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COST UPDATE: TECHNOLOGY, SAFETY,
AND COSTS OF DECOMMISSIONING A
REFERENCE URANIUM FUEL
FABRICATION PLANT

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ABSTRACT

The cost estimates originally developed in NUREG/CR-1266 for decommissioning a reference low-enrichment uranium fuel fabrication plant are updated from 1978 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-1978 value of \$3.57 million to \$8.08 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 \$19.62 million with out-of-compact radioactive waste 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 fuel fabrication 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.

SUMMARY

The purpose of this study is to update the cost estimates developed in a previous report, NUREG/CR-1266, for decommissioning a reference uranium fuel fabrication plant from the original mid-1978 dollars to values representative of January 1993. The cost updates were performed by using escalation factors derived from cost index trends over the past 14.5 years. Contemporary price quotes were used for costs which 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-1266. This report includes only information that was changed from that in NUREG/CR-1266. Thus, for those interested in detailed descriptions and associated information for the reference uranium fuel fabrication plant, a copy of NUREG/CR-1266 will be needed.

S.1 SUMMARY OF UPDATED COST ESTIMATES

To carry out the cost updates effectively, Lotus^(a) spreadsheets were developed to calculate the current total decommissioning costs. To maintain consistency, the formats of the tables in NUREG/CR-1266 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.

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-1978 value of \$3.57 million to \$8.08 million in January 1993. This represents an estimated cost increase of a factor of 2.3 over the past 14.5 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, Washington, 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. 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%.

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

TABLE S.1. Summary of Updated Costs for Decommissioning the Reference Uranium Fuel Fabrication Plant^(a,b)

Item	DECON			Passive SAFSTOR with Deferred Decontamination After 10 Years		
	1978 Cost Estimate	1993 Cost Estimate ^(c)	1993 Cost Estimate ^(d)	1978 Cost Estimate	1993 Cost Estimate ^(c)	1993 Cost Estimate ^(d)
	(Million \$)	U.S. Ecology (Million \$)	Chem-Nuclear (Million \$)	(Million \$)	U.S. Ecology (Million \$)	Chem-Nuclear (Million \$)
Initial Decommissioning ^(e)	3.57	8.08	19.62	0.85	1.46	1.46
Safe Storage	--	--	--	2.83	5.07	5.07
Deferred Decontamination	--	--	--	<u>3.84</u>	<u>8.79</u>	<u>20.33</u>
Total Costs	3.57	8.08	19.62	7.52	15.32	26.86
Other Possible Costs ^(f)						
Chemical Sludge Disposal	0.40	2.62	16.18			
Contaminated CaF ₂ Disposal	9.00	53.24	320.72			
Misc. Contaminated Metals	<u>1.20</u>	<u>6.83</u>	<u>40.73</u>			
Total Other Possible Costs	10.60	62.69	377.64			

(a) Update of Table 2.8-1 in NUREG/CR-1266.

(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, or if the uranium in the solids is recovered.

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 \$19.62 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.) Their 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 less than 1.8, the current in-compact radioactive waste burial costs at the Washington State burial facility are over 9.6 times higher than what they were in 1978. Out-of-compact radioactive waste burial costs at the South Carolina facility are more than 60 times higher than they were in 1978. The Northwest compact radioactive waste disposal costs are now estimated to account for nearly 32% of the total reference fuel fabrication facility DECON cost compared with about 7% in 1978. Out-of-compact radioactive waste disposal costs in the Southeast Compact account for nearly 75% of the DECON budget at the same facility.

The costs for the passive SAFSTOR option during both the planning and preparation and storage periods have a much lower rate of escalation 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 1.7, from \$0.85 million in mid-1978 to \$1.46 million in January 1993. The cost of the ten-year Safe Storage period is estimated to have increased by a factor of about 1.8, from \$2.82 million to \$4.84 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 nearly 2.3, from \$3.84 million in mid-1978 to \$8.79 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 low-level radioactive waste disposal costs, which now make up 30% of the estimated total costs, compared with just 6.4% in 1978. The total costs for the passive SAFSTOR with deferred decontamination after ten years show an increase from \$7.52 million in mid-1978 to \$15.32 million in January 1993, indicating an escalation factor of 2.04 over 14.5 years. For out-of-compact disposal in South Carolina, the estimated costs for deferred decontamination increased from \$3.84 million to \$20.33 million, which is an increase of a factor of 5.3. The total costs for passive safe storage with 10-year deferred decontamination increased from \$7.52 million to \$26.86 million, or by a factor of 3.6.

The possible additional waste management costs of burying all contaminated chemical and calcium fluoride (CaF_2) sludges and contaminated equipment and materials at the Northwest Compact low-level radioactive disposal facility were estimated to be \$63 million in 1993; and for out-of-compact disposal at the Southeast Compact disposal facility, total costs increased to about \$380 million. Approximately \$40 million could be saved by recovering the enriched uranium from the residuals. Another \$50 million could be saved by recovering hydrogen fluoride (HF). These estimates confirm the basic assumption in NUREG/CR-1266 that the uranium in the waste streams would be recovered, and the reprocessed value would more than offset the recovery costs. By recovering uranium and hydrogen fluoride in the waste streams, the decommissioning costs could be kept at a reasonable level.

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 fuel fabrication plant. The average annual escalation factors (logarithmically averaged over 14.5 years) can be used for this purpose, assuming the same decommissioning approach and activities as developed in NUREG/CR-1266. However, caution is urged when applying escalation factors to costs that might behave erratically during the projection time period (such as waste disposal costs).

S.2 FORMULA FOR ESCALATING COSTS TO A FUTURE TIME

Decommissioning costs for the reference uranium fuel fabrication 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 below with minor modifications, decommissioning costs are divided into five general cost elements 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.

$$\text{Cost in Year X} = [\text{Adjusted Total Base Cost in Year Y}] * [AL_x + BE_x + CB_x] + (\text{T\&I Costs in Year X})^{(a)} + (\text{H Costs in Year X})^{(a)}$$

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

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 the appropriate month of Year X
= (R_x + ΣS_x) / (R_y + ΣS_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.

(a) The 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.

Values for the coefficients given in Table S.2 can be used in the above equation to calculate the escalation in DECON costs in some future current time. The coefficients were calculated assuming Year Y to be January 1993. For this NUREG/CR-1266 Cost Update, the taxes and insurance costs and hazardous waste management costs were not evaluated.

TABLE S.2. Formula Coefficients for Escalating DECON Costs to Some Future Time

<u>Formula Coefficient</u>	<u>Value</u>
A	0.620
B	0.056
C	0.324
R _y (million \$)	1.090
S _y (million \$)	0.486
T&I (Year Y, million \$)	0.745
Adjusted Total (Year Y, million \$)	5.606

S.3 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.3. The factors were obtained from the mid-1978 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.3.

TABLE S.3. Average Annual Escalation Factors^(a)

<u>Cost Element</u>	<u>Escalation Factor</u>
Staffing	1.041
Equipment and Supplies	1.038
Miscellaneous Owner Expense	1.041
Specialty Contractors	1.058
Repair Allowance	1.042
Waste Transportation	1.011
Waste Burial ^(b)	1.152

(a) Log-averaged over 14.5 years from mid-1978 to January 1993.

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

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1.0 INTRODUCTION

At the request of the U.S. Nuclear Regulatory Commission (NRC), staff at the Pacific Northwest Laboratory (PNL)^(a) have updated the estimates of decommissioning costs for a reference low-enrichment uranium fuel fabrication plant (NUREG/CR-1266) (Elder and Blahnik 1980) to reflect the January 1993 economic environment. The cost update was carried out under the NRC's office of Nuclear Regulatory Research Project "Re-evaluation of Reference Fuel Cycle and Non-Fuel Cycle Facility Decommissioning," FIN L2025.

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

- The cost elements contained in the original report prepared for the NRC by PNL (NUREG/CR-1266) (Elder and Blahnik 1980) were adjusted to reflect cost escalations from mid-1978 to January 1993. The 25% contingency factor used in NUREG/CR-1266 was retained.
- 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 current quotations from reputable sources.
- The decommissioning activities in NUREG/CR-1266 (Elder and Blahnik 1980) assumed to be unchanged. Information in that document that is unchanged is not repeated in this report.
- Both the immediate dismantlement of the plant (DECON) and the delayed dismantlement after a 10-year period of passive safe storage (SAFSTOR) were reevaluated.
- The impacts of new packaging requirements on low-level radioactive waste disposal costs were taken into consideration in this report.
- The cost update was performed in an automated manner by using the Lotus 3.1 spreadsheet format. A disk with the files of the spreadsheet-developed tables in this report can be obtained from the NRC by licensees to develop their facility-specific decommissioning cost estimates.
- The cost table formats in the previous report are maintained for cost update calculations in this report, with additional columns for the updated cost information. This report is arranged somewhat differently from NUREG/CR-1266 (Elder and Blahnik 1980). The appendix contains a cross reference of table numbers in this report to those in NUREG/CR-1266 (Elder and Blahnik 1980) for easy comparison. In addition, each table in this report identifies the comparable table in NUREG/CR-1266.

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

- To show the high sensitivity of decommissioning costs relative to low-level radioactive waste 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. The evaluation of the cost escalations for DECON is given in Section 3. The cost update for SAFSTOR is presented in Section 4, and the applicability of the algorithm and the results of this report to future cost updates is discussed in Section 5.

2.0 ALGORITHM FOR THE COST UPDATES

Figure 2.1 illustrates the algorithm developed to update the cost estimates for decommissioning of the reference fuel fabrication plant. First, the requirements for staffing, equipment and supplies, and various services identified in the tables in NUREG/CR-1266 (Elder and Blahnik 1980) were reproduced in spreadsheet format. Second, the mid-1978 unit cost items were also entered into spreadsheets, such as 1) the salaries for the work force; 2) the prices for various equipment, tools, and materials; and 3) the services, such as utility, 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 costs, equipment and supplies costs, waste disposal costs, 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.

FIGURE 2.1. Algorithm for Cost Updates for DECON

For certain costs, simple escalation factors were not reasonably applicable. For example, because of the drastic increase in low-level radioactive waste disposal costs in recent years, using escalation factors to calculate the changes in the waste disposal costs could not be justified. Therefore, for these costs, as well as packaging and transportation costs, current price quotes were used. An explanation of the cost updates for each category, whether by quote or by escalation factor, is given later in this section.

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 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-1266 (Elder and Blahnik 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 Table 3.18. The cost updates for SAFSTOR (initial preparations, annual safe storage, and deferred decontamination) are summarized in Tables 4.5, 4.7, and 4.11. These cost summary tables all have the same format: the first column of each table lists the mid-1978 costs for each of the cost categories; the second column shows the costs, escalated to January 1993 dollars; the ratio of the January 1993 cost to the mid-1978 costs is given in the fourth column as the 14.5-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, this number is just the ratio of the composite January 1993 costs to the composite mid-1978 costs. For the staffing and equipment and supplies categories, the January 1993 costs were not available directly and were calculated by escalating mid-1978 costs using the 14.5-year escalation factors 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 14.5-year escalation factor; this factor could be used to predict future near-term cost escalations. Its applicability and limitations are discussed in Section 5.0.

Other tables in this report contain the 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 to the summary tables.

3.0 COST ESTIMATE UPDATE FOR DECON

The cost estimate adjustments were determined by using publications containing U.S. price index trends covering the period between mid-1978 to January 1993. However, current price quotations were used where price trends were not applicable, such as the 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 average escalation rates for the past 13 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) and the Monthly Labor Review, March 1992 edition (Labor 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). The calculation of escalation factors and the determination of the updated costs are described in detail in the following sections.

3.1 COST ESTIMATE UPDATE FOR STAFFING

The Handy-Whitman Index of Public Utility Construction Costs was used to calculate the escalation factor for the staffing costs for the planning and preparation phase, and dismantlement and decontamination phase of the fuel fabrication plant. First, the common labor salary/wages index averaged over the six regions in the United States was calculated for July 1, 1978, and then for July 1, 1991. The ratio of the two average indexes gave an escalation factor of 1.69. To cover the change in the staffing costs from July 1, 1991, to January 1993, an increase of 6% was used based on an annual average escalation of 4% over the past decade. Therefore, the final staffing escalation factor applicable from mid-1978 to January 1993 was estimated to be 1.79.

Table 3.1 shows the unit salaries for the decommissioning staff positions. Table 3.2 gives the updated summary of staffing utilization and 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 pay scale in a similar way and are summarized in Table 3.3.

TABLE 3.1. Unit Salaries for Decommissioning Staff^(a)

1978 Source	Position	Mid-1978 Base Pay/yr (\$)	Overhead Rate, %	Mid-1978 Cost/yr	14.5-Year ^(b) Escalation Factor	January 1993 Cost/Yr (\$) ^(c)
d	Project Manager	43,800	70	74,460	1.79	133,280
d	Project Engineer	37,400	70	63,580	1.79	113,810
e	Health & Safety Supervisor	28,000	70	47,600	1.79	85,200
e	Health Physicist	24,000	50	36,000	1.79	64,440
f	Health Physics Technician	16,800	50	25,200	1.79	45,110
f	Security Force Supervisor	20,000	70	34,000	1.79	60,860
g	Security Patrolman	14,200	50	21,300	1.79	38,130
e	Contracts & Accounting	19,000	70	32,300	1.79	57,820
e	Accountant	16,000	50	24,000	1.79	42,960
e	SNM Accounting Specialist	22,600	70	38,420	1.79	68,770
e	SNM Accounting Clerk	16,000	50	24,000	1.79	42,960
e	Radioactive Shipment Specialist	19,300	70	32,810	1.79	58,730
e	Q. A. Engineer	25,800	70	43,860	1.79	78,510
d	Planning Engineer	25,800	70	43,860	1.79	78,510
e	Engineering Technician	18,000	50	27,000	1.79	48,330
e	Maintenance & Crafts	24,000	70	40,800	1.79	73,030
g	Maintenance Man	17,300	50	25,950	1.79	46,450
e	Custodian	16,000	50	24,000	1.79	42,960
f	Craftsman	18,000	50	27,000	1.79	48,330
d	Operations Supervisor	25,800	70	43,860	1.79	78,510
f	Foreman	21,900	50	32,850	1.79	58,800
f	Technician	18,000	50	27,000	1.79	48,330
e	Secretary	13,500	50	20,250	1.79	36,250

The following sources are referred to in NUREG/CR-1266 (Elder and Blahnik 1980), including the reference letters in the parentheses below.

- (a) Update of Table H.1-1 in NUREG/CR-1266 (Elder and Blahnik 1980).
- (b) Base Salary data has been adjusted from mid-1978 to July 1991 using Whitman et al. (1991) Index of Public Utility Construction Costs, U.S. average. The costs were further escalated to January 1993 values using the average of labor escalation rates over the past 13 years
- (c) Number of figures is for calculational completeness and does not imply accuracy to the number of figures shown.
- (d) U.S. Department of Labor, Bureau of Labor Statistics, Bulletin, March 1975.
- (e) Author's estimate from prior report .
- (f) Hanford Atomic Metal Trades Council pay scales.
- (g) Means (1975).

TABLE 3.2. Summary of Staffing Utilization and Cost for Planning and Preparation Phase of DECON^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost^(b,c,d) (\$)</u>
Project Manager	0.75	99,963
Project Engineer	0.58	66,009
Health & Safety Supervisor	0.25	21,301
Contracts & Accounting Specialist	0.50	28,909
Radioactive Shipment Specialist	0.25	14,682
Q. A. Engineer	0.50	39,255
Planning Engineer	0.58	45,535
Engineering Technician	0.50	24,165
Operations Supervisor	0.50	39,255
Foreman	1.00	58,802
Secretary	<u>1.50</u>	<u>54,371</u>
Total Staff-Years	6.91	
Total Cost		492,246

(a) Update of Table 10.1-2 in NUREG/CR-1266 (Elder and Blahnik 1980).

(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 1.79 to update from mid-1978 dollars to January 1993 dollars.

TABLE 3.3. Summary of Staffing Utilization and Costs for the Dismantlement and Decontamination Phase of DECON^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost^(b,c,d) (\$)</u>
Project Manager	0.83	110,625
Project Engineer	0.83	94,461
Health and Safety Supervisor	0.80	68,163
Health Physics Technician	1.54	69,466
Security Force Supervisor	0.75	45,645
Security Patrolman	3.00	114,381
Contracts & Accounting Specialist	0.80	46,254
SNM Accounting Specialist	0.75	51,579
Radioactive Shipment Specialist	0.75	44,047
Q. A. Engineer	0.83	65,163
Planning Engineer	0.83	65,163
Engineering Technician	0.75	36,248
Maintenance & Crafts Supervisor	0.80	58,426
Custodian	0.75	32,220
Craftsman	4.23	204,436
Operations Supervisor	0.80	62,808
Foreman	3.80	223,446
Technician	24.48	1,183,118
Secretary	<u>1.50</u>	<u>54,371</u>
Total Staff-Years	48.82	
Total Cost		2,630,019

(a) Update of Table 10.1-3 in NUREG/CR-1266 (Elder and Blahnik 1980).

(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 1.79 to update from mid-1978 dollars to January 1993 dollars.

3.2 COST ESTIMATE UPDATE FOR MATERIALS AND EQUIPMENT

The escalation factors for the material and equipment costs for DECON were calculated based on the price index information contained in the 1992 Statistical Abstract of the United States (Commerce 1992) and the March 1992 Monthly Labor Review (Labor 1992). Information obtained from Commerce (1992) was further escalated to January 1993 costs using average annual escalation factors consistent with the prior 14 years of cost increases.

The cost escalation factors for construction machinery and equipment from mid-1978 to January 1993 were estimated to be 1.81. The escalation factor for metal cutting tools was evaluated to be 1.97.

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

TABLE 3.4. Estimated Material and Equipment Requirements and Costs for DECON^(a)

Description	Quantity	January 1993 Estimated Unit Cost (\$) ^(b)	Estimated Total Cost in January 1993 Dollars ^(c,d)
Oxyacetylene Torch	4	1,970	7,864
Guillotine Pipe Saw	2	1,970	3,932
Tube Cutter	2	590	1,179
Ratcheting Pipe Cutter	6	100	589
Reciprocating Saw	4	980	3,932
Nibbler	2	1,810	3,620
High-Velocity Liquid Jet	1	9,050	9,050
Low-Velocity Liquid Jet	2	3,620	7,240
Hydraulic Concrete Surface Spalling Device	1	9,050	9,050
Concrete Drill	3	360	1,086
Electric Pneumatic Hammer	2	910	1,810
Portable A-Frames	2	5,430	10,860
Portable Wash Sinks	2	3,620	7,240
Portable Spray Clean	1	7,240	7,240
Portable Greenhouse Erection Kit	1	3,620	3,620
Portable Powered Brushes	20	270	5,430
HEPA Filter	10	270	2,715
Roughing Filter	100	90	9,050
Decontamination Chemicals			14,530
Cleaning Supplies			30,860
Expendable Tools			18,100
Protective Clothing (incl. laundry)			27,612
Office Supplies:			
Planning and Preparation			18,100
Decommissioning			<u>10,860</u>
Total ^(b)			215,570

(a) Update of Table 10.1-4 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) Unit cost information is calculated in Table 3.5.

(c) Contingency of 25% is not included.

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

TABLE 3.5. Unit Costs for Equipment and Supplies^(a,b,c)

Item	Mid-1978 Est. Unit Cost (\$)	14.5-Year Escalation Factor	Jan. 1993 Unit Cost (\$)
Oxyacetylene Torch	1,000	1.97	1,970
Guillotine Pipe Saw	1,000	1.97	1,970
Tube Cutter	300	1.97	590
Ratcheting Pipe Cutter	50	1.97	100
Reciprocating Saw	500	1.97	980
Nibbler	1,000	1.81	1,810
High-Velocity Liquid Jet	5,000	1.81	9,050
Low-Velocity Liquid Jet	2,000	1.81	3,620
Hydraulic Concrete Surface Spalling Device	5,000	1.81	9,050
Concrete Drill	200	1.81	360
Electric/Pneumatic Hammer	500	1.81	910
HEPA Filter, each	150	1.81	270
Roughing Filter, each	50	1.81	90
Portable A-Frames	3,000	1.81	5,430
Portable Wash Tanks	2,000	1.81	3,620
Portable Greenhouse Erection Kit	2,000	1.81	3,620
Portable Spray Cleaning Booth	4,000	1.81	7,240
Hand-Powered Brushes	150	1.81	270
Soap (per thousand kg)	200	1.543	310
Freon (per thousand liters)	2,000	1.453	2,910

(a) Update of Table H.1-6 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) Contingency of 25% is not included.

3.3 COST ESTIMATE UPDATE FOR UTILITIES

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).

For the purposes of comparison, two different utility escalation factors were calculated: one based on a point-to-point ratio for the mid-1978 and January 1993 energy costs, and the other based on a linear regression of energy costs over the past 14 years.

The results of the two different analyses for updating energy costs are recorded in Table 3.6. Because of extraneous circumstances, the point-to-point ratio method actually shows a composite utility escalation factor of almost two. 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 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 1.09 was calculated. The escalation factor for all utilities was assumed to be the same as that estimated for energy requirements.

TABLE 3.6. Escalation Factors for Energy Costs

	Point-to-Point Mid-1978 to Mid-1991	Regression Curve Mid-1978 to January 1993
Escalation Factor, Electricity	1.67	1.29
Escalation Factor, Natural gas	1.93	1.08
Escalation Factor, No. 2 Distillate	<u>1.90</u>	<u>0.90</u>
Composite Energy Costs Escalation Factor	1.83	1.09

TABLE 3.7. Estimated Miscellaneous Owner Expenses For DECON^(a)

Cost Category	Mid-1978 Cost (\$)	Escalation Factor	January 1993 Cost (\$) ^(b,c)
Utilities	250,000	1.09	272,500
Taxes ^(d)	160,000	3.18	509,056
Inspections and License Amendments ^(e)	70,000	1.55	108,576
Insurance ^(d)	<u>250,000</u>	0.94	<u>236,075</u>
Total	730,000		1,126,207

(a) Update of Table 10.1-8 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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.

(d) Memo, R. Bratlee and S. Hungerford, Finance Office, General Electric Co., Wilmington, North Carolina, to K. J. Schneider, PNL. May 13, 1992.

(e) Based on a 1984 cost quote. Inspections and License Amendments were assumed to be primarily staffing charges so the 1984 value (obtained from Smith et al. 1985) was escalated to January 1993 dollars by a 8.5-year labor cost escalation factor. This does not necessarily reflect NRC's policy of full cost recovery.

3.4 COST ESTIMATE UPDATE FOR WASTE MANAGEMENT

Two different sources of 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 fabrication plant, and buried at the waste disposal site. Second, the large quantities of chemical residuals generated in the manufacturing process, such as contaminated chemical sludge and CaF₂ sludge, have to be treated and disposed of in some way.

The waste management costs can be 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 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 are described in detail. For each of the three categories, costs were not escalated according to price index information but according to contemporary cost quotes. This is because of the recent rapid escalation in waste disposal costs.

TABLE 3.8. Estimated Waste Management Costs for DECON^(a)

Waste Category	Costs in January 1993 Dollars ^(b,c)					
	Container	Transportation	U.S. Ecology Facility		Chem-Nuclear Facility	
			Burial	Total	Burial	Total ^(a)
<u>To Low-Level Waste Burial:</u>						
Hoods, Equipment & Components	181,369	21,960	1,096,185	1,299,515	7,569,556	7,772,885
Pipe, Conduits, Ducts, etc.	28,121	8,540	169,963	206,624	1,173,657	1,210,319
HEPA & Roughing Filters	12,257	1,220	74,083	87,560	511,569	525,046
Concrete Rubble	5,139	2,440	56,874	64,453	392,738	400,316
Contam. Liner & Soil Materials	21,592	6,100	130,498	158,190	901,138	928,829
Miscellaneous	1,620	1,220	17,926	20,765	123,783	126,622
Miscellaneous	<u>2,966</u>	<u>1,220</u>	<u>17,926</u>	<u>22,111</u>	<u>123,783</u>	<u>127,969</u>
Total	253,063	42,700	1,563,455	1,859,219	10,796,222	11,091,986

(a) Update of Table 10.1-6 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) Number of figures is for computational completeness and does not imply accuracy to the number of figures shown. Costs are escalated from 1978 values given in NUREG/CR-1266 (Elder and Blahnik 1980).

(c) Contingency of 25% is not included.

There are three general alternatives in managing the chemical and CaF₂ sludges:

- Recover the enriched uranium and HF from CaF₂ and chemical sludge
- Ship to low-level burial site
- Decontaminate and store in lagoons at the plant site.

The first option is the one assumed in NUREG/CR-1266, which resulted in essentially zero net disposal costs. The second option is the alternative case in NUREG/CR-1266. The third option was not evaluated because it was deemed to be unacceptable. These options are discussed in Section 3.4.4.

TABLE 3.9. Details of Estimated January 1993 Costs for Radioactive Waste Management for DECON^(a,b,c,d)

Waste Category	Shipping Wt. (kg)	Shipping ^(e) Vol. (m ³)	Type of Container	No. of Shipments	Total Packaging Cost (\$)	Basic Transp. Cost (\$)	GVW (Mg)	Overweight Cost \$/Mile	Overweight Charge (\$)	Total Transp. Cost (\$)	Burial Cost (\$)	Total Waste Management Cost (\$)
TO LOW-LEVEL WASTE BURIAL												
Hoods, Equip. & Component	314,800	764.40	Steel Boxes	18	181,369	21,960	30.19	0.00	0	21,960	1,096,185	1,299,515
Pipe, Conduit, Duct, Trays, Fixtures, etc.	133,200	118.52	Steel Boxes	7	28,121	8,540	31.73	0.00	0	8,540	169,963	206,624
HEPA & Roughing Filters	16,500	51.66	Steel Boxes	1	12,257	1,220	29.20	0.00	0	1,220	74,083	87,560
Concrete Rubble	23,800	39.66	Steel Drums	2	5,139	2,440	24.60	0.00	0	2,440	56,874	64,453
Contaminated Liner & Soil Material	63,600	91.00	Steel Boxes	5	21,592	6,100	25.42	0.00	0	6,100	130,498	158,190
Miscellaneous	17,400	12.50	Steel Drums	1	1,620	1,220	30.10	0.00	0	1,220	17,926	20,765
Miscellaneous	9,100	12.50	Steel Boxes	1	2,966	1,220	21.80	0.00	0	1,220	17,926	22,111
Totals	578,400	1,090.24		35	253,063					42,700	1,575,705	1,859,219

(a) Update of Table H.2-5 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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 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 Appendix B of NUREG/CR-1266 (Elder and Blahnik 1980).

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 reinforced plywood boxes NUREG/CR-1266 (Elder and Blahnik 1980). Table 3.10 lists January 1993 prices paid for the waste disposal containers (Konzek et al. 1993).

TABLE 3.10. Shipping Containers Used in this Study^(a)

<u>Shipping Containers</u>	<u>1978 Estimated Unit Cost (\$)</u>	<u>January 1993 Unit Cost (\$)</u>
208-l Steel Drum	20	26.95 ^(b)
Plywood Box	50/m ³	NA
Steel Box	NA	237.27/m ^{3(c)}

(a) Update of Table H.1-2 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) 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 low-level radioactive waste 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 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.

TABLE 3.11. Basic Transportation Rates for Legal Size and Weight Shipments in Effect 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	302	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 B.3-1 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) Table taken from Tri-State Motor Transit Co., Docket No. MC-10937. Effective September 19, 1992 (Tri-State 1993).

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

(d) Column 2 rates apply only to continuous excursion moves in which a subsequent shipment is made available to the 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^(a,b,c)

Gross Vehicle Weight (Mg)		Base Surcharge (\$/mi)	Additional Surcharge (\$/mi)	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 B.3-2 in NUREG/CR-1266 (Elder and Blahník 1980).

(b) In addition to the charges shown in the table, a flat charge of \$30.00 per shipment is levied.

(c) From Tri-State (1993) for the State of Washington.

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 estimated. The low cost estimate is based on "Washington Nuclear Center Schedule of Disposal Charges" for in-compact burial of radioactive material at their 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 additional fees, surcharges, and taxes that are summarized in Table 3.13, Part II. These total 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.

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

Part II^(a)

**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 in effect as of February 9, 1993, at the U.S. Ecology facility at Richland, Washington (Ecology 1993).

(b) Update of Table B.4-1 in NUREG/CR-1266 (Elder and Blahnik 1980).

(c) Maximum reading at container surface, irrespective of physical size or configuration.

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 of \$59/ft³ for "standard waste", a surcharge for containers that weigh more than 1,000 pounds, an "excess curie surcharge" of \$4,150 per 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.

TABLE 3.14. Barnwell Low-Level Radioactive Waste Management Facility Rate Schedule^(a,b)

<u>Base Disposal Charges</u>	
Standard Waste	59 \$/ft ³
Biological Waste	61 \$/ft ³
SNM	59 \$/ft ³
<u>Surcharges</u>	
<u>Weight of Container</u>	<u>Surcharge per container</u>
0 to 1,000 lbs	No Surcharge
1,001 to 5,000 lbs	\$675.00
5,001 to 10,000 lbs	\$1,200.00
10,001 to 20,000 lbs	\$1,685.00
20,001 to 30,000 lbs	\$2,170.00
30,001 to 40,000 lbs	\$3,185.00
40,001 to 50,000 lbs	\$4,185.00
greater than 50,000 lbs	By Special Request
<u>Curie Content per Shielded Shipment</u>	<u>Surcharge per Shielded Shipment</u>
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) Chem-Nuclear (1993).

(b) Effective January 1, 1993.

3.4.4 Alternative Waste Management Costs

In NUREG/CR-1266 (Elder and Blahnik 1980), as in this cost update, it was assumed that the CaF_2 and chemical sludges were processed by a contractor to recover the uranium, and the credit for the uranium value compensated for the processing and subsequent waste management costs. Thus, no costs are allocated for this option. An alternative to disposal of the CaF_2 and chemical sludges as low-level waste was evaluated in NUREG/CR-1266 and in this cost update.

The alternative waste management costs are summarized in Table 3.15. A detailed explanation of the calculations for the costs associated with contaminated CaF_2 disposal was given in Appendix H.4 of NUREG/CR-1266 (Elder and Blahnik 1980). These cost estimates are updated in the same manner described previously (escalation factors for the staffing and material costs and contemporary cost analysis for waste packaging, transport, and disposal). The charges for the alternatives to CaF_2 disposal are summarized in Table 3.15. Composite 14.5-year escalation factors of 1.415, 1.180, and 15.309 were calculated from the ratios of the January 1993 costs to the mid-1978 costs for packaging, transportation, and burial costs (at Richland, Washington), respectively. These factors were then applied to each cost category to update the chemical sludge and miscellaneous contaminated material costs. As shown in Table 3.15, the alternative waste disposal costs, including contingency, are almost \$63 million for in-compact disposal at the Richland, Washington, facility. The alternative waste disposal costs, including contingency, for out-of-compact disposal at the Barnwell, South Carolina, facility are estimated to exceed \$377 million.

The concentration of uranium in 29,600 m^3 or 38,000 MT of CaF_2 is 2%. The recoverable uranium is thus 76 MT, which is equivalent to 197,100 lb of U_3O_8 . Assuming a price of \$8.00/lb U_3O_8 , uranium credit would be \$11.1 million. The separative work for enriching 76 MT of natural uranium to an enrichment of 3.2% with 0.3% ^{235}U in the tails is estimated to be 287,620 SWU. At \$100/SWU, the enrichment credit of the recovered uranium is about \$28.8 million. Therefore, a total value of \$39.9 million could be gained by recovering the enriched uranium from CaF_2 . In addition, an estimated 6,320 MT of HF could be recovered from CaF_2 residuals. Assuming a price of \$35/lb (the unit purchase price of anhydrous HF at the Department of Energy's Hanford facility), the recovered HF would have a value of \$49.4 million.

TABLE 3.15. Alternative Waste Management Costs for Low-Level Waste Burial Disposal^(a,b)

Waste Category	Cost in January 1993 Dollars ^(c)							
	Richland, WA			Contingency	Richland, WA		Barnwell, SC	
	Packaging	Transportation	Burial		Total	Burial	Contingency	Total
Chemical Sludge	155,694	106,224	1,837,038	524,739	2,623,694	12,685,409	3,236,831	16,184,157
Contaminated CaF ₂	3,929,139	2,427,800	36,235,570	10,648,127	53,240,636	205,219,683	64,144,156	320,720,778
Misc. Contaminated Material	552,004	318,671	4,592,594	1,365,817	6,829,087	31,713,521	8,146,049	40,730,246
Total Alternative Waste Management Cost					62,693,417			377,635,181

(a) Update of Table 10.1-7 in NUREG/CR-1266 (Elder and Blahník 1980).

(b) Contingency of 25% is not included.

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

TABLE 3.16. Cost Assessment for Contaminated CaF_2 Disposal at LLW Burial Ground

<u>Item</u>	<u>Waste Disposal at Richland, WA Cost^(a,b,c)</u>	<u>Waste Disposal at Barnwell, SC Cost^(a,b,c)</u>
<u>Packaging Costs A - Loading into Containers</u>		
Staffing		
Technicians (6 staff-years)	289,980	289,890
Health Physics Technician (1 staff-year)	45,108	45,108
Foreman (1 staff-year)	58,802	58,802
Equipment Lease	325,800	325,800
Supplies <u>45,250</u>	<u>45,250</u>	
Total Loading Cost	<u>\$764,940</u>	<u>\$764,940</u>
<u>Packaging Costs B - Container Costs</u>		
Weight per Load (Mg)	19.08	19.08
Number of Truck Loads	1,990	1,990
Number Drums per Load	59	59
Purchase Cost per Drum	26.95	26.95
Total Container Costs ^(d)	3,164,200	3,164,200
Total Packaging Cost ^(d)	<u>\$3,929,139</u>	<u>\$3,929,139</u>
<u>Total Transportation Cost Estimate</u>		
Transport Cost per Mile	2.44	2.44
Total Miles	500	500
Number of Truck Loads	1,990	1,990
One Way Basic Charges, all Shipments	2,427,800	2,427,800
Extra-Weight Charge per Mile	0.00	0.00
Extra-Weight Charge	0	0
Total Transportation	<u>\$2,427,800</u>	<u>\$2,427,800</u>
<u>Burial Fees</u>		
Number of Truck Loads	1,990	1,990
Number Drums per Load	59	59
Ft ³ per Drum	7.6	7.6
Cost per Ft ³	38.13	280.42
Total Burial Fee	<u>\$36,235,570</u>	<u>\$250,219,683</u>

(a) Units are in dollars unless otherwise stated.

(b) 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.

(d) The total packaging costs for shipping the contaminated CaF_2 consist of the loading costs (A) and the container costs (B).

3.5 ESTIMATE OF MISCELLANEOUS OWNER'S EXPENSES

The licensing fee was estimated based on a value of \$88,000 for 1984 given in Smith et al. (1985). To further update the licensing fee to the January 1993 level, an 8.5-year labor escalation factor of 1.22 was used. (Note that this may 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 referenced in Table 3.7.

3.6 ESTIMATE OF SPECIAL CONTRACTOR COSTS

Specialized services to complete the DECON for the fuel fabrication plant include the excavation and refill of the pipe trenches, and the reclamation of the waste treatment lagoons. The costs are updated in Table 3.17.

3.7 SUMMARY OF COST ESTIMATE UPDATES FOR DECON

The updated costs for the DECON of the reference fuel fabrication plant are summarized in Table 3.18. As shown in Table 3.18, the total decommissioning cost has increased from \$3.57 million to over \$8.08 million, with in-compact radioactive waste disposal at the U.S. Ecology facility near Richland, Washington, from mid-1978 to January 1993. The disposal cost of radioactive wastes experienced a dramatic increase in recent years, climbing from less than \$0.2 million to over \$1.8 million. Radioactive material disposal in this updated estimate accounts for over 32% of the total DECON cost compared with just 7% in mid-1978. Out-of-compact radioactive waste disposal costs at the Chem-Nuclear facility near Barnwell, South Carolina, are almost \$20 million, with nearly three-quarters of the total decommissioning costs committed to waste disposal.

The possible additional waste management costs of burying all contaminated chemical and CaF_2 sludges, and contaminated equipment and materials, at the in-compact low-level radioactive waste disposal facility near Richland, Washington, were estimated to be \$62.7 million in 1993. These charges rise for out-of-compact radioactive waste disposal at the Barnwell facility to over \$390 million.

TABLE 3.17. Subcontractor Costs for Reclamation of the Waste Treatment Lagoons for DECON^(a)

Activity	No. of Units	Mid-1978 (\$/Unit)	Mid-1978 Costs (\$)	Escal. Factor	Jan. 1993 (\$/Unit)	January 1993 Costs (\$) ^(b,c)
Excavation	3,800 (m ³)	1.30	4,940	3.285	\$4.27 ^(d)	\$16,226
Puncturing of Liners	15,900 (m ²)	0.10	1,590	1.720	0.17 ^(e)	2,735
Backfilling	38,900 (m ³)	0.50	19,450	2.200	1.10 ^(f)	42,790
Grader Rental	4 (wk)	500.00	2,000	3.260	1,630.00 ^(g)	6,520
Dump Truck Rental	4 (wk)	500.00	2,000	1.880	940.00 ^(h)	3,760
Loader Rental	4 (wk)	1,000.00	4,000	2.750	2,750.00 ⁽ⁱ⁾	11,000
Foreman	4 (wk)	900.00	3,600	1.720	1,548.00 ^(e)	6,192
Equipment Operators	8 (wk)	750.00	6,000	1.720	1,290.00 ^(e)	10,320
Laborers	8 (wk)	550.00	4,400	1.720	946.00 ^(e)	7,568
Grade, Seed, Fertilize	15,900 (m ²)	0.80	12,720	2.325	1.86 ^(j)	29,574
Total			60,700			136,685

(a) Update of Table 10.1-9 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) Contingency of 25% is not included.

(d) Means 1993 (Identification no. 022-242-4400).

(e) January 1993 value calculated by using labor escalation factor.

(f) Means 1993 (Identification no. 022-204-1300).

(g) Means 1993 (Identification no. 016-408-1860).

(h) Means 1993 (Identification no. 016-408-5250).

(i) Means 1993 (Identification no. 016-408-4530).

(j) Means 1993 (Identification no. 029-304-310).

TABLE 3.18

Summary of Estimated DECON Costs^(a,b)

Cost Category	1978 ^(c) Estimated Cost (Million \$)	Disposal at Richland, WA			Disposal at Barnwell, SC		
		1993 Estimated Cost (Million \$)	Percent of Total	14.5-Year Escalation Factor	1993 Estimated Cost (Million \$)	Percent of Total	14.5-Year Escalation Factor
Disposal of Radioactive Material	0.192	1.859	32.5	9.682	11.092	74.2	57.761
Staffing							
Planning and Preparation	0.275	0.492	8.6	1.790	0.492	3.3	1.790
Decommissioning	1.469	2.630	46.0	1.790	2.630	17.6	1.790
Equipment and Supplies	0.126	0.216	3.8	1.711	0.216	1.4	1.711
Specialty Contractors	0.061	0.137	2.4	2.252	0.137	0.9	2.252
License Fees	0.070	0.109	1.9	1.551	0.109	0.7	1.551
Total Labor/Matl. Costs	2.001	3.583	62.7	1.791	3.583	24.0	1.790
Energy	0.250	0.273	4.8	1.090	0.273	1.8	1.090
Total Labor/Energy/Disposal Costs	2.443	5.715	100.0	2.339	14.948	100.0	6.119
25% Contingency	0.611	1.426			3.737		
Adjusted Cost with Contingency	3.054	7.144			18.684		
Nuclear Insurance with Contingency	0.513	0.931		1.817	0.931		1.817
Total DECON Cost	3.566	8.075		2.264	19.616		5.500
Other Possible Waste Management Costs							
Chemical Sludge Disposal	0.320	2.099		6.559	12.947		40.460
Contaminated CaF ₂ Disposal	7.192	42.593		5.922	256.577		35.674
Misc. Contaminated Material	0.960	5.463		5.691	32.584		33.942
Subtotal	8.472	50.155			302.108		
25% Contingency	2.118	12.539			75.527		
Total other Possible Waste Management Costs	10.590	62.693		5.920	377.635		36.659

(a) Update of Table 10.1-1 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) Values in NUREG/CR-1266 (Elder and Blahnik 1980).

4.0 COST ESTIMATE UPDATE FOR SAFSTOR

The cost estimates were updated for the passive safe storage (SAFSTOR) of the reference uranium fuel fabrication 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 are 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 consist of staffing, materials and equipment, owner's expenses, and special contractor costs.

4.1.1 Costs for Staffing

The staffing requirements and 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.

TABLE 4.1. Summary of Staffing Utilization and Costs for the Planning and Preparation Phase of Safe Storage^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost^(b,c,d) (\$)</u>
Project Manager	0.5	66,600
Project Engineer	0.5	56,500
Health and Safety Supervisor	0.25	21,300
Contracts and Accounting Specialist	0.25	14,500
Q.A. Engineer	0.38	29,800
Radioactive Shipment Specialist	0.25	14,700
Operations Supervisor	0.25	19,600
Maintenance and Crafts Supervisor	0.25	18,300
Secretary	<u>0.5</u>	<u>18,100</u>
Total Staff-Years	3.13	
Total Cost		259,800

(a) Update of Table 10.2-2 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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.

(d) Includes escalation factor of 1.79 from mid-1978 dollars to January 1993 dollars.

TABLE 4.2. Summary of Staffing Utilization and Staff for the Decommissioning Phase of Preparations for Safe Storage^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost (b,c,d) (\$)</u>
Project Manager	0.25	33,300
Project Engineer	0.25	28,500
Health & Safety Supervisor	0.25	21,300
Health Physics Technician	0.35	15,800
Security Force Supervisor	0.25	15,200
Security Patrolman	0.70	26,700
Contracts & Accounting Specialist	0.25	14,500
SNM Accounting Specialist	0.17	11,700
QA Engineer	0.35	27,500
Radioactive Shipment Specialist	0.17	10,000
Maintenance & Crafts Supervisor	0.25	18,300
Custodian	0.17	7,300
Craftsman	0.67	32,400
Operations Supervisor	0.25	19,600
Technician	0.75	36,200
<u>Secretary</u>	<u>0.25</u>	<u>9,100</u>
Total Staff-Years	5.33	
Total Cost		327,300

(a) Update of Table 10.2-3 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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.

(d) Includes escalation factor of 1.79 to update dollars from mid-1978 to January 1993.

4.1.2 Costs for Materials and Equipment

The update of the equipment and supply costs for SAFSTOR preparations is presented in Table 4.3.

TABLE 4.3. Estimated Costs of Equipment and Supplies for Preparations for Safe Storage^(a)

<u>Description</u>	<u>Mid-1978 Estimated Total Cost (b) (\$)</u>	<u>Escalation Factor</u>	<u>January 1993 Estimated Total Cost (\$)</u>
Decontamination Chemical	1,000	1.453	1,453
Cleaning Supplies	2,000	1.543	3,086
Expendable Tools	2,000	1.81	3,620
Protective Clothing	4,000	1.53	6,136
Intrusion Alarm System ^(c)	100,000	1.81	181,000
Miscellaneous	5,000	1.81	9,050
Office Supplies			
Planning & Preparation	4,000	1.81	7,240
Decommissioning	<u>2,000</u>	<u>1.81</u>	<u>3,602</u>
Total	120,000 ^(d)		215,205 ^(d)

(a) Update of Table 10.2-4 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) Contingency of 25% is not included.

(c) An cost of intrusion alarm system at the decommissioned plant is included as an equipment item in Table 4.3. The cost of installing and testing the system by an outside contractor was estimated at \$15,000 without contingency in mid-1978; the escalation of this cost in Table 4.5 was calculated by using the staffing escalation factor of 1.79.

(d) Total is addition of prior numbers to retain calculational information; precision less than shown.

4.1.3 Owner's Expenses

Table 4.4 gives the updated owner's expenses during the preparation stage for SAFSTOR.

4.1.4 Specialty Contractor Costs

Specialized services required to prepare the reference plant for SAFSTOR are assumed to be supplied by the specialty contractor.

TABLE 4.4. Estimated Miscellaneous Owner Expenses During Preparations for Safe Storage^(a)

<u>Cost Category</u>	<u>Mid-1978 Cost (\$)^(b,c)</u>	<u>Escalation Factor</u>	<u>January 1993 Cost (\$)^(a,b)</u>
Utilities	56,000	1.09	61,000
Taxes ^(d)	36,000	2.94	105,800
Regulatory Fees ^(e)	70,000	1.55	108,600
Insurance ^(d)	<u>56,000</u>	0.95	<u>53,200</u>
Total	218,000		337,000

(a) Update of Table 10.2-5 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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

(d) Memo, R. Bratlee and S. Hungerford, Finance Office, General Electric Co., Wilmington, North Carolina, to K.J. Schneider, PNL. May 13, 1992.

(e) Based on 1984 cost in Smith et al. (1985). Inspections and License Amendments were assumed to be essentially staffing charges, so the value was escalated to January 1993 dollars by a 8.5-year labor cost escalation factor. This does not necessarily reflect NRC's policy for full cost recovery.

4.1.5 Summary of Cost Updates for the Preparations for SAFSTOR

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

TABLE 4.5. Summary of Estimated Costs of Preparations for Safe Storage^(a,b)

Cost Category	1978 ^(b)	Disposal at Richland, WA			Disposal at Barnwell, SC		
	Estimated Cost (Million \$)	Estimated Cost (Million \$)	Percent of Total	14.5-Year Escalation Factor	Estimated Cost (Million \$)	Percent of Total	14.5 Year Escalation Factor
Disposal of Radioactive Material	0.000	0.000	0.0	-----	0.000	0.0	-----
Staffing							
Planning and Preparation	0.145	0.260	22.3	1.790	0.260	22.3	1.790
Decommissioning (5 yr)	0.183	0.327	28.0	1.790	0.327	28.0	1.790
Specialty Contractors ^(d)	0.015	0.027	2.3	1.800	0.027	2.3	1.800
License Fees	0.070	0.109	9.3	1.551	0.109	9.3	1.551
Equipment and Supplies	0.120	0.215	18.4	1.790	0.215	18.4	1.790
Energy	0.056	0.061	5.2	1.090	0.061	5.2	1.090
Nuclear Insurance	0.092	0.167	14.3	1.815	0.167	14.3	1.815
Subtotal	0.681	1.166	100.0		1.166	100.0	
Contingency (25%)	0.170	0.292			0.292		
Total Cost of Preparation Safe Storage	0.851	1.458		1.713	1.458		1.713

(a) Update of Table 10.2-1 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) Values in NUREG/CR-1266.

(d) Used labor escalation factor (1.79) for installation of the intrusion alarm system.

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 fuel fabrication 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 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.

4.2.1 Costs for Staffing

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

TABLE 4.6. Estimated Annual Staff Requirements for Safe Storage^(a,b)

<u>Title or Function</u>	<u>Staff-Yrs/Yr</u>	<u>Jan. 1993 Annual Cost (\$/Yr)^(b,c)</u>	<u>Escalation Factor</u>	<u>Annual Cost 1991 Dollars</u>
Facility Manager	1.00	63,600	1.79	113,844
Maintenance and Operation	1.00	25,900	1.79	46,361
Secretary	0.50	10,125	1.79	18,124
Third-Party Inspection Team ^(d)	<u>0.03</u>	<u>4,000</u>	1.79	7,160
Total Staff-Years/Year	2.53			
Total Costs/Year		103,625		185,489

(a) Update of Table 10.3-2 in NUREG/CR-1266 (Elder and Blahnik 1980).

(b) 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.

(d) Third-party inspection costs are based on an assumed \$500 per staff-day for mid-1978.

4.2.2 Costs for Security and Surveillance

The annual cost for security and surveillance has been escalated from \$50,000 to \$89,500, using the staffing cost escalation factor of 1.79.

4.2.3 Costs for Materials, Equipment, and Repairs

The annual allowance of \$2,000 for equipment and supplies is updated to \$3,600 by applying an escalation factor of 1.59. The annual allowance of \$3,000 for major equipment repairs is updated to \$5,400 based on an escalation factor of 1.79.

4.2.4 Owner's Expenses

Miscellaneous owner's expenses during the safe storage period include the costs for utilities, taxes, regulatory fees, and insurance.

The total cost for utilities is updated from \$25,000 to \$27,300 based on the escalation factor of 1.09 for energy resources.

The tax and insurance expenses are updated using the escalation factors developed for DECON in Section 3.5 (see Table 3.7).

Regulatory fees are updated using the method described in Table 4.4.

4.2.5 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 plant in January 1993 dollars is \$484,100, compared with \$282,500 in mid-1978.

TABLE 4.7. Estimated Annual Costs of the Safe Storage Period^(a)

Cost Category	1978 ^(b,c)	Disposal at Richland, WA			Disposal at Barnwell, SC		
	Estimated Cost (Dollars \$)	Estimated Cost (Dollars \$)	Percent of Total	14.5-Year Escalation Factor	Estimated Cost (Dollars \$)	Percent of Total	14.5-Year Escalation Factor
Staff Labor	104,000	185,500	47.9	1.784	185,000	47.9	1.784
Supplies and Equipment	2,000	3,600	0.9	1.810	3,600	0.9	1.810
Security Contractor	50,000	89,500	23.1	1.790	89,500	23.1	1.790
Annual Allowance for Repairs	3,000	5,400	1.4	1.790	5,400	1.4	1.790
Utilities	25,000	27,300	7.0	1.090	27,300	7.0	1.090
Taxes	16,000	50,900	13.1	3.182	50,900	13.1	3.182
Insurance	25,000	23,600	6.1	0.944	23,600	6.1	0.944
Regulatory Fees	1,000	1,600	0.4	1.551	1,600	0.4	1.551
Subtotal	226,000	387,300	100.0		387,300	100.0	
25% Contingency	56,500	96,800			96,800		
Total Annual Cost	282,500	484,100		1.714	484,100		1.714

(a) Update of Table 10.3-1 in NUREG/CR-1266 (Elder and Blahník 1980).

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

(c) From NUREG/CR-1266.

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 for deferred decontamination is given in Table 4.8. The update of the staffing costs for deferred decontamination is presented in Table 4.9. The escalation factor used in the staffing cost updates is 1.79.

4.3.2 Costs for Materials and Equipment

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

4.3.3 Waste Management Costs

The January 1993 deferred decontamination waste management cost estimates are the same as for immediate DECON of the fuel fabrication plant, namely, \$1.857 million for in-compact disposal at the Richland, Washington, facility and \$11.589 million for out-of-compact disposal at the Barnwell, South Carolina, facility.

4.3.4 Total Costs for Deferred Decontamination

The updated total costs for deferred decontamination are presented in Table 4.11. They strongly 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 increased by a factor of 2.29 from \$3.84 million in mid-1978 to \$8.79 million for in-compact disposal (i.e., in the Northwest and Rocky Mountain compacts) at the Richland, Washington, facility. January 1993 deferred decontamination costs for out-of-compact disposal at the Barnwell, South Carolina, facility have risen by a factor of 5.29 from \$3.84 million to \$20.33 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 30% of the total estimated costs with in-compact disposal at the Richland Washington, facility and 72% of the total estimated costs with out-of-compact disposal at the Barnwell, South Carolina, facility compared to just 6.4% in 1978.

TABLE 4.8. Summary of Staffing Utilization and Costs for Planning and Preparation Phase of Deferred Decontamination^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost^(b,c,d) (\$)</u>
Project Manager	1.00	133,300
Project Engineer	0.75	85,400
Health and Safety Supervisor	0.67	57,100
Contracts and Accounting Specialist	0.67	38,700
Radioactive Shipment Specialist	0.38	22,300
Q.A. Engineer	0.67	52,600
Planning Engineer	0.67	52,600
Engineering Technician	0.67	32,400
Maintenance and Crafts Supervisor	0.67	48,900
Operations Supervisor	0.67	52,600
Foreman	1.50	88,200
Technician (training)	2)	96,700
Craftsman (training)	0.30	14,500
<u>Secretary</u>	<u>1.50</u>	<u>54,400</u>
Total Staff-Years	12.12	
Total Cost		829,600

(a) Update of Table 10.4-2 in NUREG/CR-1266 (Elder and Blahnik 1980).

(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 1.79 to update from mid-1978 dollars to January 1993 dollars.

TABLE 4.9. Summary of Staffing Utilization and Costs for
Decommissioning Phase of Deferred Decontamination^(a)

<u>Title or Function</u>	<u>Staff-Years</u>	<u>January 1993 Cost^(b,c,d) (\$)</u>
Project Manager	0.83	110,600
Project Engineer	0.83	94,500
Health and Safety Supervisor	0.80	68,200
Health Physics Technician	1.54	69,500
Security Force Supervisor	0.83	50,500
Security Patrolman	3.00	114,400
Contracts and Accounting Specialist	0.80	46,300
SNM Accounting Specialist	0.75	51,600
Radioactive Shipment Specialist	0.75	44,000
Q.A. Engineer	0.83	65,200
Planning Engineer	0.83	65,200
Engineering Technician	0.75	36,200
Maintenance and Crafts Supervisor	0.80	58,400
Custodian	0.75	32,200
Craftsman	4.23	204,400
Operations Supervisor	0.80	62,800
Foreman	4.00	235,200
Technician	25.09	1,212,600
Secretary	<u>1.50</u>	<u>54,400</u>
Total Staff-Years	49.71	
Total Cost		2,676,100

(a) Update of Table 10.4-3 in NUREG/CR-1266 (Elder and Blahnik 1980).

(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 1.79 to update from mid-1978 to January 1993 dollars

TABLE 4.10. Estimated Material and Equipment Requirements and Costs for Deferred Decontamination^(a)

Description	Quantity	Estimated Unit Cost (\$) ^(b)	Estimated Total Cost in January 1993 Dollars ^(c)
Oxyacetylene Torch	4	1,966	7,860
Guillotine Pipe Saw	2	1,966	3,930
Tube Cutter	2	590	1,180
Ratcheting Pipe cutter	6	98	590
Reciprocating Saw	4	983	3,930
Nibbler	2	1,810	3,620
High-Velocity Liquid Jet	1	9,050	9,050
Low-Velocity Liquid Jet	2	3,620	7,240
Hydraulic Concrete Surf. Spalling Device	1	9,050	9,050
Concrete Drill	3	362	1,090
Electric/Pneumatic Hammer	2	905	1,810
Portable A-Frames	2	5,430	10,860
Portable Wash Tanks	2	3,620	7,240
Portable Spray Clean Booth	1	7,240	7,240
Portable Greenhouse Erection Kit	1	3,620	3,620
Hand Powered Brushes	20	272	5,430
HEPA Filter	10	272	2,720
Roughing Filter	100	91	9,050
Decontamination Chemicals			14,530
Cleaning Supplies			30,860
Expendable Tools			18,100
Protective Clothing (including laundry)			27,610
Office Supplies			
Planning and Preparation			21,720
Dismantlement			10,860
Total			219,190 ^(d)

(a) Update of Table 10.4-4 in NUREG/CR-1266 Elder and Blahnik 1980).

(b) Includes escalation factors listed in Table 3.17 from mid-1978 dollars to January 1993 dollars.

(c) Contingency of 25% is not included.

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

TABLE 4.11. Summary of Estimated Deferred Decontamination Costs^(a,b)

Cost Category	1978 ^(c) Estimated Cost (Million \$)	Disposal at Richland, WA			Disposal at Barnwell, SC		
		1993 Estimated Cost (Million \$)	Percent of Total	14.5-Year Escalation Factor	1993 Estimated Cost (Million \$)	Percent of Total	14.5-Year Escalation Factor
Disposal of Radioactive Material	0.197	1.859	29.6	9.438	11.092	71.5	56.304
Staffing							
Planning and Preparation	0.462	0.830	13.2	1.790	0.830	5.3	1.790
Decommissioning	1.495	2.676	42.6	1.790	2.676	17.2	1.790
Equipment and Supplies	0.128	0.219	3.5	1.712	0.219	1.4	1.712
Specialty Contractors	0.061	0.137	2.2	2.241	0.137	0.9	2.241
License Fees	0.070	0.109	1.7	1.551	0.109	0.7	1.551
Total Labor/Matl. Costs	2.216	3.970	63.1	1.792	3.970	25.6	1.792
Energy	0.250	0.458	7.3	1.832	0.458	3.0	1.832
Total Labor/Energy/Disposal Costs	2.663	6.287	100.0	2.361	15.520	100.00	5.828
25% Contingency	0.666	1.572			3.886		
Adjusted Cost with Contingency	3.329	7.859			19.400		
Nuclear Insurance with Contingency	0.513	0.931		1.815	0.931		1.815
Total Deferred Decontamination Cost	3.842	8.790		2.288	20.331		5.292
Other Possible Costs							
Chemical Sludge Disposal	0.320	2.099		6.559	12.947		40.460
Contaminated CaF ₂ Disposal	7.200	42.593		5.916	256.577		35.636
Misc. Contaminated Material	0.960	5.463		5.691	32.584		33.942
Subtotal	8.480	50.155			102.108		
25% Contingency	2.120	12.539			75.527		
Total Decommissioning Costs	10.600	62.693		5.914	377.635		35.626

(a) Update of Table 10.4-1 in NUREG/CR-1266 (Elder and Blahnik 1980).

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

(c) Values in NUREG/CR-1266.

4.4 UPDATE OF TOTAL COST ESTIMATES FOR 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 4.12. As shown in Table 4.12, the total costs, with radioactive waste disposal at the U.S. Ecology facility near Richland, Washington, have increased from \$7.52 million in mid-1978 to \$15.32 million in January 1993, indicating an overall escalation factor of 2.04. Radioactive waste disposal at the Chem-Nuclear facility near Barnwell, South Carolina, raises the total costs to nearly \$27 million as summarized in Table 4.13.

TABLE 4.12. Summary of the Total SAFSTOR Costs with Radioactive Waste Disposal at Richland, WA

Passive SAFSTOR with Deferred Decontamination after 10 Years ^(a,b)					
Item	Cost in Millions of Mid-1978 Dollars	Disposal at Richland, Wa		Disposal at Barnwell, SC	
		Cost in Millions of January 1993 Dollars	14.5-Year Escalation Factor	Cost in Millions of January 1993 Dollars	14.5-Year Escalation Factor
Preparations	0.85	1.46	1.71	1.46	1.71
Safe Storage	2.83	5.07	1.80	5.07	1.80
Deferred Decontamination	3.84	8.79	2.29	20.33	5.29
Total Costs	7.52	15.32	2.04	26.86	3.57

(a) 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%.

5.0 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 as Equation 5.1 below with minor modifications,^(a) decommissioning costs are divided into five general elements that tend to escalate in a similar way: 1) labor, materials and services; 2) energy and waste transportation; 3) radioactive waste disposal; 4) taxes and insurance; and 5) hazardous waste management.

$$\text{Cost in Year X} = [\text{Adjusted Total Base Cost in Year Y}] * [AL_x + BE_x + CB_x] + (\text{T\&I Costs in Year X})^{(a)} + (\text{H Costs in Year X})^{(a)} \quad (5.1)$$

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 and 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
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 + ΣS_x) / (R_y + ΣS_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)

(a) The 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 not been considered in this cost update.

Values for L_x and E_x should 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 should be taken from actual cost schedules (basic disposal costs plus surcharges, some of which depends upon the state compacts where the waste originates and where the waste is disposed).

The coefficients to be used in Equation 5.1 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 each of the summary tables (Tables 3.18, 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 are given in Table 5.1 and Table 5.2 for each of the decommissioning alternatives. For this update of the NUREG/CR-1266 report, the hazardous waste management costs were not evaluated.

TABLE 5.1. Formula Coefficients for Escalating Decommissioning Costs for the Reference Uranium Fuel Fabrication 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	0.620	0.056	0.324	1.090	0.486	0.745	5.606
Preparations/ SAFSTOR	0.931	0.069	0.000	0.000	0.000	0.167	0.890
Annual Costs/ SAFSTOR	0.911	0.089	0.000	0.000	0.000	0.074	0.306
Deferred Decontamination	0.644	0.053	0.303	1.090	0.486	0.745	5.993

(a) Costs are in millions of dollars.

TABLE 5.2. Formula Coefficients for Escalating Decommissioning Costs for the Reference Uranium Fuel Fabrication 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	0.234	0.021	0.745	2.272	8.525	0.745	14.839
Preparations/ SAFSTOR	0.931	0.069	0.000	0.000	0.000	0.167	0.890
Annual Costs/ SAFSTOR	0.911	0.089	0.000	0.000	0.000	0.074	0.306
Deferred Decontamination	0.254	0.021	0.726	2.272	8.525	0.715	15.226

(a) Costs are 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. Equation 5.2 uses annual escalation factors derived in this study. The last column of the summary tables (Tables 3.18, 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 14.5-year escalation factor listed in the summary tables. This number could be used to estimate future decommissioning costs with the following equation.

$$F=P(i)^n \quad (5.2)$$

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 14.5 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 categories was radical and not consistent. For example, the waste disposal costs have increased dramatically in recent years when 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

<u>Description</u>	<u>Escalation Factor^(a)</u>
Staffing	1.041
Equipment and Supplies	1.036
Miscellaneous Owner Expense	1.041
Specialty Contractors	1.074
Repair Allowance	1.042
Waste Transportation	1.011
Waste Burial ^(a)	1.152

(a) Average annual escalation factors for 14.5-year period from mid-1978 to January 1993.

(b) Includes waste packaging, burial, and associated surcharges.

6.0 REFERENCES

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APPENDIX

CROSS REFERENCE TO TABLES IN NUREG/CR-1266

APPENDIX

CROSS REFERENCE TO TABLES IN NUREG/CR-1266

No. in Current Report	Title	No. in 1980 NUREG/CR-1266
S.1	Summary of Updated Costs for Decommissioning the Reference Uranium Fuel Fabrication Plant	2.8-1
S.2	Formula Coefficients for Escalating DECON costs to some Future Time	N/A
S.3	Average Annual Escalation Factors	N/A
3.1	Unit Salaries for Decommissioning Staff	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 Equipment and Supplies	H.1-6
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3.8	Estimated Waste Management Costs for DECON	10.1-6
3.9	Details of Estimated January 1993 Costs for Radioactive Waste Management for DECON	H.2-5
3.10	Shipping Containers Used in this Study	H.1-2
3.11	Basic Transportation Rates for Legal Size and Weight Shipments in Effect January 1, 1993	H.1-3
3.12	Additional Charges when Gross Vehicle Weight Exceeds 36.28 Mg	H.1-4
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3.14	Barnwell Low-Level Radioactive Waste Management Facility Rate Schedule	N/A
3.15	Alternative Waste Management Costs for Low-Level Waste Burial Disposal	10.1-7
3.16	Cost Assessment for Contaminated CaF ₂ Disposal at LLW Burial Ground	N/A
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4.1	Summary of Staffing Utilization and Costs for Planning and Preparation Phase of Safe Storage	10.2-2
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4.3	Estimated Costs of Equipment and Supplies for Preparations for Safe Storage	10.2-4
4.4	Estimated Miscellaneous Owner Expenses During Preparations for Safe Storage	10.2-5
4.5	Summary of Estimated Costs of Preparations for Safe Storage	10.2-1
4.6	Estimated Annual Staff Requirements for Safe Storage	10.3-2
4.7	Estimated Annual Costs of the Safe Storage Period	10.3-1
4.8	Summary of Staffing Utilization and Costs for Planning and Preparation Phase of Deferred Decontamination	10.4-2
4.9	Summary of Staffing Utilization and Costs for Decommissioning Phase of Deferred Decontamination	10.4-3
4.10	Estimated Material and Equipment Requirements and Costs for Deferred Decontamination	10.4-4
4.11	Summary of Estimated Deferred Decontamination Costs	10.4-1
4.12	Summary of the total SAFSTOR Costs with Radioactive Waste Disposal at Richland, Wa	2.8-1
5.1	Formula Coefficients for Escalating Decommissioning Costs for the Reference Uranium Fuel Fabrication Plant with Waste Disposal at the U.S. Ecology Facility near Richland, Wa	N/A
5.2	Formula Coefficients for Escalating Decommissioning Costs for the Reference Uranium Fuel Fabrication Plant with Waste Disposal at the Chem-Nuclear Facility near Barnwell, SC	N/A
5.3	Average Annual Escalation Factors	N/A

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