from 1983 to 1986.

Table 3.2: Comparison of Total System Life Cycle Cost Estimates for the Reference Program

Dollars in billions

Major cost category	1983 estimate	1984 estimate	1985 estimate	1986 estimate
Development and evaluation	$5 4	$8 4	$8 3	$9.2–9 6
Transportation	4 5	2 8–4.3	3 5–5 4	1 5–2 6
Repository	12 2–12 8	11 6–14 2	13 3–17 9	12 8–21 3
Total[a]	**$22.1–22.7**	**$23.0–26.9**	**$25.2–31.5**	**$24.2–33.1**

Note Estimates are in constant 1986 dollars

[a]The range in total costs may not equal the sum of minimum maximum costs for each category because (1) the ranges for each category may not be based on the same case and (2) independent rounding of the costs for each category was made

In comparing the annual cost estimates, the 1986 TSLCC report listed several broad reasons why the estimates change over time. These reasons generally fall into the following categories:

- Definitions of the cases to be analyzed have changed. For example, the 1986 TSLCC analysis introduced cases reflecting both a generic high-cost

[2]We used the GNP deflator to convert dollar values to 1986. Index numbers for the years 1982 through 1985 were taken from The Economic Report of the President (Jan 1987), table B-3, p 248 The index number used for 1986 was the latest we could obtain from the Commerce Department at the time we did our analysis

Table 3.3: Repository Cost Comparison—Basalt

Dollars in millions

	Engineering and construction			Operations and maintenance		
Cost category	**1984**	**1985**	**1986**	**1984**	**1985**	**1986**
Land acquisition	$0 0	$5 6	$0 0	$0 0	$0.0	$0 0
Site preparation	35 2	76 9	47 5	0 0	97.0	69 4
Surface facilities	1 064.7	632 9	898 0	2,189 9	3,111.1	3 621 1
Shafts/ramps	819 1	646 1	977.8	0.0	0.0	69 9
Underground development	462 4	1,139 7	309.9	2,182 2	4,496 0	3 989 0
Waste package fabrication	0 0	0 0	0 0	777 3	1,131 3	1 377 5
Total[a]	**$2,381.5**	**$2,501.1**	**$2,233.0**	**$5,149.4**	**$8,835.4**	**$9,126.7**

Note Costs are in constant 1986 dollars

[a]Totals may not add because of rounding

Many of the changes in the estimates between 1984 and 1985 occurred because the 1984 estimates were based on earlier site-specific designs, while the 1985 estimates were based on the Nevada Nuclear Waste Storage Investigations Project's facility design requirements for the potential tuff site in Nevada. The tuff design was adjusted to allow for the major differences between the host rocks. DOE refers to this as a "parametric" approach, which assumes that many features of the surface facilities and underground layout are generic for all rock types. In contrast, the 1986 TSLCC analysis was based on the most recent site-specific engineering design and cost data instead of parametric costing techniques. The cost estimates for all of the sites showed significant changes from 1985 to 1986 as a result of the differences in design, methods, and assumptions.

Total cost estimates shown in DOE's TSLCC analyses for a repository in basalt, including engineering and construction, operations and maintenance, and decommissioning costs, were $7.729 billion in 1984, $11.489 billion in 1985, and $11.634 billion in 1986 About $3 billion (79 percent) of the $3.8-billion increase in costs between 1984 and 1985 was in the "underground development" cost category. Underground development costs are determined by the unit mining costs (including labor, material, and equipment) and linear feet of drift or tons of rock mined. In its 1985 TSLCC analysis, DOE stated that the cost increase was "attributed to several factors, the main one being a newly designed underground layout." The new design required more underground development and rooms and corridors.

The total cost estimates for the three annual analyses, including engineering and construction, operations and maintenance, and decomissioning costs, for a repository in the salt medium are $6.177 billion in 1984, $7.127 billion in 1985, and $8.153 billion in 1986. About $0.4 billion, or 40 percent of the $1-billion increase between 1984 and 1985, was in the category called "surface facilities." For the salt repository estimates, underground development actually decreased about $70 million from 1984 to 1985, as compared with the 1985 increase of $3 billion for the basalt estimates in the same category. The design changes and the parametric costing methods used in 1985 apparently had less impact overall on the salt estimates for underground development.

Another cost component we selected for further discussion with DOE was in the surface facilities category. The component, called "waste handling building number 1," had cost estimates for engineering and construction and operations and maintenance of $176.5 million in 1985 and $546 million in 1986. In our discussions with DOE, the staff explained that the 1984 design did not include a waste-handling building. They pointed out that the 1985 salt estimate was also based on the tuff design, and the 1986 estimate was based on a salt site-specific design. As with the basalt estimates, the salt repository cost estimate changes appear to be directly related to the changes in the cost-estimating methodology.

Tuff

As was the case with the cost analyses for basalt and salt repositories, cost estimates for a repository in the tuff medium were affected by the evolving program strategy and changes in the repository design concept. Table 3.5 shows the 1984, 1985, and 1986 estimated life cycle costs for a repository in tuff. The estimated costs for decommissioning were $199.3 million in 1984, $130.8 million in 1985, and $114.4 million in 1986.

DOE's Forecasting Approach

DOE estimates future quantities of spent fuel from commercial nuclear power plants for each year through 2020. In making such estimates, DOE does not anticipate that 2020 will represent the last year of nuclear plant operations in the United States. Rather, DOE uses that year as a cut-off date for estimating the amount and schedule of spent fuel to be disposed of in the first and second waste repositories. This approach is consistent with subsection 302(a) of NWPA, which required the Secretary of Energy to prepare a mission plan that would provide an informational basis sufficient to permit informed waste program decisions. Among other things, the subsection required the Secretary to include in the mission plan an estimate of the total repository capacity required for spent fuel and high-level waste expected to be generated through 2020.

The first commercial nuclear power plants in the United States began operating almost 30 years ago, and 109 plants now have operating licenses. (Six of these plants have been issued operating licenses for fuel loading and low power testing but not for commercial operations.) Therefore, DOE has hundreds of reactor-years of operating experience available to it to estimate how much spent fuel a reactor of a particular design and size will produce over its operating lifetime of up to 40 years Thus, the key to projecting the accumulation of spent fuel more than 30 years into the future is the number, type, and size of the nuclear power plants that will be operated during the period.

DOE uses projected spent fuel inventories through the year 2020 prepared and published by its Energy Information Administration (EIA). EIA's spent fuel projections are based on its published forecasts of future commercial nuclear power capacity. In developing these forecasts, EIA uses the actual number of nuclear plants already in operation and under construction as its basis for forecasting through 2000. For 2001 through 2020, EIA uses an economic model to sequentially project (1) long-term economic growth and an energy demand growth rate, (2) delivered energy, including electricity's share, for each year of the forecast period (3) nuclear energy's share of projected electricity generation, and (4) the nuclear power generating capacity required to satisfy nuclear energy's share of delivered electrical energy.

EIA makes four projections of spent fuel inventories—high, middle, low, and "no new orders." The first three projections are based on different assumptions about long-term economic growth, while the last projection

DOE's Approach Introduces Uncertainty and Overestimates Future Generating Capacity

As table 3.7 illustrates, the annual nuclear generating capacities and spent fuel inventories that DOE uses for waste program planning in its reference case differ markedly from the projections made in the decreased spent fuel case. In comparing the two projections, less uncertainty exists in the decreased spent fuel case because it is based on the actual nuclear plants operating and under active construction, while DOE's reference case is based on long-range modeling of economic activity and energy demand.

To achieve the level of nuclear generating capacity projected in DOE's reference case, enough new plants would have to be ordered from manu facturers of nuclear power plants and constructed to increase total generating capacity by 140 gigawatts-electric, from 108 gigawatts-electric ii 1995 (the peak capacity year for actual plants operating and under construction) to 248 gigawatts-electric in 2020. In addition, as table 3.7 shows, without new plant orders, nuclear generating capacity will begin to decline after 1995 as plants reach the end of their useful lives and are retired. Thus, an additional 62 gigawatts-electric of new generating capacity—the EIA-projected difference between capacity on-line in 1995 and 2020 if no new plants are ordered—would have to be constructed by 2020 to achieve DOE's reference case projections. Furthermore, with a minimum of 10 years from a utility's application for a construction permit until plant operation, the 202 gigawatts-electric of new capacity would have to be ordered by utilities from their suppliers by 2010 to be on-line by 2020. Based on the average size of plants currently operating and those under construction, about 200 nuclear power plants would be needed to generate the 202 gigawatts-electric.

In contrast, the decreased spent fuel generation case that DOE used for sensitivity analysis shows a peak of 108 gigawatts-electric in 1995 with a decline to 46 gigawatts-electric by 2020 as existing plants are retired. Under this scenario, 87,400 MTU, or 39,200 MTU (31 percent) less spent fuel than projected in DOE's reference case, would be generated.

In either the DOE reference or the decreased spent fuel case, DOE would still be faced with providing repository capacity for the spent fuel to be generated after 2020. For the reference case, the volume of spent fuel that would be generated after 2020 by the 248 gigawatts-electric of capacity on-line that year would be large. One indication of how large the volume would be is the fact that the current inventory of nuclear plants—with 108 gigawatts-electric projected to be on-line at the peak period—is projected to produce 87,400 MTU of spent fuel by 2020. However, disposing of the spent fuel from nuclear generating capacity on-

DOE's Approach Makes Sufficient Revenue Collection Uncertain

DOE is required by the Nuclear Waste Policy Act to recover the full cost of the program through the fees paid by owners and generators of nuclear wastes and to invest amounts in the Nuclear Waste Fund that are in excess of current fund requirements. Each year DOE submits a report to the Congress addressing the adequacy of the fee, and all reports to date have concluded that the present fee is adequate.[4]

DOE has reached its conclusions, however, on the basis of the optimistic rate of spent fuel generation—the EIA middle case projection—that it also uses for waste system planning and TSLCC analyses. Quantities of spent fuel generated and revenues collected in the form of fees paid into the Nuclear Waste Fund are directly related to the generation of electricity from nuclear power plants. If DOE's optimistic projections of future spent fuel inventories are not realized, revenues from fee collections and interest on invested funds will also be less than currently projected. Program costs, however, will not decrease proportionately because of the relatively large fixed costs of the waste disposal program. Thus, DOE's forecasting approach heightens uncertainty about whether fees collected from waste generators and interest earnings will be sufficient, in the long run, to cover all program costs without increasing the fee rate.

DOE's March 1986 Fee Adequacy Analysis Considered Effects of Decreased Spent Fuel

In its March 1986 fee adequacy report, DOE analyzed projected revenues from fee collections and matched them against the estimated life cycle costs of various repository host rock combinations, and with and without an MRS facility, using the spent fuel projections for the waste program reference case. In addition, to determine the sensitivity of a decreased volume of spent fuel on revenues and fee adequacy, DOE also selected the highest and lowest reference case repository combinations and calculated life cycle costs for both the authorized (no MRS facility) and improved performance (with an MRS facility) systems. Table 3.8 compares projected revenues to life cycle costs for high-and low-cost repository host rock combinations for both the reference and decreased spent fuel cases. Revenue figures in the table are from DOE's March 1986 fee adequacy report. These figures do not include revenues from interest earned on investments of waste funds. Life cycle cost figures are from DOE's April 1986 TSLCC report. These figures do not include interest expenses that might be incurred from borrowing funds from the U.S.

[4]Report on Financing the Disposal of Commercial Spent Fuel and Processed High-Level Radioactive Waste (DOE/S-0020/1, July 1983); Nuclear Waste Fund Fee Adequacy: An Assessment (July 1984); Nuclear Waste Fund Fee Adequacy: An Assessment (DOE/RW-0020, Feb. 1985); Nuclear Waste Fund Fee Adequacy: An Assessment (DOE/RW-0020, Mar. 1986); and Nuclear Waste Fund Fee Adequacy: An Assessment (DOE/RW-0020, June 1987)

86 decrease was attributed to the shifting of some commercial waste to a second repository from a potential first repository in the tuff medium.

Crystalline Rock

As with the estimates discussed in the previous sections, the cost estimates for a repository in the crystalline rock medium were affected by the evolving program strategy and changes in the repository design concept. Table 3.6 shows the estimated costs from DOE's 1984 through 1986 life cycle cost analyses for a repository in crystalline rock. The estimated costs for decommissioning were $159.6 million in 1984, $99.3 million in 1985, and $193.3 million in 1986.

The 1986 estimates shown in table 3.6 are for a repository in low-cost (see table 3.1) crystalline rock. These low-cost estimates are comparable with previous years because estimates for high-cost crystalline rock were not previously considered. The high-cost scenario assumes more difficult geologic excavation conditions in combination with higher labor rates. In 1986 the cost estimate for a second repository in high-cost crystalline rock was nearly 50 percent greater than that of the low-cost site.

Table 3.6: Repository Cost Comparison—Crystalline Rock

Dollars in millions

	Engineering and construction			Operations and maintenance		
Cost category	**1984**	**1985**	**1986**	**1984**	**1985**	**1986**
Land acquisition	$0.0	$1 4	$24.0	$0 0	$0 0	$0 0
Site preparation	134.3	51.6	47 6	91 4	63.7	62 4
Surface facilities	994.2	488 0	595.6	2 283 5	2 825 3	2 318 8
Shafts/ramps	213.6	146 3	719 7	0 0	0.0	47 4
Underground development	414 0	317 8	162 7	753 1	2 021.4	1 385 9
Waste package fabrication	0 0	0 0	0 0	437 1	1 176 3	1 065 2
Total[a]	**$1,756.1**	**$1,005.1**	**$1,549.6**	**$3,565.0**	**$6,086.8**	**$4,879.7**

Note Costs are in constant 1986 dollars

[a]Totals may not add because of rounding.

The total cost estimates for the three annual analyses, including engineering and construction, operations and maintenance, and decommissioning costs, for a repository in crystalline rock are $5.481 billion in 1984, $7.191 billion in 1985, and $6.623 billion in 1986. About $1.17 billion (68 percent) of the $1.71-billion increase in cost estimates between 1984 and 1985 was in the underground development category. In its 1985 TSLCC analysis, DOE said that the use of the parametric scaling

Illustration of Potential Effects of Decreased Spent Fuel and 5-Year Repository Delay

The above analysis assumed 1998 and 2008 startup dates for the first and second repositories, respectively. As discussed earlier, however, DOE has extended the startup date for the first repository to 2003 and, subject to congressional approval, deferred the second repository for several years. In analyzing, for sensitivity purposes, the cost effects of a 5-year delay in both the first and second repository in its April 1986 TSLCC analyses, DOE determined that the life cycle cost of a two-repository waste system would increase by $3.4 billion for both the highest and lowest cost repository combinations. This is a 10- to 15-percent cost increase. DOE also estimated a $3.2-billion increase for the waste system with an MRS facility. This is a 9- to 12-percent cost increase. These calculations are based on the DOE reference case of 126,600 MTU of spent fuel by 2020.

DOE's TSLCC report does not analyze the combined effects of decreased spent fuel and a 5-year delay in the two repositories. Table 3.9 shows the combined effects of these sensitivity cases assuming that the costs would increase in the same ratio as in DOE's analysis of the cost impact of a 5-year repository delay on the reference case spent fuel projections Under these assumptions, as the table illustrates, cumulative revenues from fees would be insufficient to cover the lowest cost alternative.

Table 3.9: Comparison of Revenues and Costs of Decreased Spent Fuel and 5-Year Delay in Repositories

Dollars in billions

Waste system	Cumulative fee revenues[a]	Life cycle costs[b]	Difference
Authorized system (no MRS)			
Highest cost	$23.9	$31.2	$(7.
Lowest cost	23.9	24.5	(0.
Improved performance system (with MRS):			
Highest cost	23.9	33.7	(9.
Lowest cost	23.9	26.1	(2.

[a]Does not include interest earned on investment of waste program funds

[b]Does not include interest expense incurred from borrowing funds

Note: Costs are in constant 1985 dollars

As tables 3.8 and 3.9 illustrate, if the nation's utilities do not begin to build new nuclear power plants at the rate that would be required to fulfill DOE's reference case spent fuel projections, at some future time DOE will be faced with reducing its spent fuel estimates. Such a reduction would also reduce projected revenues from fee collections more than it would reduce estimated life cycle costs. DOE would then be faced with the possibility of increasing the waste disposal fee.

nuclear plant and to allow spent fuel to cool in reactor storage pools at plant sites before removing it from the plants for disposal in a repository. On the basis of information collected by EIA, the average lead time between a utility application to NRC for a nuclear power plant construction permit and the time the plant begins operation is about 14 years. For example, in December 1984 the average lead time from the application for a construction permit to commercial operation for 38 nuclear plants in the construction pipeline at that time was about 14 years, and the minimum estimated lead time was about 10 years. Added to the construction lead time would be a year or more of operation before spent fuel is removed from the reactor and a minimum of another 5 years before spent fuel is ready for shipment to a repository.[6] Thus, the total lead time then becomes a minimum of 16 years, and 20 years is not unrealistic in view of experience to date with older operating nuclear plants.

In addition, as discussed earlier, the cumulative spent fuel projected through 2020—whether it is the amount DOE projects for planning purposes or the decreased spent fuel case—is not the total amount of spent fuel to eventually be disposed. In either case, a significant quantity of nuclear generating capacity would remain on-line (248 gigawatts-electric in the DOE reference case and 46 gigawatts-electric in the decreased spent fuel generation case) after 2020, and that capacity would generate additional quantities of spent fuel that DOE would eventually have to dispose of in a repository.

Conclusions

Costs for some categories within the TSLCC estimates can change as much as several hundred million dollars from year to year. Although DOE has offered specific reasons for the changes, the final design and operation of the waste system remains uncertain. The uncertainty has led to both increases and decreases in various cost categories as DOE has periodically revised its cost-estimating assumptions and methods. In its TSLCC analyses, DOE has recognized that the estimates are substantially uncertain because of factors such as possible future changes in the design of the repositories.

Although DOE's cost estimates have improved, it is unclear whether the future cost of the waste disposal system can be accurately predicted now. Given the scope and nature of this "first of a kind" waste disposal

[6]Five years is the amount of time required by DOE for spent fuel to cool down in reactor holding pools before transporting the waste to a repository.

the agency's view, prudent planning includes the design of a waste system adequate to dispose of the maximum amount of waste that can be reasonably projected.

We agree that prudent planning would provide for the maximum quantity of spent fuel and other nuclear waste that can reasonably be projected. However, we disagree that DOE's forecasting approach provides "reasonable" estimates of spent fuel from commercial nuclear power plants and the revenues that will be paid into the Nuclear Waste Fund for disposal of this spent fuel.

According to DOE, the EIA middle case projection of nuclear generating capacity (and spent fuel to be generated by that capacity) represents the maximum amount of spent fuel that can reasonably be projected. DOE recognizes that this projection is based on positive developments in the nuclear power industry, but states that it also reflects progress (or lack of progress) in achieving those developments. For example, DOE points out that the most recent EIA projection shows a decrease in projected nuclear generating capacity in 2020 from 248 to 219 gigawatts-electric. In DOE's view, the EIA projections reflect current nuclear industry conditions and, if these conditions do not improve, future EIA projections will reflect lower long-range fuel projections.

We do not agree with DOE's views on the reasonableness of using the EIA middle case projection as the basis for planning the waste system and for estimating life cycle costs and program revenues. As discussed in this chapter, although EIA bases its nuclear generating capacity and spent fuel projections through 2000 on the current inventory of nuclear plants, for the period 2001 through 2020, EIA derives its projections by means of an economic model that projects long-range economic activity and, from that starting point, eventually projects nuclear power's share of estimated electrical energy demand. In making this projection, EIA assumes that utilities will continue to rely on both coal and nuclear power to reduce reliance on oil and gas and meet projected growth in electricity demand.

Thus, the EIA middle case, long-range projection is much more dependent on the economic assumptions that EIA uses in modeling long-range economic activity than it is on the current state of the nuclear power industry. An indication of this is the nuclear generating capacity that EIA projected in the year 2020 in its three most recent projections. In 1984, 1985, and 1986, EIA projected nuclear generating capacity in the year 2020 of 212, 248, and 219 gigawatts-electricity, respectively. Thus, plants, even if no new plants are ordered, will extend beyond that year and these plants will continue to produce spent fuel until they are retired. Therefore, many years will pass before DOE can begin to anticipate total geologic disposal needs. DOE's decision on the initial potential maximum disposal capacity of the first repository is only the first in a number of decisions that it will eventually make on the total capacity of the nuclear waste storage system. For these two reasons, the risk of harm in underestimating initial repository needs appears small, particularly in view of the compelling need to ensure that sufficient revenues are collected to pay all waste program costs. In addition, as shown in table 3.8, DOE estimates that planning the waste system on the basis of actual plants could reduce total system life cycle costs by $2 billion to $ billion depending on the host rock combinations selected for the two repositories. Therefore, we believe that the best approach to waste disposal planning and cost, revenue, and fee adequacy analyses is using the actual number of plants operating and under construction as the basis for estimating future volumes of spent fuel and waste program revenues.

Work Breakdown Structure Tasks

The systems task includes systems engineering and analysis, performance assessments, and management of the project's technical data base.

The waste package task includes development, design, fabrication, assembly, and testing of the waste package and its component parts.

The site task includes activities dealing with site characterization and evaluations to (1) determine earth science, environmental, and socioeconomic characteristics of the site and (2) close sites where further work is not required.

The repository task deals with all repository work required for site selection and preparation of a construction authorization application, including (1) the development and test program, (2) preparation of designs, and (3) identification of operating, maintenance, and decommissioning requirements.

The regulatory and institutional task includes activities involving safety analyses; licensing; environmental compliance; communications; and liaison with affected states, Indian tribes, and the public.

The exploratory shaft task deals with (1) all exploratory shaft work, including development, design, construction, operation, maintenance, and decommissioning of exploratory shafts required for detailed site characterization and (2) planning and implementing the in situ testing program.

The test facilities task includes acquisition, development, operation, maintenance, and decommissioning of test facilities.

The land acquisition task includes strategy, plans, and plan execution for land access and protection, cooperative agreements, and rights and easements. It also includes all efforts in acquiring licenses, permits, leases, titles, withdrawal agreements, cooperative agreements, and any other agreement that indicates an interest in surface and subsurface lands for principal boreholes, exploratory shafts, packaging facilities, or repositories.

The program management task deals with project management and control and with quality assurance, including identifying and defining interfaces among all project tasks and integrating the tasks with each other.

Funds Obligated by the First Repository Project Offices in the Site Task

Table II.1: Salt Repository Project

Dollars in thousands

Contractor[a]	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Fiscal year 1985 Total	Budge
Battelle Memorial Institute	$14,390	$14,522	$28,912	$21,30
Grand Junction Operations	977	579	1,556	1,23
Lawrence Berkeley Laboratory	0	22	22	2
U.S. Geological Survey	7	101	108	32
Texas Bureau of Economic Geology	538	2,473	3,011	2,85
Pacific Northwest Laboratory	(1)	1	0	6
Lawrence Livermore National Laboratory	0	408	408	3
Total	**$15,911**	**$18,106**	**$34,017**	**$25,84**

[a]All prime contractors are included except Tennessee Valley Authority

Table II.2: Nevada Nuclear Waste Storage Investigations Project

Dollars in thousands

Contractor	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Fiscal year 1985 Total	Budge
Sandia National Laboratory	$0	$0	$0	$
Lawrence Livermore National Laboratory	0	630	630	53
Los Alamos National Laboratory	14	5,967	5,981	5,66
U.S. Geological Survey	0	6,779	6,779	6,67
Science Applications International Corporation	0	470	470	75
Reynolds Engineering Company	0	5,586	5,586	2,90
Holmes and Narver, Inc	0	265	265	16
Fenix and Scisson	0	835	835	81
Lawrence Berkeley Laboratory	0	300	300	30
PAN AM	0	46	46	5
EG&G Idaho Inc	0	75	75	7
Desert Research Institute	0	158	158	15
Total	**$14**	**$21,111**	**$21,125**	**$18,08**

[a]Does not include the Nevada Test Site allocation of $250,000

Funds Obligated by the First Repository Project Offices in the Regulatory and Institutional Task

Table III.1: Salt Repository Project

Dollars in thousands

Contractor	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Total	Budg
Battelle Memorial Institute	$6,593	$19,956	$26,549	$18,3
Argonne National Laboratory	0	387	387	3
U.S. Army Corps of Engineers	0	200	200	
Bureau of Land Management	0	62	62	[illegible]
National Park Service	79	40	119	[illegible]
Tennessee Valley Authority	0	8	8	
Oak Ridge National Laboratory	(2)	325	323	
Oak Ridge Operations-Science Applications, Inc	0	535	535	5
Pacific Northwest Laboratory	(18)	216	198	2
Total	**$6,652**	**$21,729**	**$28,381**	**$19,57**

Table III.2: Nevada Nuclear Waste Storage Investigations Project

Dollars in thousands

Contractor	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Total	Budg
Sandia National Laboratory	$129	$442	$571	$4
Lawrence Livermore National Laboratory	0	203	203	1
Los Alamos National Laboratory	0	206	206	1
U S Geological Survey	0	580	580	4
Science Applications International Corporation	0	2,790	2,790	3,1
Total	**$129**	**$4,221**	**$4,350**	**$4,38**

Table III.3: Basalt Waste Isolation Project

Dollars in thousands

Contractor	Fiscal year 1984 uncosted obligations	Fiscal year 1985 Obligations	Total	Budge
Rockwell Hanford Operations	$327	$7,214	$7,541	$6,21
Morrison Knudsen	0	261	261	26
Total	**$327**	**$7,475**	**$7,802**	**$6,48**

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The Department believes GAO has oversimplified the task of projecting system requirements and of analyzing the adequacy of the disposal fee. The Department is unable to agree that "DOE's approach introduces uncertainty and overestimates future generating capacity." Future generating capacity is neither the only nor the most important variable that must be projected to ensure that the waste management system and the disposal fee are adequate. DOE believes that GAO's recommendation to simplify the planning, life cycle cost analysis and fee adequacy determination by using a single projection of spent nuclear fuel (SNF) inventories would increase, rather than decrease, uncertainty regarding the adequacy of the planned system and the fee. Therefore, the Department does not concur with the recommendation to the Secretary of Energy.

GAO's basic conclusion is that only reactors operating and actively under construction, essentially the Energy Information Administration's (EIA's) "no new orders" case, should be used as DOE's planning base for projecting the adequacy of fees collected to fund the program. DOE develops its annual estimates of total program costs and assessments of Nuclear Waste Fund (NWF) fee adequacy on a range of nuclear growth and waste generation projections. Over the past several years, DOE has used the EIA middle and "no new orders" cases to provide a reasonable range of spent fuel generation through the year 2020. This range of spent fuel generation, along with other ranges of uncertainty (site selection, system configuration, inflation, interest rates and program schedule), is considered in making the Department's assessment of system requirement and NWF fee adequacy (see DOE/RW-0020, Nuclear Waste Fund Fee Adequacy: An Assessment).

The Department believes that prudent planning includes the design of a system that will be adequate to dispose of the maximum amount of waste that can be reasonably projected. For that reason, the EIA middle case is used as the design basis for the system and its repositories. However, the lower bound, as represented by EIA's "no new orders" case, is also evaluated to consider scenarios with lower revenues in evaluating the adequacy of the fee. The middle case is based on assumptions of positive developments in the nuclear power industry, but also reflects progress in achieving those developments. For example, the most recent EIA projections (used in the Department's fee assessment being prepared at this time) have reduced the year 2020 middle case estimate of installed nuclear capacity to 219 GWe from the previous year's estimate of 246 GWe. EIA has renamed this middle case as "upper reference" this year. The Department recognizes the shortcoming of long-term projections and believes this was reflected in the

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obvious that cumulative SNF projections will decline, but the Department also believes that industry condition will be reflected in the growth projections themselves. Even if no new plants were to be ordered, a range of SNF projections would be needed to account for uncertainties in plant performance and operating life.

The Department hopes that these comments will be helpful to GAO in its preparation of the final report. Additional editorial comments are being provided directly to Mr. Dwayne Weigel.

Sincerely,

Lawrence F. Davenport
Assistant Secretary
Management and Administration

Glossary

Allotment	An authorization by the head (or other authorized employee) of an agency to his/her subordinates to incur obligations within a specified amount.
Approved Funding Program	A system for distributing the obligational authority available to DOE and its programs. It sets forth the funds available for program activities in each appropriation and fund account and establishes responsibility that control levels set by the Congress, OMB, or DOE are not exceeded.
Borehole	A hole drilled into the earth, often for exploratory purposes. A borehole is generally of such a small diameter that workers cannot work inside it. It is most often drilled into the ground vertically, or possibly on a small slant or horizontally. A borehole could be shallow, or it could penetrate the repository formation or even deeper strata.
Brine	Water that is saturated or nearly saturated with salt.
Budget Amendment	A revision to some aspect of a previous budget request submitted to the Congress by the President before the Congress completes appropriation action.
Budget Call	Schedules and instructions are issued for preparation of budget submission.
Drift	A horizontal opening excavated underground.
Environmental Assessment	A concise public document for which a federal agency is responsible that (1) serves to briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or finding of no significant impact, (2) serves to aid an agency's compliance with the National Environmental Policy Act of 1969 when an environmental impact statement is necessary, and (3) serves to facilitate preparation of an environmental impact statement when necessary.

Site Characterization Plan	The program document that will reflect expected site conditions for each of the three sites recommended for site characterization. This document will provide the basis to identify the quantity and types of tests and analyses to be performed during site characterization and will reflect the integration of the site characterization (exploratory shaft) facilities with the repository in terms of design, construction, and performance so that their impacts with respect to suitability of the site can be assessed.
Spent Nuclear Fuel	The used uranium fuel that has been removed from a nuclear reactor and used to the extent that it can no longer be useful in the production of electricity.
Work Breakdown Structure	A formalized method for subdividing activities into manageable segments and defining each segment.

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