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**Cost Update Technology, Safety, and
Costs of Decommissioning a
Reference Uranium Hexafluoride
Conversion Plant**

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August 1995

Prepared for
Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
under Contract DE-AC06-76RLO 1830
NRC JCN L2025

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Abstract

The cost estimates originally developed in NUREG/CR-1757 for decommissioning a reference uranium hexafluoride conversion plant are updated from 1981 to early 1993 dollars. During this time, the costs for labor and materials increased approximately at the rate of inflation, the cost of energy increased more slowly than the rate of inflation, and the cost of low-level radioactive waste disposal increased much more rapidly than the rate of inflation.

The results of the analysis indicate that the estimated costs for the immediate dismantlement and decontamination for unrestricted facility release (DECON) of the reference plant have increased from the mid-1981 value of \$4.31 million to \$8.04 million in 1993 with in-compact low-level radioactive waste disposal at the U.S. Ecology facility near Richland, Washington. The cost estimate rises to \$21.35 million with out-of-compact radwaste disposal at the Chem-Nuclear facility near Barnwell, South Carolina.

A methodology and a formula are presented for estimating the cost of decommissioning the reference uranium hexafluoride conversion plant at some future time, based on these early 1993 cost estimates. The formula contains essentially the same elements as the formula given in 10 CFR 50.75 for escalating the decommissioning costs for nuclear power reactors to some future time.

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Summary

The purpose of this study is to update the cost estimates developed in a previous report, NUREG/CR-1757 (Elder 1980) for decommissioning a reference uranium hexafluoride conversion plant from the original mid-1981 dollars to values representative of January 1993. The cost updates were performed by using escalation factors derived from cost index trends over the past 11.5 years. Contemporary price quotes were used for costs that have increased drastically or for which it is difficult to find a cost trend. No changes were made in the decommissioning procedures or cost element requirements assumed in NUREG/CR-1757. This report includes only information that was changed from NUREG/CR-1757. Thus, for those interested in detailed descriptions and associated information for the reference uranium hexafluoride conversion plant, a copy of NUREG/CR-1757 will be needed.

Summary of Updated Cost Estimates

To carry out the cost updates effectively, Lotus¹ spreadsheets were developed to calculate the current total decommissioning costs. To maintain consistency, the table formats in NUREG/CR-1757 were followed as closely as possible. The spreadsheets containing the cost information were linked with those containing the requirements for staffing, equipment and materials, and services to calculate and summarize the major cost components. The updated cost estimates are given in Table S.1.

Table S.1 Summary of updated costs for decommissioning the reference uranium hexafluoride conversion plant^(a,b)

Item	DECON			Passive SAFSTOR with deferred decontamination after 10 years		
	1981 cost estimate (million \$)	1993 cost estimate ^(c) U.S. Ecology (million \$)	1993 cost estimate ^(d) Chem-Nuclear (million \$)	1981 cost estimate (million \$)	1993 cost estimate ^(c) U.S. Ecology (million \$)	1993 cost estimate ^(d) Chem-Nuclear (million \$)
Initial decommissioning ^(a)	4.31	8.04	21.35	0.88	1.28	1.28
Safe storage	--	--	--	0.95	1.41	1.41
Deferred decontamination	--	--	--	4.79	8.71	22.02
Total costs	4.31	8.04	21.35	6.62	11.40	24.71
Lagoon waste management costs^(f)						
Ship to mill	1.64	12.63	28.52	1.64	12.63	28.52
Ship to LLW burial	16.36	62.35	487.87	16.36	62.35	487.87
Ship to commercial dump	2.84	12.6	8.52	2.84	12.63	28.52

(a) Update of Table 2.8-1 in NUREG/CR-1757.

(b) Cost estimates include 25% contingencies.

(c) Assumes in-compact radioactive waste disposal in U.S. Ecology facility, Richland, Washington.

(d) Assumes out-of-compact radioactive waste disposal in Chem-Nuclear facility, Barnwell, South Carolina.

(e) Costs are based on five shifts/week (single shift/day) for most of the decommissioning. Decommissioning on a two-shift/day basis would reduce time requirements but costs would be about the same.

(f) These costs are not appropriate if the wastes are disposed of during operation or plant cleanup.

¹Lotus 3.1 is a trademark of Lotus Development Corporation, Cambridge, Massachusetts.

For disposal of the low-level radioactive wastes at the U.S. Ecology disposal facility near Richland, Washington, the estimated costs for the immediate dismantlement and decontamination for unrestricted facility release (DECON) of the reference plant have increased from the mid-1981 value of \$4.31 million to \$8.04 million in January 1993. This represents an estimated cost increase of a factor of 1.87 over the past 11.5 years. The magnitude of the new cost estimates is mainly attributed to the drastic escalation in low-level radioactive waste disposal costs. The U.S. Ecology facility at Richland only accepts low-level radioactive wastes generated from within the Northwest and Rocky Mountain Compacts.

Beginning in 1993, the Northwest Compact imposed on eligible waste generators an annual permit fee based on the volume of waste to be shipped to the U.S. Ecology burial facility in Washington State. The annual fee ranges from \$350 to \$35,000. For the purposes of this report, the annual fee for fuel cycle facility decommissioning was taken to be \$12,250. The Washington facility also levies surcharges on top of the base rate totaling \$9.83/ft³ and a tax of 6.5%.

For disposal of the low-level radioactive wastes at the Chem-Nuclear disposal facility at Barnwell, South Carolina, from outside the Southeast Compact, the estimated costs for immediate dismantlement and decontamination to unrestricted use (DECON) increased to \$21.35 million. The Barnwell facility is the only facility accepting wastes from states that are outside its compact. (However, as of July 1994, the Southeast Compact is proposing to no longer accept wastes from outside its compact.) The out-of-compact waste charges include a significant surcharge beginning in January 1993. The Southeast Compact imposes an access fee of \$220/ft³ on all eligible out-of-region waste generators to use the Barnwell, South Carolina, facility. Barnwell also levies a curie surcharge of \$4,150/shipment and a tax of 2.4% on top of its base rate. These schedules provide the basis for the in-compact and out-of-compact radioactive waste disposal estimates outside of the Northwest and Rocky Mountain Compacts.

Although staffing, energy, and equipment/supply costs increased by a factor of 1.51, the current in-compact radwaste burial costs at the Washington State burial facility, with the surcharge, are almost 4.2 times what they were in 1981. Out-of-compact radioactive waste burial costs at the South Carolina facility are estimated to be almost 25 times higher than they were in 1981. The Northwest Compact radioactive waste disposal costs are now estimated to account for one-third of the total DECON cost, compared with just 15.2% in 1981. Out-of-compact radioactive waste disposal costs in the Southeast Compact are estimated to account for three-quarters of the DECON budget at the same facility.

The costs for the passive SAFSTOR option during both the planning/preparation and storage periods have a much lower rate of escalation than the DECON option due to the absence of the rapidly increasing waste disposal cost during these stages. The preparatory cost for Safe Storage is estimated to have increased by a factor of about 1.5, from \$0.875 million in mid-1981 to \$1.277 million in January 1993, including a 25% contingency cost for both. The cost of the 10-year Safe Storage period is estimated to have increased by a factor of 1.5, from \$0.947 million to \$1.405 million over the same time span.

The deferred decontamination costs at the end of the Safe Storage period are estimated to have increased by a factor of over 1.8, from \$4.79 million in mid-1981 to \$8.71 million in January 1993 for in-compact waste disposal in Washington. These costs are comparable to the DECON costs in both magnitude and structure. Again, the largest increase is caused by waste disposal costs, which now make up nearly 31% of the estimated total costs compared to just 13.7% in 1981. The total costs for the passive SAFSTOR with deferred decontamination after 10 years, including a 25% contingency, show an increase from \$6.62 million in mid-1981 to almost \$11.4 million in January 1993, indicating an escalation factor of 1.72 over 11.5 years. For out-of-compact disposal in South Carolina, the estimated costs for deferred decontamination increased from \$4.79 million to \$22.02 million, which is an increase of a factor of 4.6. The total costs for passive safe storage with 10-year deferred decontamination increased from \$6.62 million to \$24.71 million or an increase by a factor of 3.76.

NUREG/CR-1757 evaluated four different options for disposing of the extraction and fluoride wastes presently stored in lagoons. One of the four options analyzed was onsite burial, which is no longer permitted under current regulations. The other three options explored in the report were shipping the waste to a mill for uranium recovery, removing the wastes to a low-level waste (LLW) burial ground, and shipping the wastes to a commercial waste dump. The elimination of the onsite burial option also had an impact on the other options for disposal of lagoon wastes as well. The effects of this change are summarized in Table S.2. Extraction wastes cannot be shipped to a commercial waste dump, so it was assumed in NUREG/CR-1757 that they are shipped to a mill for uranium recovery. Because fluoride wastes cannot be shipped to a uranium mill and can no longer be buried onsite, it is now assumed that they are shipped to a commercial waste dump. This effectively renders the shipment of lagoon waste to a uranium mill and to a commercial waste dump into the same decommissioning steps as the reference conversion facility. The cost of shipping the lagoon waste to a uranium mill has increased from \$1.64 million in mid-1981 (with onsite burial of fluoride wastes) to \$12.63 million in January 1993 (with disposal of fluoride wastes in a commercial waste dump). The cost of handling, shipping, and disposing of the waste in a LLW burial site has increased by a factor of nearly 4.0 from mid-1981 to January 1993, from \$16.36 million to over \$62 million. The cost of shipment to and disposal of fluoride wastes in a commercial dump is estimated to have escalated in cost from \$2.84 million in mid-1981 to \$12.63 million in January 1993.

The spreadsheet system, using escalation factors, that was developed in this study provides an effective tool for future near-term cost projections for decommissioning the reference uranium hexafluoride conversion plant. The average annual escalation factors (logarithmically averaged over 11.5 years) can be used for this purpose, assuming that the same decommissioning approach and activities as developed in NUREG/CR-1757 are used. However, caution is urged when applying escalation factors to costs that might behave erratically during the projected time period (such as waste disposal costs).

Formula for Escalating Costs to a Future Current Time

Decommissioning costs for the reference uranium hexafluoride conversion plant can be escalated from an estimate made at some previous time to a future current time using an escalation formula given in 10 CFR 50.75 (NRC 1993). In this formula, shown with minor modifications, decommissioning costs are divided into five general areas that tend to escalate similarly: 1) labor, materials and services; 2) energy and waste transportation; 3) radioactive waste disposal; 4) taxes and insurance; and 5) hazardous waste management.

$$\text{Cost in year X} = \frac{[\text{Adjusted total base cost in year Y}] * [AL_x + BE_x + CB_x] + \text{T\&I costs in year X}^{(1)} + \text{H costs in year X}^1}{\text{H costs in year X}^1}$$

where Cost in year X = the approximate costs for decommissioning activities in year X

Adjusted total
base cost in

year Y = the estimated or known decommissioning cost for year Y (taken to be January 1993 costs from this report) after subtracting the costs for taxes, insurance, and hazardous materials handling

Table S.2 Change in assumptions for handling of lagoon wastes

Option	1981	1993
Onsite burial	-All lagoon wastes	-No longer permitted
Ship to mill	-Fluoride waste buried onsite -Extraction wastes to uranium mill	-Fluoride waste to commercial disposal -Extraction wastes to uranium mill
Ship to LLW burial	-All lagoon wastes	-All lagoon wastes
Ship to commercial disposal	-Fluoride waste to commercial disposal -Extraction wastes to uranium mill	-Fluoride wastes to commercial disposal -Extraction wastes to uranium mill

A = fraction of the adjusted total decommissioning cost attributable to labor, materials and services costs in year Y

B = fraction of the adjusted total decommissioning cost attributable to energy and waste transportation costs in year Y

C = fraction of the adjusted total decommissioning cost attributable to waste burial costs in year Y

L_x = labor, materials and services cost escalation factor from January 1993 to the appropriate month of year X

E_x = energy and waste transportation cost escalation factor from January 1993 to the appropriate month of year X

B_x = radioactive waste burial and surcharge cost escalation factor from January 1993 to appropriate month of year X

$$= (R_x + \Sigma S_x) / (R_y + \Sigma S_y)$$

where R_x = the radioactive waste burial basic costs (excluding surcharges) in year X

ΣS_x = the summation of surcharges in year X

R_y = the radioactive waste burial basic costs (excluding surcharges) in year Y

ΣS_y = the summation of surcharges in year Y

T&I = taxes and insurance costs during decommissioning

H = costs for hazardous waste management beyond those required for radioactive wastes (obtained from direct estimates).

Values for L_x and E_x are to be obtained from the U.S. Department of Labor Bureau of Labor Statistics cost indexes, preferably for the regional conditions for a given site. The values to be used in determining B_x are to be taken from actual cost schedules (basic disposal costs plus surcharges resulting from the Low-Level Radioactive Waste Policy Amendments Act of 1985), plus other surcharges that may vary for wastes originating in states other than the host state for the waste disposal facility, for low-level waste disposal facilities.

Values for the coefficients given below in Table S.3 can be used in the above equation to calculate the escalation in the DECON costs in some future current time. The coefficients were calculated assuming Year Y to be January 1993. For the NUREG/CR-1757 Cost Update, the taxes, insurance, and hazardous waste management costs were not evaluated.

Formula for Approximating Near Future Decommissioning Costs

The results in this study can be used, if desired, to approximate near future (i.e., one to two years hence) decommissioning costs for similar facilities. One method, given in the equation below, is to use annual escalation factors derived in this study. Annual escalation factors for the cost elements used in this study are given in Table S.4. The factors were obtained from the mid-1981 and January 1993 unit costs and are summarized in Section 5.2.

$$F = P(i)^n$$

where P = present cost
 F = future cost
 i = the average annual escalation factor
 n = the number of years of escalation.

The average annual escalation factors used in the above equation have been developed in this study. They are shown in Table S.4.

Table S.3 Formula coefficients for escalating DECON costs to some future current time

Formula coefficient	Value
A	0.549
B	0.076
C	0.375
R _y (million \$)	1.090
S _y (million \$)	0.486
T&I (year Y - million \$)	0.744
Adjusted total (year Y - million \$)	5.589

Table S.4 Average annual escalation factors^(a)

Description	Escalation factor
Staffing	1.030
Equipment and supplies	1.034
Miscellaneous owner expense	1.044
Repair allowance	1.030
Waste transportation	0.989
Waste burial ^(b)	1.162

(a) Log-averaged over 11.5 years, from mid-1981 to January 1993.

(b) Includes waste packaging, burial, and associated surcharges at the U.S. Ecology facility at Richland, Washington.

¹The taxes and insurance costs were separated from the total base cost because escalation of these factors is difficult to predict. Hazardous waste management costs are added to the formula but also kept separate because their costs have generally not been considered to date.

1 Introduction

At the request of the U.S. Nuclear Regulatory Commission (NRC), staff at the Pacific Northwest Laboratory (PNL)¹ have updated the estimates of decommissioning costs for a reference uranium hexafluoride conversion plant (NUREG/CR-1757) (Elder 1980) to reflect the January 1993 economic environment. The cost update was carried out under the NRC's Office of Nuclear Regulatory Research Project "Reevaluation of Reference Fuel Cycle and Non-Fuel Cycle Facility Decommissioning," JCN L2025.

This cost update was performed using the following major basis and approach:

- The cost elements contained in the original report prepared for the NRC by PNL (NUREG/CR-1757) (Elder 1980) were adjusted to reflect cost escalations from mid-1981 to January 1993. The 25% contingency factor used in NUREG/CR-1757 was retained.
- Both the immediate dismantlement of the plant (DECON) and the delayed dismantlement after a 10-year period of passive safe storage (SAFSTOR) were reevaluated.
- Most January 1993 costs are estimated by using published cost escalation factors. Some costs (e.g., waste disposal, waste transportation, some waste packages) are updated by direct quotations from reputable sources.
- The decommissioning activities in NUREG/CR-1757 (Elder 1980) (except for onsite burial of some lagoon wastes) are assumed to be unchanged. Information in that document that is unchanged is not repeated in this report.
- The impacts of new packaging requirements on radioactive LLW disposal costs were taken into consideration in this report. The change in the value of uranium was also accounted for in estimating credits (not included in the decommissioning costs) for uranium recovery.
- The cost update was performed in an automated manner by using the Lotus 3.1 spreadsheet format. A floppy disk with the files of the spreadsheet-developed tables in this report can be obtained from NRC by licensees to develop their facility-specific decommissioning cost estimates.
- The format of the cost tables in the previous report are maintained for cost update calculations in this report, with additional columns for the updated cost information. This report is organized somewhat differently from NUREG/CR-1757 (Elder 1980). Appendix A contains a cross-reference of table numbers in this report to those in NUREG/CR-1757 (Elder 1980) for easy comparison. In addition, each table in this report identifies the comparable table in NUREG/CR-1757.
- To show the high sensitivity of decommissioning costs relative to LLW disposal costs, estimates are provided for in-compact disposal of wastes at the Northwest Compact disposal facility (lowest cost) and for out-of-compact disposal of wastes at the Southeast disposal facility (highest cost).

The cost update algorithm development is described in Section 2. Section 3 describes the evaluation of the cost escalations for DECON. The cost update for SAFSTOR is presented Section 4, and the applicability of the algorithm and the results of this report to future cost updates is discussed in Section 5.

¹Prepared for the Division of Regulatory Applications, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission under Contract DE-AC06-76RLO 1830 NRC JCN L2025.

2 Algorithm for the Cost Updates

Figure 2.1 illustrates the algorithm developed to update the cost estimates for decommissioning the reference uranium hexafluoride conversion plant. First, the requirements for staffing, equipment and supplies, and various services identified in the tables in NUREG/CR-1757 (Elder 1980) were reproduced in spreadsheet format. Second, the mid-1981 unit cost items were also entered into spreadsheets: 1) salaries for the work force; 2) prices for various equipment, tools, and materials; and 3) services, such as utilities, waste disposal, insurance, licensing, taxes, and reclamation of the land. Third, the escalation factor for each of the cost categories was evaluated based on price index trends contained in the then current publications, such as the *Handy-Whitman Index of Public Utility Construction Costs* (Whitman et al. 1991) and the *Monthly Energy Review* (DOE 1993). These escalation factors were then entered into the tables, and the

individual costs were calculated by combining the unit cost, the escalation factor, and the quantity required for each item. Once the individual cost items were estimated, the major cost components were calculated: staffing, equipment and supplies, waste disposal, the owner's expense, and the special contractor charge. Finally, the total DECON costs were estimated by summarizing the major cost components. The costs for the SAFSTOR option were estimated in a similar manner.

For certain costs, simple escalation factors were not reasonably applicable. For example, because of the drastic increase in LLW disposal costs in recent years, the use of escalation factors to calculate the changes in the waste disposal costs could not be justified. Therefore, for these costs, as well as for packaging and transportation costs, current price quotes were used. An explanation of the

Figure 2.1 Algorithm for cost updates for DECON

Algorithm

cost updates for each category, whether by quote or by escalation factor, is contained in the following paragraphs.

Computerized spreadsheet tables allow easy adjustment in each cost item resulting from escalation or new requirements so that the changes can be reflected immediately in the total decommissioning costs. The spreadsheets can be used to perform future updates quickly and easily when required. The economic impacts of technological advancements or regulatory changes can be evaluated by adjusting the input to the tables. In addition, sensitivity studies can be performed by changing one particular cost parameter so that the impact of this particular cost parameter on the total cost can be determined. Further, the percentage of each component is calculated and listed in the summary cost tables to provide the weight of each cost component in the total decommissioning cost.

The spreadsheet cost tables, repeated from those in NUREG/CR-1757 (Elder 1980), are organized in three hierarchical orders according to their functions: the cost summary tables, the intermediate cost component tables, and the tables containing basic cost-related information. The updated cost estimates for DECON are summarized in Tables 3.20 and 3.21. The cost updates for SAFSTOR (initial preparations, annual safe storage, and deferred decontamination) are summarized in Tables 4.5, 4.7, 4.11, and 4.12. These cost summary tables all have the same format. The first column of each table lists the

mid-1981 costs for each of the cost categories. The second column shows the costs escalated to January 1993 dollars. The ratio of the January 1993 costs to the mid-1981 costs is given in the fourth column as the 11.5-year escalation factor. To maintain consistency and allow for ease in future cost updates, cost escalations based on price indexes were used whenever meaningful. Except for the staffing categories, these escalation factors are just the ratio of the composite January 1993 costs to the composite mid-1981 costs. For the staffing and equipment and supplies categories, the January 1993 costs were not available directly and were calculated by escalating mid-1981 cost estimates using the 11.5-year escalation rates shown in the table.

To obtain updated costs for waste disposal, the contemporary cost schedule from the reference disposal facility was used. In this study, an average annual escalation factor was calculated based on the 11.5-year escalation factor; this factor could be used to predict future near-term cost escalations. Its applicability and limitations are discussed in Section 5.

Other tables in this report contain basic information such as the requirements in staffing, materials, equipment, and services for each stage of the decommissioning process, and the unit costs. A number of intermediate calculations were performed in these tables, using both escalation factors and current cost information, so that the constituent costs were made available in the summary tables.

3 Cost Estimate Update for DECON

The cost estimate adjustments were determined by using publications containing U.S. price index trends covering the period from mid-1981 to January 1993. However, current price quotations were used where price trends were not applicable, such as waste transportation and disposal costs. Labor costs were escalated using the July 1, 1991, data from the 1991 *Handy-Whitman Index of Public Utility Construction Costs* (Whitman et al. 1991), with escalation of the final 18 months using escalation rates for the previous 10 years. The escalation factors for materials and equipment were calculated in the same manner using the 1992 edition of the *Statistical Abstract of the United States* (Commerce 1992). The *Monthly Energy Review*, February 1993 edition (DOE 1993), was the source for escalating the energy costs. Waste packaging costs were based on the current purchase costs from Chem-Nuclear Systems, Inc. Waste transportation costs were provided by Tri-State Motor Transit Co. (Tri-State 1992). Waste disposal costs were computed based on the Schedule of Charges from U.S. Ecology Inc. at Richland, Washington (effective February 9, 1993) (Ecology 1993), and the Rate Schedule from Chem-Nuclear Systems, Inc. for disposal at the Barnwell facility in South Carolina (Chem-Nuclear 1993). Tax and insurance information was obtained from Allied Signal Inc. The calculation of escalation factors and the determination of the current prices are described in detail in the following sections.

3.1 Cost Estimate Update for Staffing

The 1991 *Handy-Whitman Index of Public Utility Construction Costs* was used to calculate the escalation factor for staffing costs for the planning and preparation and the dismantlement and decontamination phases of the uranium hexafluoride conversion plant. First, the common labor salary/wages index averaged over the six regions in the United States was calculated for July 1, 1981, and then for July 1, 1991. The ratio of the two average indexes resulted in an escalation factor of 1.34. To cover the change in staffing costs from July 1, 1991, to January

1993, an increase of 1.5% was used based on an annual average escalation rate of 3% over the past decade. Therefore, the final staffing escalation factor applicable from mid-1981 to January 1993 was estimated to be 1.40.

Table 3.1 shows the unit salaries for the decommissioning staff positions. Table 3.2 gives the updated summary of staffing utilization and staff costs for the planning and preparation phase of DECON by using January 1993 salary information from Table 3.1. The staffing utilization and staff costs for the dismantlement and decontamination phase of DECON are updated to the January 1993 salary scale in a similar way and are summarized in Table 3.3.

3.2 Cost Estimate Update for Materials and Equipment

The escalation factors for the material and equipment cost elements for DECON were calculated based on the price index information contained in the 1992 *Statistical Abstract of the United States* (Commerce 1992). The information obtained was further escalated to January 1993 costs using average annual escalation factors consistent with the prior 11 years of cost increases.

The cost escalation factors for construction machinery and equipment from mid-1981 to January 1993 were estimated to be 1.52. The escalation factor for metal cutting tools was evaluated at 1.71.

Table 3.4 summarizes the updated material and equipment cost elements for DECON, using the escalated unit cost information contained in Table 3.5.

3.3 Cost Estimate Update for Miscellaneous Owner's Expenses

The escalation factors for electricity, natural gas, and fuel oil (No. 2 distillate) were calculated based on the price trend information contained in the February 1993 *Monthly Energy Review* (DOE 1993).

¹Honey, J. E., Regulatory Affairs, Allies-Signal Inc., Metropolis, Illinois. Memo to T. L. Miles, PNL, August 28, 1992.

Table 3.1 Decommissioning labor cost data^(a,b)

1981 Source	Position	Mid-1981 Base Pay/yr (\$)	Overhead Rate, %	Burdened Mid-1981 Cost/yr	11.5-Year ^(c) Escalation Factor	Burdened January 1993 Cost/yr (\$)
	Management and support staff					
a	Decommissioning superintendent	52,000	70	88,400	1.40	123,760
a	Decommissioning engineer	44,700	70	75,990	1.40	106,386
a	Asst. decommissioning engineer	30,800	70	52,360	1.40	73,304
d	Secretary	16,100	50	24,150	1.40	33,810
d	Clerk	16,100	50	24,150	1.40	33,810
d	Health and safety supervisor	35,200	70	59,840	1.40	83,776
d	Health physicist	27,600	70	46,920	1.40	65,688
d	Industrial safety specialist	30,800	70	52,360	1.40	73,304
d	Radioactive shipment specialist	23,100	70	39,270	1.40	54,978
d	Procurement specialist	23,100	70	39,270	1.40	54,978
a	Contracts and accounting	27,700	70	47,090	1.40	65,926
d	Accounting clerk	16,100	50	24,150	1.40	33,810
d	Security supervisor	32,900	70	55,930	1.40	78,302
d	Security shift supervisor	21,400	70	36,380	1.40	50,932
b	Security patrolman	16,900	50	25,350	1.40	35,490
d	Quality assurance supervisor	30,700	70	52,190	1.40	73,066
d	Quality assurance engineer	27,600	70	46,920	1.40	65,688
d	Quality assurance technician	18,500	50	27,750	1.40	38,850
d	Control room attendant	23,000	50	34,500	1.40	48,300
c	Tool crib attendant	18,500	50	27,750	1.40	38,850
d	Protective equipment attendant	18,500	50	27,750	1.40	38,850
d	Consultant	100,000	0	100,000	1.40	140,000
	Decommissioning workers					
d	Shift engineer	30,700	70	52,190	1.40	73,066
d	Craft supervisor	27,600	70	46,920	1.40	65,688
c	Craftsperson	21,400	50	32,100	1.40	44,940
c	Crew leader	26,100	70	44,370	1.40	62,118
c	Utility operator	21,400	50	32,100	1.40	44,940
b	Laborer	20,600	50	30,900	1.40	43,260
c	Health physics technician	20,000	50	30,000	1.40	42,000

(a) Update of Table H.1-1 in NUREG/CR-1757 (Elder 1980).

(b) The number of figures is for calculational completeness and does not imply accuracy to the number of figures shown.

(c) Base salary data have been adjusted from mid-1981 to January 1992 using Whitman et al. (1991) Index of Public Utility Construction Costs, U.S. average plus escalation from mid-1981 to January 1993.

(d) U.S. Department of Labor 1975.

(e) Author's estimate from prior report.

(f) Means 1975.

(g) HAMTC 1975.

Table 3.2 Summary of staffing utilization and costs for planning and preparation phase of DECON^(a,b)

Title or Function	Staff-Years	January 1993 Cost ^(c,d) (\$)
Decommissioning superintendent	0.65	80,444
Decommissioning engineer	0.50	53,193
Health and safety supervisor	0.20	16,755
Contracts and accounting specialist	0.50	32,963
Radioactive shipment specialist	0.20	10,996
Quality assurance engineer	0.50	32,844
Asst. decommissioning engineer	0.50	36,652
Procurement specialist	0.50	27,489
Quality assurance supervisor	0.50	36,533
Crew leader	0.85	52,800
Secretary	1.25	42,263
Total staff-years	6.15	
Total cost		422,932

(a) Update of Table 10.1-2 in NUREG/CR-1757 (Elder 1980).

(b) The number of figures shown is for computational accuracy and does not imply accuracy to the nearest thousand dollars.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

For the purposes of comparison, two different utility escalation factors were calculated: one based on a point-to-point ratio of the mid-1981 and January 1993 energy costs, and the other based on a linear regression of energy costs over the past 11 years.

The results of the two different analyses for updating energy costs are recorded in Table 3.6. Because of extraneous circumstances (such as the peak of the late 1970s inflation after the second oil crisis on one end and the sharp downward bounce following the 1991 Gulf War on the other), the point-to-point ratio method actually shows a composite utility escalation factor of less than one. Because of this, it was judged that creating a curve of the energy costs using linear regression would best represent the energy cost trend for the purpose of escalating costs into the future. The points listed on the regression side in Table 3.6 are not actual data points found in the *Monthly Energy Review* but are points on the regression-generated curve for those specific times. From this, a composite energy cost escalation factor of 1.066 was calculated.

Table 3.3 Summary of staffing utilization and costs for the dismantlement and decontamination phase of DECON^(a,b)

Title or Function	Staff-Years	January 1993 Cost ^(c,d) (\$)
Decommissioning superintendent	0.75	92,820
Decommissioning engineer	0.75	79,790
Health and safety supervisor	0.75	62,832
Health physics technician	1.25	52,500
Security shift supervisor	0.75	38,199
Security patrolman	3.00	106,470
Contracts and accounting	0.75	49,445
Radioactive shipment specialist	0.75	41,234
Quality assurance engineer	0.75	49,266
Shift engineer	0.75	54,800
Engineering technician	0.75	41,234
Craft supervisor	1.50	98,532
Laborer	0.75	32,445
Craftsperson	3.41	153,245
Quality assurance supervisor	0.75	54,800
Crew leader	3.29	204,368
Technician	21.17	1,163,884
Secretary	1.50	50,715
Total staff-years	43.37	
Total cost		2,426,577

(a) Update of Table 10.1-3 in NUREG/CR-1757 (Elder 1980).

(b) The number of figures shown is for computational accuracy and does not imply accuracy to the nearest thousand dollars.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

The escalation factor for all utilities was assumed to be the same as that estimated for energy requirements.

The licensing fee cost estimate was calculated by increasing the value by the labor escalation factor. (This does not necessarily reflect NRC's policy of full cost recovery for licensing activities.) The 1993 tax and insurance expenses shown in Table 3.7 are quoted figures from Allied Signal.¹

¹Honey, J. E., Regulatory Affairs, Allies-Signal Inc., Metropolis, Illinois. Memo to T. L. Miles, PNL, August 28, 1992.

Table 3.4 Estimated material and equipment requirements and costs for DECON^(a,b)

Description	Quantity	Estimated Unit Cost 1993 (\$) ^(c)	Estimated Total Cost in January 1993 (\$) ^(d)
Oxyacetylene torch	4	1,705	6,820
Guillotine pipe saw	2	6,820	13,640
Tube cutter	2	699	1,398
Ratcheting pipe cutter	6	119	716
Reciprocating saw	4	1,364	5,456
Nibbler	2	1,517	3,034
High-velocity liquid jet	1	10,467	10,467
Low-velocity liquid jet	2	4,187	8,374
Hydraulic concrete surface spalling device	1	7,585	7,585
Concrete drill	3	425	1,274
Electric pneumatic hammer	2	1,062	2,174
Portable A-frames	2	6,220	12,439
Portable wash sinks	2	4,187	8,374
Portable spray clean	1	8,374	8,374
Portable greenhouse erection kit	1	4,187	4,187
Portable powered brushes	20	319	6,371
HEPA filter	5	303	1,517
Roughing filter	20	152	3,034
Decontamination chemicals			13,662
Cleaning supplies			29,084
Expendable tools			16,687
Protective clothing (including laundry)			27,343
Office supplies: planning and preparation			16,687
Decommissioning			10,012
Total			218,659

(a) Update of Table 10.1-4 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Unit cost information is taken from that calculated in Table 3.5.

(d) Contingency of 25% is not included.

Table 3.5 Unit costs for special tools and equipment^(a,b)

Item	Mid-1981 Estimated Unit Cost (\$)	11.5-Year Escalation Factor	January 1993 Unit Cost (\$)
Arc saw	100,000	1.71	170,500
Portable plasma-arc torch	20,000	1.71	34,100
Portable oxyacetylene torch	1,000	1.71	1,705
Guillotine pipe saw	4,000	1.71	6,820
Power-operated reciprocating hacksaw	800	1.71	1,364
Nibbler	1,000	1.52	1,517
Submersible pump with disposable filter	2,000	1.52	3,034
High-pressure water jet	20,000	1.52	30,340
Electropolishing system	100,000	1.52	151,700
Mobile chemical decontamination unit	20,000	1.52	30,340
Mobile chemical mixing and heating unit	5,000	1.52	7,585
Powered floor scrubber	300	1.52	455
Wet-dry vacuum cleaner (HEPA filtered)	5,000	1.52	7,585
Supplied-air plastic suit	50	1.52	76
Respirator facepiece	100	1.52	152
Power-operated mobile manlift	40,000	1.52	60,680
10-ton mobile hydraulic crane	28,000	1.52	42,480
10-ton forklift	28,000	1.52	42,480
Concrete drill with HEPA filtered dust collection system	2,000	1.52	3,034
Concrete surface spaller	5,000	1.52	7,585
Front-end loader (light duty)	20,000	1.52	30,340
Portable filtered ventilation enclosure	10,000	1.52	15,170
Filtered-exhaust fan unit	5,000	1.52	7,585
Blasting mat	500	1.52	759
Paint sprayer	1,000	1.52	1,517
HEPA filter	200	1.52	303
Roughing filter	100	1.52	152
Waste compactor	12,000	1.52	18,204
Incinerator	300,000	1.52	455,100
Tube cutter	410	1.71	700
Ratcheting pipe cutter	70	1.71	120
High-velocity liquid jet	6,900	1.52	10,468
Low-velocity liquid jet	2,760	1.52	4,187
Concrete drill	280	1.52	425
Electric/pneumatic hammer	700	1.52	1,062
Portable A-frames	4,100	1.52	6,220
Portable wash sinks	2,760	1.52	4,187
Portable spray clean booth	5,520	1.52	8,373
Portable greenhouse erection kit	2,760	1.52	4,187
Portable powered brushes	210	1.52	320
Hand-powered brushes	210	1.52	320
Soap (per thousand kg)	280	1.52	425
Freon (per m ³)	2,760	1.24	3,430

(a) Update of Table H.1-6 in NUREG/CR-1757.

(b) Number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

Table 3.6 Escalation factors for energy costs

	Point-to-Point Ratio Mid-1981 to January 1993	Linear Regression Mid-1981 to January 1993
Escalation factor, electricity	1.093	1.216
Escalation factor, natural gas	0.793	1.063
Escalation factor, No. 2 distillate	<u>1.028</u>	<u>0.920</u>
Composite energy costs escalation factor	0.972	1.066

Table 3.7 Estimated miscellaneous owner expenses for DECON^(a,b,c)

Cost Category	Mid-1981 Cost (\$)	Escalation Factor	January 1993 Cost (\$)
Utilities	340,000	1.066	362,400
Taxes	180,000	1.794	322,900
Inspections and license Amendments ^(d)	70,000	1.400	98,000
Insurance	150,000	2.806	420,900
Total	740,000		1,204,200

(a) Update of Table 10.1-8 in NUREG/CR-1757.

(b) Number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Estimates do not necessarily take into account the full cost recovery for NRC staff.

3.4 Cost Estimate Update for Waste Management

Two different sources of radioactive wastes need to be managed. First, the dismantled contaminated plant and equipment need to be disposed. They have to be packaged and shipped from the conversion plant and buried at the waste disposal site. Second, sludges from the solvent extraction and fluoride lagoons must be disposed of in some way.

The waste management costs are divided into three constituent cost categories: packaging, transportation, and burial. A summary of the estimated waste management costs is given in Table 3.8, with a more detailed breakdown of the cost calculations in Table 3.9. Because the waste disposal cost trends are more erratic than any of the other cost categories, each of the three aspects of the waste management cost escalation is described in detail. Because of the recent rapid escalation in waste disposal costs, costs were not escalated according to price index information but according to contemporary cost quotes.

There are three alternatives in managing the extraction and fluoride wastes stored in lagoons in the reference facility:

Table 3.8 Summary of estimated waste management costs for DECON^(a,b)

Waste Category	Costs in January 1993 Dollars ^(c)					
	Container	Transportation	U.S. Ecology Facility		Chem-Nuclear Facility	
			Burial	Total	Burial	Total
To LLW burial:						
Hoods, equip. and components	202,890	29,280	1,226,253	1,458,423	8,467,722	8,699,892
Pipe, conduit, duct, trays, fixtures, etc.	46,220	14,640	279,352	340,213	1,929,029	1,989,889
Concrete rubble	12,856	8,540	142,544	163,940	984,319	1,005,715
Disposal of solid waste buried onsite during operations ^(d)	10,347	6,100	114,724	131,170	792,209	808,656
Miscellaneous	1,552	1,220	17,209	19,981	118,831	121,603
Miscellaneous	4,271	2,440	25,813	32,524	178,247	184,958
One time registration fee			12,250	12,250		
Totals	278,135	62,220	1,818,145	2,158,500	12,470,358	12,810,713

(a) Update of Table 10.1-6 in NUREG/CR-1757.

(b) The number of figures is for computational completeness and does not imply accuracy to the number of figures shown. Costs are escalated from 1981 values given in NUREG/CR-1757.

(c) Contingency of 25% is not included.

(d) This waste is exhumed and shipped to LLW burial site.

Table 3.9 Details of estimated costs for radioactive waste management for DECON^(a,b,c,d)

Waste Category	Shipping Wt (kg)	Shipping Vol. (m ³) ^(e)	Type of Container	No. of Shipments	Total Packaging Cost (%)	Basin Transp. Cost (%) ^(f)	Wt/Load (Mg)	Weight Cost %/Mile	Weight Charge (%)	Total Transp. Cost (%)	Burial Cost (\$)	Total January 1993 Waste Management Cost (\$)
Low-level waste burial												
Equipment and component	380,000	855	Steel Boxes	24	202,890	29,280	15.83	0.00	0	29,280	1,226,253	1,458,423
Pipe, conduit, duct, trays	219,200	195	Steel Boxes	12	46,220	14,640	18.27	0.00	0	14,640	279,352	340,213
Concrete rubble	64,000	99	Steel Drums	7	12,856	8,540	9.14	0.00	0	8,540	142,544	163,940
Solid waste buried onsite ^(g)	48,000	80	Steel Drums	5	10,347	6,100	9.60	0.00	0	6,100	114,724	131,170
Miscellaneous	17,500	12	Steel Drums	1	1,552	1,220	17.50	0.00	0	1,220	17,209	19,981
Miscellaneous	12,000	18	Steel Boxes	2	4,271	2,440	6.00	0.00	0	2,440	25,813	32,524
One-time registration fee											12,250	12,250
Totals	740,700	1259		51	278,135					62,220	1,818,145	2,158,500

(a) Update of Table H.2-4 in NUREG/CR-1757.

(b) The number of significant figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Assumes in-compact radioactive waste disposal at the U.S. Ecology facility in Richland, Washington.

(d) Contingency of 25% is not included.

(e) The shipping volumes are calculated in Tables H.2-2, H.2-3, and H.2-4 in NUREG/CR-1757.

(f) Transportation costs are based on a transport distance of 500 miles.

(g) This waste is exhumed and shipped to LLW burial site.

- removal of waste to a uranium mill for recovery of residual uranium
- removal of waste to a LLW burial ground
- removal of waste to a chemical or commercial waste dump.

NUREG/CR-1757 also included a discussion of disposal of the lagoon wastes by means of onsite burial. The cost of this option was escalated using the cost escalation factors for the cost elements.

3.4.1 Costs for Waste Packaging

Steel drums and steel boxes are the containers typically used to package radioactive LLW for transportation. The January 1993 costs for waste packaging were calculated by multiplying the volume of waste by the container cost (per unit volume) for boxes and by multiplying the number of containers referenced by the cost per container for steel drums. The steel boxes have replaced the fiberglass plywood boxes referenced in NUREG/CR-1757 (Elder 1980). Table 3.10 lists January 1993 prices paid for the waste disposal containers (Konzek et al. 1993).

Table 3.10 Shipping containers used for wastes in this study^(a)

Shipping container	Mid-1981 Estimated Unit Unit Cost (\$)	January 1993 Unit Cost (\$)
208-l steel drum	30	26.95 ^(b)
110-l steel drum	20	NA
Polyethylene drum liner ^(c)	1	1
Fiberglass plywood box (3.456m ³) ^(d)	100	NA
Fiberglass plywood box	Variable	NA
Steel box	NA	237.27/m ^{3(e)}

(a) Update of Table H.1-2 in NUREG/CR-1757.

(b) Cost estimate for a DOT 17-H steel drum with a volume of 55 gallons (Konzek et al. 1993).

(c) Included in outer steel drum, no added burial volume.

(d) 1981 values used fiberglass plywood box at a cost of \$28.94/m³.

(e) Cost estimate for a B25 steel box with a volume of 96 ft³ (Konzek et al. 1993).

NA = Not Applicable.

3.4.2 Costs for Waste Transportation

Waste transportation costs are based on a 500-mile trip to the radioactive LLW disposal site. The cost per mile is taken from the cost schedule provided by the Tri-State Motor Transit Co. (Tri-State 1993) and is summarized in Table 3.11. Charges for a 500-mile trip to the Richland, Washington, disposal facility were used in this reference analysis. According to Table 3.11, a charge of \$2.44/mile is applicable for each truck shipment in a 500-mile trip. Based on current transportation rate schedules, overweight shipments do not apply to the waste shipments hypothesized in this study. For reference, however, current overweight shipment fees for the state of Washington are summarized in Table 3.12.

3.4.3 Costs for Waste Burial

Because of the large discrepancy in burial costs, depending on the disposal sites and the state the waste originated in, high and low estimates of burial costs were made. The low cost estimate is based on *Washington Nuclear Center Schedule of Disposal Charges* for in-compact burial of radioactive material at the U.S. Ecology facility near Richland, Washington (Ecology 1993). The early 1993 rate schedule for the U.S. Ecology disposal facility in Washington is summarized in Part I of Table 3.13.

Basic U.S. Ecology burial fees are based on the exposure rate at the surface of the container. According to Table 3.13, the burial charge is \$28.30/ft³ for a package with a low surface exposure rate (used in this study). There are fees, surcharges, and taxes that are summarized in Table 3.13, Part II, totaling an additional \$9.83/ft³ plus 6.5% on the base charges. Further, there is a variable one-time registration fee for each waste generator, taken to be \$12,250 for this study. It should be noted that currently the U.S. Ecology disposal facility is only accessible to waste generators in the Northwest and Rocky Mountain Compacts.

The high waste disposal costs are estimated from the *Barnwell LLW Management Facility Rate Schedule* for out-of-compact burial of radioactive material (Chem-Nuclear 1993). The January 1993 rate schedule for the Barnwell Facility is summarized in Table 3.14. According to the schedule, there are five basic charges for waste burial at Barnwell. These include a base disposal charge

Table 3.11 Basic transportation rates for legal size and weight shipments effective January 1, 1993^(a,b)

One-Way Mileage (not over)	Transportation Rates, Cents Per Mile			
	Mid-1978 Rates		January 1993 Rates	
	Column 1	Column 2	Column 1 ^(c)	Column 2 ^(d)
100	319	229	525	358
125	293	212	487	332
150	269	196	448	306
175	244	182	412	284
200	212	166	364	260
225	201	158	349	247
250	192	147	334	230
275	184	138	322	216
300	175	132	308	206
325	171	124	203	194
350	165	120	295	188
375	159	116	284	181
400	152	112	273	175
425	147	109	267	172
450	141	107	257	167
475	137	104	251	164
500	132	103	244	161
550	128	100	239	158
600	125	97	235	151
650	122	97	228	151
700	119	97	224	151
750	117	97	222	151
800	112	97	215	151
850	111	97	214	151
900	109	97	212	151
950	108	97	209	151
1000	105	97	205	151
1100			204	151
1200			201	151
1300			199	151
1400			198	151
1500			197	151
1600			196	151
1700			194	151
1800			193	151
1900			192	151
2000			191	151
2100			190	151
2200			188	151
2300			187	151
2400			186	151
2500			184	151

(a) Update of Table H.1-3 in NUREG/CR-1266.

(b) Table taken from Tri-State Motor Transit Co., Docket No. MC-109397, January 1993 rates are the same as October 1990 rates (Tri-State 1991).

(c) Column 1 rates applicable to one-way shipments having a destination west of the Mississippi River. Destinations east of the Mississippi River are less expensive.

(d) Column 2 rates apply only to continuous excursion moves in which a subsequent shipment is made available to carrier within 24 hours after arrival at point of loading or unloading. Only one stop in transit allowed.

Table 3.12 Additional transportation charges when gross vehicle weight exceeds 36.28 Mg (effective January 2, 1993)^(a,b,c)

Gross Vehicle Weight (Mg)		Base Cost (\$/mi)	Additional Surcharge (\$)	Total Charge (\$/mi)
Lower Limit	Upper Limit			
36.28	45.36	0.21	0.21	0.42
45.36	47.63	0.35	0.21	0.56
47.63	49.90	0.49	0.21	0.70
49.90	52.16	0.63	0.21	0.84
52.16	54.43	0.84	0.21	1.05
54.43	58.97	1.05	0.21	1.26
58.97	63.50	1.26	0.21	1.47
63.50	65.77	1.47	0.21	1.68
65.77	72.58	1.68	0.21	1.89
72.58	77.11	2.03	0.21	2.24
77.11	81.65	2.38	0.21	2.59
81.65	90.72	2.80	0.21	3.01
90.72	95.26	2.90	0.21	3.11
>95.26		3.00	0.21	3.21

(a) Update of Table H.1-4 in NUREG/CR-1266.

(b) In addition to the charges shown in the table, a flat charge of \$25.00 per shipment is levied per shipment.

(c) Referenced for the state of Washington (Tri-State 1991).

of \$59/ft³ for "standard waste," a surcharge for containers that weigh more than 1,000 pounds, an "excess curie surcharge" of \$4,150/shipment when shielding casks are used (not applicable in this study), a Barnwell surcharge of 2.4%, and an out-of-compact access fee of \$220/ft³ for all eligible out-of-compact waste generators. It should be noted that, as of early 1994, the South Carolina facility was considering closing its facility to out-of-compact waste generators. If that occurs, waste generators not in the Southeast Compact or the Northwest and Rocky Mountain Compacts will have no disposal facility accessible to them until another facility is opened or until the policies are changed.

3.4.4 Lagoon Waste Management Options

Four different options for disposal of the solvent extraction and fluoride wastes presently stored in lagoons were explored in NUREG/CR-1757 (Elder 1980). Of these, the onsite burial option is no longer permitted. However, to provide continuity and cost comparisons, an economic

update of this option was performed. The elimination of onsite burial also changed the disposition of fluoride wastes in the ship-to-mill option from onsite burial to commercial disposal. (See the Summary for more discussion of the four options.)

Details of the costs associated with onsite burial are summarized in Table 3.15. The staffing cost escalation factor of 1.40 described in Section 3.1 was used to update the staffing, soil analysis, and contractor fees. The material and equipment cost escalation factor of 1.52, described in Section 3.2, was used to update the equipment and material costs. The updated costs for onsite burial are estimated to be \$80,880. Again, this option is no longer permitted by the current regulations.

Implementation of the option where the extraction lagoon wastes are shipped to a uranium mill for uranium extraction establishes whether uranium recovery for salvage value is cost effective (i.e., the cost of shipping and recovery less the value of the recovered uranium is less than the cost of burial as a waste). The present market price of uranium is estimated to be \$17.65/kg (\$8.00/lb). With 34,400 kg of material, and assuming a recovery rate of 95%, the value of the uranium credit would be \$679,680.

Details of the waste management costs for shipment of the solvent extraction lagoon wastes to a uranium mill are summarized in Table 3.16. Costs are updated in the same manner described for costs given in Table 3.9. The total costs for the shipment of extraction wastes to a uranium mill option are estimated to be just over \$7.8 million (exclusive of processing and waste management costs at the mill). Since fluoride wastes cannot be shipped to a uranium mill, it is assumed that the fluoride wastes are shipped to a commercial landfill. The basis for this assumption is that the costs for disposal in a commercial landfill (\$2.248 million - see Table 3.18) are significantly lower than disposal in a LLW burial ground (\$10.365 million - see Table 3.17). Waste management costs for shipment to a commercial landfill are described below. However, it should be noted that it is not clear that the fluoride wastes can now be disposed of in a commercial landfill.

Disposal of the lagoon wastes by removal to a LLW burial ground involves the packaging and transportation of the solvent extraction and fluoride wastes to the nearest LLW

Table 3.13 Low-level waste burial costs at the U.S. Ecology facility near Richland, Washington^(a,b)

Part I			
A. Steel Drums or Steel Boxes			
R/hr at Container Surface ^(c)	Price per Unit Volume		
	(\$/m ³)	(\$/ft ³)	
0.00 to 0.20	999.39	28.30	
0.21 to 1.00	1,048.83	29.70	
1.01 to 2.00	1,087.67	30.80	
2.01 to 5.00	1,130.05	32.00	
5.01 to 10.00	1,239.52	35.10	
10.01 to 20.00	1,479.66	41.90	
20.01 to 40.00	1,709.20	48.40	
over 40	by request	by request	
B. Disposable Liners			
R/hr at Container Surface	Surcharge	Price per Unit Volume	
		(\$/m ³)	(\$/ft ³)
0.00 to 0.20	none	999.39	28.30
0.21 to 1.00	207.6	999.39	28.30
1.01 to 2.00	467.1	999.39	28.30
2.01 to 5.00	787.2	999.39	28.30
5.01 to 10.00	1,254.3	999.39	28.30
10.01 to 20.00	1,643.5	999.39	28.30
20.01 to 40.00	1,885.7	999.39	28.30
over 40	by request	by request	by request
C. Minimum Disposal Charge: \$1000/Shipment			
D. Curie Surcharge (per Shipment)			
0 to 50	no surcharge		
50 to 100	\$865.00		
101 to 300	\$1,730.00		
301 to 500	2,162.50		
501 to 1,000	2,595.10		
1,001 to 5,000	3,027.60		
5,001 to 10,000	4,411.60		
10,001 to 15,000	6,228.20		
Over 15,000	by request		

Table 3.13. (contd)

Part II	
U.S. Ecology, Washington Nuclear Center, Radioactive Waste Disposal Schedule C - Tax and Fee Rider, Effective January 1, 1993	
Perpetual care and maintenance fee	\$1.75/ft ³
Business & occupation tax	5.5% of rates and charges
Site surveillance fee	\$1.58/ft ³
Surcharge (RCW 43.200.233)	\$6.50/ft ³
Commission regulatory fee	1.0% of rates and charges
One-time facility registration fee	\$12,250

- (a) Prices shown were in effect as of February 9, 1993, at the U.S. Ecology facility at Richland, Washington. Prices taken from U.S. Ecology (effective March 1, 1993).
- (b) Update of Table B.4-1 in NUREG/CR-2210.
- (c) Maximum reading at container surface, irrespective of physical size or configuration.

burial ground. Costs are updated in the same manner described in Table 3.9. Updated solvent extraction waste disposal costs are estimated to be almost \$40 million. Fluoride waste costs are estimated to be almost \$10.4 million. The cost structure for LLW burial is summarized in Table 3.17. From these costs, uranium recovery for the salvage value of the uranium is not cost-effective. However, uranium recovery to reduce the costs of waste disposal may be cost-effective.

Updated estimated costs for shipment of the lagoon fluoride wastes to a commercial landfill are summarized in Table 3.18. Simple escalation factors for packaging, transportation, and burial costs were calculated by taking the ratio of the January 1993 costs to mid-1981 costs for each of the constituent categories in Table 3.17. This resulted in packaging, transportation, and burial cost escalation factors of 8.20, 0.89, and 4.51, respectively. Applying these factors gives an estimate of nearly \$2.25 million to dispose of fluoride wastes at a commercial landfill. Extraction wastes cannot be shipped to a commercial landfill. The cost associated with extraction waste is for shipment to a uranium mill.

The updated estimates for the lagoon waste management options are summarized in Table 3.19.

3.5 Summary of Cost Estimate Updates for DECON

The updated costs for the DECON of the reference uranium hexafluoride conversion plant are summarized in Tables 3.20 and 3.21. As shown in Table 3.20, the total decommissioning cost, not including a 25% contingency, has increased from just under \$3.5 million to over \$6.4 million, with in-compact radioactive waste disposal at the U.S. Ecology facility near Richland, Washington, from mid-1981 to January 1993. Among the cost components, the disposal of radioactive material showed the largest increase over the 11.5-year span, climbing from \$0.523 million to \$2.146 million in January 1993 costs. Radioactive material disposal in this updated estimate accounts for over 33% of the total DECON cost compared to just 15% in mid-1981. Total DECON costs, without the 25% contingency, with out-of-compact radioactive waste disposal at the Chem-Nuclear facility near Barnwell, South Carolina, are over \$17 million, with three-quarters of the total decommissioning costs committed to waste disposal. DECON costs with out-of-compact radioactive waste disposal at the Chem-Nuclear facility are summarized in Table 3.21.

Table 3.14 Barnwell low-level radioactive waste management facility rate schedule^(a)

Base Disposal Charges	
Standard waste	59 \$/ft ³
Biological waste	61 \$/ft ³
SNM	59 \$/ft ³
Surcharges	
Weight of Container	Surcharge per Container
0 to 1,000 lb	No surcharge
1,001 to 5,000 lb	\$675.00
5,001 to 10,000 lb	\$1,200.00
10,001 to 20,000 lb	\$1,685.00
20,001 to 30,000 lb	\$2,170.00
30,001 to 40,000 lb	\$3,185.00
40,001 to 50,000 lb	\$4,185.00
greater than 50,000 lb	By special request
Curie Content per Shielded Shipment	Surcharge per Shielded Shipment
0 to 5	\$4,150.00
5 to 15	\$4,710.00
15 to 25	\$6,235.00
25 to 50	\$9,405.00
50 to 75	\$11,460.00
75 to 100	\$15,525.00
100 to 150	\$18,630.00
150 to 250	\$24,955.00
250 to 500	\$31,280.00
500 to 1,000	\$37,375.00
greater than 1,000	By special request
Barnwell surcharge	2.4% of above charges
Out-of-compact access fee	\$220.00 per ft ³

(a) Taken from Chem-Nuclear Systems Inc. (effective January 1, 1993).

Table 3.15 Details of estimated costs for the onsite burial option for fluoride lagoon wastes^(a,b)

Item	Mid-1981 Costs	Escalation Factor	January 1993 Values
Volume (m ³)	5,720	NA	5,720
Costs (\$)			
Staffing	15,000	1.40	21,000
Equipment	11,000	1.52	16,720
Material	22,500	1.52 ^(c)	34,200
Soil analysis	2,500	1.40 ^(d)	3,500
Contractor's fee	3,900	1.40 ^(e)	5,460
Total	54,900		80,880

(a) Update of Table H.2-5 in NUREG/CR-1757.

(b) Onsite burial is no longer permitted by current regulations.

(c) Basic construction material and equipment escalation factors were used to escalate material costs.

(d) Staffing escalation factor was used to escalate soil analysis costs.

(e) Staffing escalation factor was used to escalate contractor's fee.

Table 3.16 Details of estimated costs for management of solvent extraction lagoon wastes by shipment to uranium mill^(a,b)

Waste Category	Shipping Weight (Mg)	Shipping Volume (m ³)	Type of Container	Number of Shipments	Total Packaging Cost (\$)	Total Transp. Cost (\$) ^(c)	U.S. Ecology Facility		Chem-Nuclear Facility	
							Burial Cost (\$)	Total Waste Management Cost (\$)	Burial Cost (\$)	Total Waste Management Cost (\$)
Contaminated liner and soil	469	670	Steel box	37	158,971	45,140	960,811	1,164,922	6,634,749	6,838,860
Extraction waste to mill	37,260	21,600	Steel box	1,840	5,125,032	2,244,800	NA	7,369,832 ^(d)	NA	7,369,832 ^(d)
Subtotal								8,534,754		14,208,692
Value of recovered uranium								679,680 ^(e)		679,680 ^(e)
Total								7,855,074		13,529,012

(a) Update of Table H.2-6 in NUREG/CR-1757.

(b) The number of figures is for calculational completeness and does not imply accuracy to the number of figures shown. (c) Transportation costs are based on a transport distance of 500 miles.

(c) Transportation costs are based on a transport distance of 500 miles.

(d) Does not include processing or waste management costs at the mill. (e) Value of uranium at \$17.65/kg. 34,400 kg = \$679,680.

(e) Value of uranium at \$17.65/kg. 34,400 kg = \$679,680.

Table 3.17 Details of estimated costs of management of solvent extraction lagoon wastes by shipment to LLW burial site^(a)

Waste Category	Shipping Weight (Mg)	Shipping Volume (m ³)	Type of Container	Number of Shipments	Total Packaging Cost (\$)	Total Transp. Cost (\$) ^(c)	U.S. Ecology Facility		Chem-Nuclear Facility	
							Burial Cost (\$)	Total Waste Management Cost (\$)	Burial Cost (\$)	Total Waste Management Cost (\$)
Extraction waste	37,260	21,600	Steel box	1,840	5,125,032	2,244,800	30,975,411	38,345,243	213,896,389	221,266,221
Liner and soil	469	670	Steel box	37	158,971	45,140	960,811	1,164,922	6,634,749	6,838,860
Total								39,510,165		331,487,691
Fluoride waste	18,200	5,720	Steel box	552	1,357,184	805,920	8,202,748	10,365,852	56,642,933	58,806,037

(a) Update of Table H.2-7 in NUREG/CR-1757.

(b) Transportation costs are based on a transport distance of 500 miles.

(c) The number of figures shown is for calculational completeness and does not imply accuracy to the number of figures shown.

Table 3.18 Details of estimated costs of management of fluoride lagoon wastes by shipment to a commercial landfill^(a,b)

Item	Mid-1981 Values	Escalation Factor	Richland, WA		Barnwell, SC
			January 1993 Values	Escalation Factor	January 1993 Values
Shipping weight (Mg)	18,200	NA	18,200	NA	18,200
Shipping volume (m ³)	5,720	NA	5,720	NA	5,720
Number of shipments	552	NA	552	NA	552
Costs (\$)					
Packaging	85,000	8.20 ^(c)	697,004	8.20 ^(c)	697,004
Transportation ^(d)	726,300	0.89 ^(e)	648,976	0.89 ^(e)	648,976
Burial	200,000	4.51 ^(f)	902,484	31.16 ^(f)	6,231,976
Total cost	1,011,300		2,248,464		7,577,957

(a) Update of Table H.2-8 in NUREG/CR-1757.

(b) The number of figures is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Packaging escalation factor is based on the ratio of January 1993 costs to mid-1981 costs in Table 3.16.

(d) Transportation costs are based on a transport distance of 500 miles.

(e) Transportation escalation factor is based on the ratio of January 1993 costs to mid-1981 costs in Table 3.16.

(f) Burial escalation factor is based on the ratio of January 1993 costs to mid-1981 costs in Table 3.16.

Table 3.19 Summary costs of lagoon waste management options for DECON^(a,b)

Method of Waste Disposal	Cost in January 1993 dollars ^(c)					
	Waste disposal @ U.S. ecology LLW site or Richland, Washington, commercial site			Waste Disposal @ Chem-Nuclear LLW Site or Barnwell, South Carolina, Commercial Site		
	Extraction Waste	Fluoride Waste	Total Cost	Extraction Waste	Fluoride Waste	Total Cost
Ship to uranium mill	7,855,074	2,248,464	10,103,538 ^(d)	15,237,748	7,577,957	22,815,705
Ship to LLW burial ground	39,510,165	10,365,852	49,876,017	331,487,691	58,806,037	390,293,728
Ship to commercial landfill	7,855,074	2,248,464	10,103,538 ^(e)	15,237,748	7,577,957	22,815,705

(a) Update of Table 10.1-7 in NUREG/CR-1757.

(b) The number of figures is for computational completeness and does not imply accuracy to the number of figures shown. Costs are escalated from 1981 values given in NUREG/CR-1757.

(c) Contingency of 25% is not included.

(d) Not feasible to ship fluoride waste to uranium mill; total cost includes shipment to a commercial landfill.

(e) Not feasible to ship solvent extraction waste to a commercial landfill; total cost includes shipment to uranium

Table 3.20 Summary of estimated DECON costs with disposal at the U.S. Ecology facility^(a,b)

Cost Element	Cost in Millions of Mid-1981 Dollars ^(c)	Cost in Millions of 1993 Dollars	Percent of January 1993 Total Costs	11.5-Year Escalation Factor	Average Annual Escalation Factor
Staffing					
Planning and preparation	0.302	0.423	6.6	1.400	1.030
Decommissioning	1.734	2.427	37.7	1.400	1.030
Equipment and supplies	0.149	0.219	3.4	1.468	1.035
Disposal of radioactive material	0.523	2.159	33.6	4.128	1.131
License fees	0.098	0.070	1.5	1.400	1.030
Energy	0.340	0.362	5.6	1.065	1.005
Taxes and insurance	0.330	0.744	11.6	2.345	1.077
Subtotal	3.448	6.431	100.0	1.865	
25% contingency	0.862	1.608			
Total	4.310	8.039			

Lagoon Waste Management Options	Ship to Mill			Ship to LLW Burial			Ship to Commercial Landfill		
	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)
Subtotal from above	6.431	3.448	1.865	6.431	3.448	1.865	6.431	3.448	1.865
Solvent extraction waste	7.855	1.259	6.241	39.510	10.280	3.843	7.855 ^(g)	1.259	6.241
Fluoride waste	2.248 ^(h)	0.055	40.956	10.366	2.805	3.695	2.248	1.011	2.223
Subtotal (includes lagoon waste)	16.534	4.761	--	56.307	16.533	--	16.534	5.718	--
25% contingency	4.134	1.190	--	14.077	4.133	--	4.134	1.429	--
Total costs	20.668	5.951	3.473	70.384	20.667	3.406	20.668	7.147	2.892

(a) Update of Table 10.1-1 in NUREG/CR-1757.

(b) The number of figures shown is for computational accuracy and does not imply accuracy to the nearest thousand dollars.

(c) Values in NUREG/CR-1757.

(d) Costs in millions of January 1993 dollars.

(e) Costs in millions of mid-1981 dollars.

(f) 11.5-year escalation factor.

(g) For shipment to a uranium mill.

(h) For shipment to a commercial landfill.

Table 3.21 Summary of estimated DECON costs with disposal at the Chem-Nuclear facility^(a,b)

Cost Element	Cost in Millions of Mid-1981 Dollars ^(c)	Cost in Millions of 1993 Dollars	Percent of January 1993 Total Costs	11.5-Year Escalation Factor	Average Annual Escalation Factor
Staffing					
Planning and preparation	0.302	0.423	2.5	1.400	1.030
Decommissioning	1.734	2.427	14.2	1.400	1.030
Equipment and supplies	0.149	0.219	1.3	1.434	1.035
Disposal of radioactive material	0.523	12.811	75.0	24.502	1.356
License fees	0.098	0.070	0.6	1.400	1.030
Energy	0.340	0.362	2.1	1.065	1.005
Taxes and insurance	0.330	0.744	4.4	2.345	1.077
Subtotal	3.448	17.084	100.0	4.955	
25% contingency	0.862	4.271			
Total	4.310	21.355			

Lagoon Waste Management Options	Ship to Mill			Ship to LLW Burial			Ship to Commercial Landfill		
	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)
Total from above	17.084	3.448	4.955	17.084	3.448	4.955	17.084	3.448	4.955
Solvent extraction waste	15.238	1.259	12.107	331.488	10.280	32.246	15.238 ^(g)	1.259	12.107
Fluoride waste	7.578 ^(h)	0.055	138.032	58.806	2.805	20.961	7.578	1.011	7.493
Subtotal (includes lagoon waste)	39.899	4.761	--	407.377	16.533	--	39.899	5.718	--
25% contingency	9.975	1.190	--	101.844	4.133	--	9.975	1.429	--
Total costs	49.874	5.951	8.380	509.222	20.667	24.640	49.874	7.147	6.978 ¹

(a) Update of Table 10.1-1 in NUREG/CR-1757.

(b) The number of figures shown is for computational accuracy and does not imply accuracy to the nearest thousand dollars.

(c) Values in NUREG/CR-1757.

(d) Costs in millions of January 1993 dollars.

(e) Costs in millions of mid-1981 dollars.

(f) 11.5-year escalation factor.

(g) For shipment to a uranium mill.

(h) For shipment to a commercial landfill.

4 Cost Estimate Update for SAFSTOR

The cost estimates were updated for the passive safe storage (SAFSTOR) of the reference uranium hexafluoride conversion plant. The update was performed for the three stages of the SAFSTOR process: the preparations for SAFSTOR, the safe storage period, and deferred decontamination. The escalation factors used in the cost update for SAFSTOR were the same as those derived for DECON. Other cost information is also applied to SAFSTOR, such as current cost quotes for waste disposal activities used in updating DECON costs. The results of the cost update are presented in the following sections.

4.1 Cost Estimate Update for the Preparations for SAFSTOR

The preparation cost elements for SAFSTOR consists of staffing, materials and equipment, and owner's expenses. The updates of cost estimates for these cost elements are given in the subsequent subsections.

4.1.1 Costs for Staffing

The staffing requirements and the updated estimated costs for the planning and preparation phase for safe storage are summarized in Table 4.1. Table 4.2 shows the summary of the staff cost updates for the decommissioning phase of preparations for safe storage. Individual costs for each job in Tables 4.1 and 4.2 are based on the salaries/wages found in Table 3.1.

4.1.2 Costs for Equipment and Supplies

The update of the estimated cost of equipment and supplies for SAFSTOR preparations is presented in Table 4.3. The escalation factors used are described in Section 3.2.

4.1.3 Miscellaneous Owner's Expenses

Table 4.4 gives the update of the estimates of owner's expenses during the preparation phase for SAFSTOR. The tax and insurance costs are not a direct quotation of costs but an estimation, as was the case for the DECON

Table 4.1 Summary of staffing utilization and costs for preparation phase of safe storage^(a,b)

Title or Function	Staff-Years	January 1993 Cost(\$) ^(c,d)
Decommissioning superintendent	0.50	61,880
Decommissioning engineer	0.50	53,193
Health and safety supervisor	0.25	20,944
Contracts and accounting	0.25	16,481
Quality assurance engineer	0.25	16,422
Radioactive shipment specialist	0.25	13,744
Quality assurance supervisor	0.25	18,266
Craft supervisor	0.25	16,422
Secretary	0.50	16,905
Total staff-years	3.00	
Total cost		234,258

(a) Update of Table 10.2-2 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

Table 4.2 Summary of staffing utilization and costs for decommissioning phase of safe storage^(a,b)

Title or Function	Staff-Years	January 1993 Cost(\$) ^(c,d)
Decommissioning superintendent	0.25	30,940
Decommissioning engineer	0.25	26,596
Health and safety supervisor	0.25	20,944
Health physics technician	0.35	14,700
Security shift supervisor	0.25	12,733
Security patrolman	0.07	2,484
Contracts and accounting	0.25	16,481
Quality assurance engineer	0.35	25,573
Radioactive shipment specialist	0.17	9,346
Craft supervisor	0.25	16,422
Laborer	0.17	7,354
Craftsperson	0.67	30,109
Quality assurance supervisor	0.25	18,266
Technician	0.75	41,233
Secretary	0.25	8,452
Total staff-years	4.53	
Total cost		281,637

(a) Update of Table 10.2-3 in NUREG/CR-1757.

(b) Number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

Table 4.3 Estimated costs of equipment and supplies for preparation for safe storage^(a)

Description	Mid-1981 Estimated Total Cost(\$) ^(b)	Escalation Factor	January 1993 Estimated Total Cost(\$)
Decontamination chemicals	2,000	1.242	2,484
Cleaning supplies	2,500	1.316	3,290
Expendable tools	2,000	1.517	3,034
Protective clothing	4,000	1.374	5,496
Intrusion alarm system ^(c)	100,000	1.517	151,700
Miscellaneous	7,000	1.517	10,619
Office supplies			
Planning and preparation	5,000	1.517	7,585
Decommissioning	3,000	1.517	4,551
Total	125,500^(d)		188,759^(d)

(a) Update of Table 10.2-4 in NUREG/CR-1757.

(b) Contingency of 25% is not included.

(c) An alarm system is installed during the preparation for safe storage. The cost of the alarm system is included as an equipment item in Table 4.3. The cost of installation and testing the system by an outside contractor was estimated to be \$15,000 without contingency in mid-1981. The escalation of this cost in Table 4.5 was calculated by using the staffing escalation factor of 1.40.

(d) Total is shown as direct addition of the prior numbers to retain calculational information. Precision is less than shown.

Table 4.4 Estimated miscellaneous owner expenses during preparations for safe storage^(a,b)

Cost Category	Mid-1981 Cost(\$) ^(c)	Escalation Factor	January 1993 Cost(\$) ^(c)
Utilities	68,000	1.07	72,500
Taxes	30,000	1.79	53,800
Regulatory fees	70,000	1.40	98,000
Insurance	33,000	2.81	92,600
Total	201,000		316,900

(a) Update of Table 10.2-5 in NUREG/CR-1757.

(b) The number of figures is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

costs summarized in Table 3.7. The ratio of the January 1993 cost to the mid-1981 costs for DECON was calculated to get 11.5-year escalation factors of 1.79 and 2.81 for taxes and insurance, respectively. These escalation factors were then applied to the mid-1981 values for SAFSTOR to update them to January 1993 costs.

4.1.4 Summary of cost updates for the preparations for SAFSTOR

Table 4.5 summarizes the updated estimates of costs for the preparations for safe storage.

4.2 Update of Estimated Annual Costs for the Safe Storage Period

This section contains the updated annual costs for the 10 years of passive safe storage of the reference uranium hexafluoride conversion plant. Activities carried out at the plant to ensure the continued protection of the public safety during this 10-year period include monitoring, inspection, and maintenance of the operating equipment, alarm systems, and protective barriers; periodic radiation/environmental surveys; site and facility security; and fulfillment of regulatory requirements.

The estimated annual cost elements for safe storage consist of staffing, security and surveillance, materials and equipment, and owner's expenses. The updates of these cost estimates are provided in the following sections.

Table 4.5 Summary of the Update of Estimated Costs of Preparations for Safe Storage^(a,b)

Cost Category	Cost in Mid-1981 Dollars ^(c)	Cost in January 1993 Dollars	Percent of January 1993 Total Costs	11.5-Year Escalation Factor	Avg. Annual Escalation Factor
Disposal of radioactive material	5,000	0			
Staffing					
Planning and preparation	167,000	234,000	22.9	1.40	1.030
Decommissioning (5 yr)	201,000	282,000	27.6	1.40	1.030
Equipment and supplies	126,000	189,000	18.5	1.50	1.036
License fees	70,000	98,000	9.6	1.40	
Energy	68,000	73,000	7.1	1.07	
Nuclear insurance	<u>63,000</u>	<u>146,000</u>	14.3	2.32	
Subtotal	700,000	1,022,000	100.0	1.46	
25 % contingency	<u>175,000</u>	<u>255,000</u>			
Total	875,000	1,277,000			

(a) Update of Table 10.2-1 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Values in NUREG/CR-1757.

4.2.1 Costs for Staffing

Table 4.6 shows the annual staffing requirements and cost estimate updates for safe storage.

4.2.2 Costs for Equipment and Supplies

The mid-1981 annual equipment and supplies estimate of \$4,000 was updated to \$6,080 by applying the escalation factor of 1.52 described in Section 3.2.

4.2.3 Costs for Contractors

The security and maintenance contractor estimated annual costs were updated by using the staffing escalation factor of 1.40 described in Section 3.1.

4.2.4 Miscellaneous Owner's Expenses

Miscellaneous owner's expenses during the safe storage period include the costs for utilities, taxes, insurance, and regulatory fees. The total cost of utilities is updated from \$7,000 to \$7,462 using the energy escalation factor of 1.066 established in Section 3.3. The tax and insurance costs are updated in the same manner as that described in

Section 4.1.3. The licensing fee was updated in the same manner described in Section 3.4.

4.2.5 Estimated Total Annual Costs

The annual costs of safe storage are summarized in Table 4.7. The updated estimate for total annual cost for the safe storage of the conversion plant in January 1993 dollars increased to almost \$140,500 from \$94,670 in mid-1981.

4.3 Cost Estimate Update for Deferred Decontamination

The components of the total cost for the deferred decontamination activities are the costs for staffing, for materials and equipment, and for waste management. The update of these cost estimates is presented in the following sections.

4.3.1 Costs for Staffing

The update of the staffing cost estimates for the planning and preparations of the deferred decontamination is given in Table 4.8. The update of the staffing costs for the

Table 4.6 Estimated annual staff requirements for safe storage^(a,b)

Title or Function	Staff-Yrs/yr	1981 Annual Cost (\$/yr) ^(c)	Escalation Factor	January 1993 Annual Cost (\$/yr) ^(c)
Facility manager	0.25	18,998	1.40	26,597
Secretary	0.25	6,038	1.40	8,453
Third-party inspection team ^(d)	<u>0.03</u>	<u>4,700</u>	1.40	<u>6,580</u>
Total staff-years	0.53			
Total cost/years		29,735		41,629

(a) Update of Table 10.3-2 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Third-party inspection costs are based on an assumed \$600 per staff-day for mid-1981.

Table 4.7 Summary of estimated annual costs of the safe storage period^(a,b)

Cost Category	Cost in Mid-1981 Dollars ^(c)	Cost in January 1993 Dollars	11.5-Year Escalation Factor	Percent of Total Costs	Avg. Annual Escalation Factor
Staff labor	29,740	41,629	1.400	37.0	1.030
Supplies and equipment	4,000	6,068	1.517	5.4	1.037
Security contractor	12,000	16,800	1.400	15.0	1.030
Maintenance contractor	10,000	14,000	1.400	12.5	1.030
Annual allowance for repairs	4,000	5,600	1.400	0.5	1.030
Utilities	7,000	7,462	1.066	6.6	1.006
Taxes	3,000	5,382	1.794	4.8	1.052
Insurance	5,000	14,028	2.806	12.5	1.094
Regulatory fees ^(d)	<u>1,000</u>	<u>1,400</u>	<u>1.400</u>	<u>1.2</u>	<u>1.030</u>
Subtotal	75,740	112,369		100.0	
25% contingency	<u>18,930</u>	<u>28,092</u>			
Total annual cost	94,670	140,462	1.484		

(a) Update of Table 10.3-1 in NUREG/CR-1757.

(b) The number of figures is for computational completeness and does not imply accuracy to the number of figures shown.

(c) From NUREG/CR-1757.

(d) Estimates do not necessarily take into account the full cost recovery for NRC staff.

decommissioning phase of deferred decontamination is presented in Table 4.9. The escalation factor used in the staffing cost updates is 1.40, as described in Section 3.1.

4.3.2 Costs for Equipment and Supplies

Table 4.10 shows the cost estimate updates for materials and equipment for deferred decontamination.

4.3.3 Costs for the Disposal of Radioactive Material

The waste management cost estimates for deferred decontamination are the same as for the DECON option, namely, \$2.159 million for in-compact disposal at the

Table 4.8 Summary of staffing utilization and costs for planning and preparations phase of deferred decontamination^(a,b)

Title or Function	Staff-Years	January 1993 Cost(\$) ^(c,d)
Decommissioning superintendent	1.00	123,800
Decommissioning engineer	0.75	79,800
Health and safety supervisor	0.67	56,100
Contracts and accounting	0.67	44,200
Radioactive shipment specialist	0.38	20,000
Quality assurance engineer	0.67	44,000
Engineering technician	0.67	49,000
Shift engineer	0.67	36,800
Craft supervisor	0.67	44,000
Operations supervisor	0.67	49,000
Crew leader	1.50	93,200
Technician (training)	2.00	107,400
Craftsperson (training)	0.50	22,500
Secretary	1.50	50,700
Total staff-years	12.32	
Total cost		821,300

(a) Update of Table 10.4-2 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

Richland, Washington, facility and \$12.811 million for out-of-compact disposal at the Barnwell, South Carolina, facility.

4.3.4 Miscellaneous Owner's Expenses

The miscellaneous owner's expenses for deferred decontamination are the same as for the DECON option, namely, \$1.204 million for January 1993 (see Table 3.7 for the cost structure).

4.3.5 Total Costs for Deferred Decontamination

The updated total costs for deferred decontamination are presented in Table 4.11. They reflect the same trends and relative costs as the immediate DECON cost schedule. As the results show, the January 1993 deferred decontamination estimated costs at the end of the storage period have

Table 4.9 Summary of staffing utilization and costs for decommissioning phase of deferred decontamination^(a,b)

Title or Function	Staff-Years	January 1993 Cost(\$) ^(c,d)
Decommissioning superintendent	0.75	92,800
Decommissioning engineer	0.75	79,800
Health and safety supervisor	0.75	62,800
Health physics technician	1.50	63,000
Security shift supervisor	0.75	58,700
Security patrolman	3.00	106,500
Contracts and accounting	0.75	49,400
Radioactive shipment specialist	0.75	41,200
Quality assurance engineer	0.75	49,300
Shift engineer	0.75	55,000
Engineering technician	0.75	41,200
Craft supervisor	0.75	49,300
Laborer	0.75	32,400
Craftsperson	3.00	134,800
Quality assurance supervisor	0.75	54,800
Crew leader	3.50	217,400
Technician	24.00	1,319,500
Secretary	1.50	50,700
Total staff-years	45.50	
Total cost		2,558,700

(a) Update of Table 10.4-3 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Contingency of 25% is not included.

(d) Includes escalation factor of 1.40 to update from mid-1981 dollars to January 1993 dollars.

increased by a factor of 1.82 from \$3.83 million in mid-1981 to \$6.96 million for in-compact disposal (i.e., in the Northwest and Rocky Mountain Compacts) at the U.S. Ecology facility near Richland, Washington. January 1993 deferred decontamination costs with out-of-compact disposal at the Chem-Nuclear facility near Barnwell, South Carolina, have risen by a factor of 4.60 from \$3.83 million to \$17.08 million. These costs are comparable to the DECON costs in both magnitude and structure. Again, the largest increase is caused by waste disposal costs, which now make up nearly 31% of the total estimated costs with in-compact disposal at the Richland, Washington, facility and 73% of the total estimated costs with out-of-compact disposal at the Barnwell, South Carolina, facility, compared with just 13.7% in 1981.

Table 4.10 Estimated material and equipment requirements and costs for deferred decontamination^(a,b)

Description	Quantity	Estimated Unit Cost(\$) ^(c)	Estimated Total Cost in January 1993 Dollars ^(d)
Oxyacetylene torch	4	1,705	6,820
Guillotine pipe saw	2	6,820	13,640
Tube cutter	2	699	1,398
Ratcheting pipe cutter	6	119	716
Reciprocating saw	4	1,364	5,456
Nibbler	2	1,517	3,034
High-velocity liquid jet	1	10,467	10,467
Low-velocity liquid jet	2	4,187	8,374
Hydraulic concrete surface spalling device	1	7,585	7,585
Concrete drill	3	425	1,274
Electric/pneumatic hammer	2	1,062	2,124
Portable A-frames	2	6,220	12,439
Portable wash tanks	2	4,187	8,374
Portable spray clean booth	1	8,374	8,374
Portable greenhouse erection kit	1	4,187	4,187
Hand-powered brushes	20	319	6,371
HEPA filter	5	303	1,517
Roughing filter	20	152	3,034
Decontamination chemicals			13,662
Cleaning supplies			29,084
Expendable tools			16,687
Protective clothing (including laundry)			27,343
Office supplies			
Planning and preparation			20,024
Dismantlement			<u>10,012</u>
Total			221,997

(a) Update of Table 10.4-4 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Unit cost information is taken from that in Table 3.5.

(d) Contingency of 25% is not included.

4.4 Cost Estimate Update for Total of SAFSTOR and Deferred DECON

The updated cost estimates for the passive SAFSTOR with deferred decontamination after 10 years of safe storage are summarized in Table 4.13. As shown in Table 4.13, the total costs, with radioactive waste disposal at the U.S.

Ecology facility near Richland, Washington, are estimated to have increased from \$6.62 million in mid-1981 to \$11.4 million in January 1993, indicating an overall escalation factor of 1.72. Radioactive waste disposal at the Chem-Nuclear facility near Barnwell, South Carolina, raises the total costs to nearly \$25 million, as summarized in Table 4.13.

Table 4.11 Summary of estimated deferred decontamination costs with waste disposal at the U.S. Ecology facility^(a,b)

Cost Element	Cost in Millions of Mid-1981 Dollars ^(c)	Cost in Millions of 1993 Dollars	Percent of January 1993 Total Costs	11.5-Year Escalation Factor	Avg. Annual Escalation Factor
Staffing					
Planning and preparation	0.589	0.821	11.8	1.400	1.030
Decommissioning	1.828	2.559	36.8	1.400	1.030
Equipment and supplies	0.157	0.222	3.2	1.472	1.035
Disposal of radioactive material	0.523	2.146	30.9	4.104	1.131
License fees	0.070	0.098	1.4	1.400	1.030
Energy	0.340	0.362	5.2	1.065	1.005
Taxes and insurance	<u>0.330</u>	<u>0.744</u>	<u>10.7</u>	2.255	1.073
Subtotal	3.831	6.953	100.0	1.816	
25% contingency	<u>0.958</u>	<u>1.738</u>			
Total	4.789	8.691			

Lagoon Waste Management Options	Ship to Mill			Ship to LLW Burial			Ship to Commercial Landfill		
	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)
Subtotal from above	6.953	3.831	1.815	6.953	3.831	1.815	6.953	3.831	1.815
Solvent extraction waste	7.855	1.259	6.241	39.510	10.280	3.843	7.855 ^(g)	1.259	6.241
Fluoride waste	<u>2.248^(h)</u>	<u>0.055</u>	40.956	<u>10.366</u>	<u>2.805</u>	3.695	<u>2.248</u>	<u>1.011</u>	2.223
Subtotal (includes lagoon waste)	17.056	5.145	-----	56.829	16.916	-----	17.056	6.101	-----
25% contingency	<u>4.264</u>	<u>1.286</u>	-----	<u>14.207</u>	<u>4.229</u>	-----	<u>4.264</u>	<u>1.525</u>	-----
Total costs	21.320	6.430	3.316	71.036	21.145	3.359	21.320	7.626	2.796

(a) Update of Table 10.4-1 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Values in NUREG/CR-1757.

(d) Costs in millions of January 1993 dollars.

(e) Costs in millions of mid-1981 dollars.

(f) 11.5-year escalation factor.

(g) For shipment to uranium mill.

(h) For shipment to a commercial landfill.

Table 4.12 Summary of estimated deferred decontamination costs with waste disposal at Chem-Nuclear facility^(a,b)

Cost Element	Cost in Millions of Mid-1981 Dollars ^(c)	Cost in Millions of 1993 Dollars	Percent of January 1993 Total Costs	11.5-Year Escalation Factor	Avg. Annual Escalation Factor
Staffing					
Planning and preparation	0.589	0.821	4.7	1.400	1.030
Decommissioning	1.828	2.559	14.5	1.400	1.030
Equipment and supplies	0.157	0.222	1.3	1.472	1.035
Disposal of radioactive material	0.523	12.811	72.7	24.495	1.322
License fees	0.070	0.098	0.6	1.400	1.030
Energy	0.340	0.362	2.1	1.065	1.005
Taxes and insurance	0.330	0.744	4.2	2.255	1.073
Subtotal	3.831	17.617	100.0	4.599	
25 % contingency	0.958	4.404			
Total	4.789	22.021			

Lagoon Waste Management Options	Ship to Mill			Ship to LLW Burial			Ship to Commercial Landfill		
	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)	1993 ^(d)	1981 ^(e)	Escalation Factor ^(f)
Subtotal from above	17.617	3.831	4.599	17.617	3.831	4.599	17.617	3.831	4.599
Solvent extraction waste	15.238	1.259	12.107	331.488	10.280	32.246	15.238 ^(g)	1.259	12.107
Fluoride waste	7.578 ^(h)	0.055	138.032	58.806	2.805	20.961	7.578	1.011	7.493
Subtotal (includes lagoon waste)	40.433	5.145	-----	407.911	16.916	-----	40.433	6.101	-----
25 % contingency	10.108	1.286	-----	101.978	4.229	-----	10.108	1.525	-----
Total costs	50.541	6.430	7.860	509.899	21.145	24.114	50.541	7.626	6.628

(a) Update of Table 10.4-1 in NUREG/CR-1757.

(b) The number of figures shown is for computational completeness and does not imply accuracy to the number of figures shown.

(c) Values in NUREG/CR-1757.

(d) Costs in millions of January 1993 dollars.

(e) Costs in millions of mid-1981 dollars.

(f) 11.5-year escalation factor.

(g) For shipment to uranium mill.

(h) For shipment to a commercial landfill.

Table 4.13 Summary of the total SAFSTOR costs

Item	Passive SAFSTOR with Deferred Decontamination after 10 Years ^(a,b)				
	Cost in Millions of Mid-1981 Dollars	Disposal at U.S. Ecology		Disposal at Chem-Nuclear	
		Cost in Millions of January 1993 Dollars	11.5-Year Escalation Factor	Cost in Millions of January 1993 Dollars	11.5-Year Escalation Factor
Preparations		1.28	1.42	1.28	1.42
Safe storage ^(c)	0.95	1.41	1.48	1.41	1.48
Deferred decontamination	<u>4.79</u>	<u>8.71</u>	1.82	<u>22.02</u>	4.60
Total costs	6.62	11.40	1.72	24.71	3.73

(a) The number of figures shown is for calculational completeness and does not imply accuracy to the number of figures shown.

(b) Values include a contingency of 25%.

(c) Safe storage for 10 years.

4.5 DECON Costs with Onsite Disposal of Lagoon Wastes

NUREG/CR-1757 covered the disposal of lagoon wastes in detail, including a summary of the estimated cost for DECON of the uranium hexafluoride plant with onsite burial of the lagoon waste. However, since onsite burial is no longer permitted by the current regulations, analysis

of this option was not included in the overall cost update. For the sake of continuity between the original report and the update, Table 3.15, which breaks down the costs of onsite burial, has been updated, but the results were not included in the cost summaries. The options covered in this cost update are discussed and results are presented in Section 3.4.4.

5 Applicability of Results to Future Cost Estimate Updates

5.1 Escalating Costs to a Future Time

Escalation of decommissioning costs for the types of reference fuel-cycle facilities covered in this study can be made from an estimate made at some previous time to a future time using an escalation formula of a form given in 10 CFR 50.75. In this formula, shown in the equation below with minor modifications,¹ decommissioning costs are divided into five general areas that tend to escalate in similar ways: 1) labor, materials, and services; 2) energy and waste transportation; 3) radioactive waste disposal; 4) taxes and insurance; and 5) hazardous waste management.

$$\text{Cost in year X} = [\text{adjusted total base cost in year Y}] * [AL_x + BE_x + CB_x] + \text{T\&I Costs in Year X}^d + \text{H Costs in year X}^d$$

where

Cost in year X = the approximate costs for decommissioning activities in year X

Adjusted total base

cost in year Y = estimated or known decommissioning cost for year Y (taken as January 1993 costs from this report) after subtracting costs for taxes, insurance, and hazardous materials handling

A = fraction of the adjusted total decommissioning cost attributable to labor, materials, and services costs in year Y

B = fraction of the adjusted total decommissioning cost attributable to energy and waste transportation costs in year Y

C = fraction of the adjusted total decommissioning cost attributable to waste burial costs in year Y

¹The taxes and insurance costs were separated from the total base cost because escalation of these factors is difficult to predict. Hazardous waste management costs are added to the formula but also kept separate because their costs have generally not been considered to date.

L_x = labor, materials, and services cost escalation factor from January 1993 to appropriate month of year X

E_x = energy and waste transportation cost escalation factor from January 1993 to the appropriate month of year X

B_x = radioactive waste burial and surcharge cost escalation factor from January 1993 to appropriate month of year X
 $X = (R_x + \Sigma S_x) / (R_y + \Sigma S_y)$

where

R_x = the radioactive waste burial basic costs (excluding surcharges) in year X

ΣS_x = the summation of surcharges in year X

R_y = the radioactive waste burial basic costs (excluding surcharges) in year Y

ΣS_y = the summation of surcharges in year Y

T&I = Taxes and insurance costs during decommissioning

H = Costs for hazardous waste management beyond those required for radioactive wastes (obtained from direct estimates).

Values for L_x and E_x are to be obtained from the U.S. Department of Labor Bureau of Labor Statistics cost indexes, preferably for the regional conditions for a given site. The values to be used in determining B_x are to be taken from actual cost schedules (basic disposal costs plus surcharges resulting from the Low-Level Radioactive Waste Policy Amendments Act of 1985), plus other surcharges that may vary for wastes originating in states other than the host state for the waste disposal facility, for LLW disposal facilities.

The coefficients used in the equation for decommissioning a reference uranium fuel fabrication plant were developed from January 1993 cost estimate updates. The coefficients were calculated based on the information found in the summary tables (Tables 3.19, 4.5, 4.7, and 4.11) and Tables 3.8 and 3.9 for the waste management cost breakdown. A set of coefficients and values is given in Tables 5.1 and 5.2 for each of the decommissioning alternatives. For this report, the hazardous waste management costs were not evaluated.

Table 5.1 Formula coefficients for escalating decommissioning costs for the reference uranium hexafluoride conversion plant with waste disposal at the U.S. Ecology facility near Richland, Washington

Decommissioning Activity	A	B	C	$\Sigma R_y^{(a)}$	$\Sigma S_y^{(a)}$	$T \& I_y^{(a)}$	1993 Adjusted Cost ^(a)
DECON	0.549	0.076	0.375	1.090	0.486	0.744	5.589
Preparations/SAFSTOR	0.07	0.093	0.000	0.000	0.000	0.146	0.777
Annual costs/SAFSTOR	0.919	0.081	0.000	0.000	0.000	0.019	0.092
Deferred Decontamination	0.588	0.069	0.342	1.090	0.486	0.744	6.123

(a) Costs in millions of dollars.

Table 5.2 Formula coefficients for escalating decommissioning costs for the reference uranium hexafluoride conversion plant with waste disposal at the Chem-Nuclear facility near Barnwell, South Carolina

Decommissioning Activity	A	B	C	$\Sigma R_y^{(a)}$	$\Sigma S_y^{(a)}$	$T \& I_y^{(a)}$	1993 Adjusted Cost ^(a)
DECON	0.189	0.026	0.785	2.272	8.525	0.744	16.241
Preparations/SAFSTOR	0.907	0.093	0.000	0.000	0.000	0.146	0.777
Annual costs/SAFSTOR	0.919	0.081	0.000	0.000	0.000	0.019	0.092
Deferred Decontamination	0.215	0.025	0.760	2.272	8.525	0.744	16.775

(a) Costs in millions of dollars.

5.2 Extrapolating to Future Estimated Decommissioning Costs

The results in this study can be used, if desired, to approximate near-future (i.e., one to two years hence) decommissioning costs for similar facilities. One method given in the equation below, is to use annual escalation factors derived in this study. The last column of the summary tables (Tables 3.19, 4.5, 4.7, 4.11, and 4.12) shows the average annual escalation factors. These numbers represent the annual rate of increase, compounded yearly, to achieve the 11.5-year escalation factor listed in the summary tables. This number could be used to estimate future decommissioning costs with the following equation:

$$F = P(i)^n$$

where P = present (January 1993) cost
 F = future cost
 i = the average annual escalation factor
 n = the number of years of escalation.

The average annual escalation factors were calculated assuming a consistent rate of increase over the last 11.5 years. Because of this assumption, some caution must be used in escalating the total cost. As was discussed in Section 2.0, in some cases the escalating nature of the constituent cost elements was radical and not consistent. For example, the LLW disposal costs have increased dramatically in recent years compared with most other costs. The drastic escalation of the waste disposal costs is the consequence of significant cost increases in waste packaging and burial and associated surcharges. In light of this development, caution should be used when

using the escalation factors for waste disposal in future cost predictions. As technologies, the economic situation, and regulatory policy change, the costs associated with the disposal charges should be calculated with great caution. These disposal cost trends have resulted from significant step increases and are not well described by average annual escalation factors.

Table 5.3 presents a number of average annual escalation factors derived in this study. In addition to the factors given in the last column of the summary tables, average annual escalation factors for waste transportation and waste burial were calculated based on the information in Tables 3.8 and 3.9. These could be used in combination with the algorithm established to predict some of the cost trends for future decommissioning activities.

Table 5.3 Average annual escalation factors

Description	Escalation Factor ^(a)
Staffing	1.030
Equipment and supplies	1.035
Miscellaneous owner expense	1.044
Repair allowance	1.030
Waste transportation	0.989
Waste burial ^(b)	1.162

(a). Average annual escalation factors for the 11.5-year period between mid-1978 and January 1993.

(b). Includes waste packaging, burial, and associated surcharges at the U.S. Ecology facility at Richland, Washington.

6 References

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Appendix

Table Number Cross-Reference List Between Current and Previous Reports

Appendix

Table Number Cross-Reference List Between Current and Previous Reports

No. in Current Report	Title	No. in 1981 NUREG/CR-1757
S.1	Summary of updated costs for decommissioning the reference uranium hexafluoride conversion plant	--
S.2	Change in assumptions for handling of lagoon wastes	--
S.3	Formula coefficients for escalating DECON costs to some future current time	--
S.4	Average annual escalation factors	--
S.1	Decommissioning labor cost data	H.1-1
3.2	Summary of staffing utilization and costs for planning and preparation phase of DECON	10.1-2
3.3	Summary of staffing utilization and costs for the dismantlement and decontamination phase of DECON	10.1-3
3.4	Estimated material and equipment requirements and costs for DECON	10.1-4
3.5	Unit costs for special tools and equipment	H.1-6
3.6	Escalation factors for energy costs	--
3.7	Estimated miscellaneous owner expenses for DECON	10.1-8
3.8	Estimated waste management costs for DECON	10.1-6
3.9	Details of estimated costs for radioactive waste for DECON	H.2-4
3.10	Shipping containers used for wastes in this study	H.1-2
3.11	Basic transportation rates for legal size and weight shipments effective January 1, 1993	H.1-3
3.12	Additional charges when gross vehicle weight exceeds 36.28 Mg	H.1-4
3.13	Low-level waste burial costs at the U.S. Ecology facility near Richland, Washington	H.1-5
3.14	Barnwell LLW management facility rate schedule	H.1-5
3.15	Details of estimated costs for the onsite burial option for fluoride lagoon wastes	10.2-5
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