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Cost Update: Technology, Safety,
and Costs of Decommissioning
Reference Independent Spent Fuel
Storage Installations

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Abstract

The cost estimates originally developed in NUREG/CR-2210 for decommissioning five conceptual Independent Spent Fuel Storage Installations (ISFSIs) and their supporting ancillaries (hot cell and transporter) are updated from 1981 to 1993 dollars. 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.

A methodology and a formula are presented for estimating the cost of decommissioning the ISFSIs at some future time, based on these current 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-2210, Reference 1) for decommissioning five different reference Independent Spent Fuel Storage Installations (ISFSI) 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 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-2210.

S.1 Summary of Updated Cost Estimates

To carry out the cost updates effectively, spreadsheets were developed to calculate the current total decommissioning costs. To maintain consistency, the formats of the tables in NUREG/CR-2210 were followed as closely as possible. The spreadsheets containing the cost information were linked with those containing the requirements for manpower, equipment and materials, and services to calculate and summarize the major cost components. The updated cost estimates are given in the following table:

Table S.1. Summary of Estimated Costs of Various Decommissioning Alternatives at the Reference ISFSIs^(a)

Type of ISFSI	DECON	SAFSTOR Costs (millions of 1993 \$) ^(b,c)				ENTOMB
		Dismantlement Deferred for				
		10 yr	30 yr	50 yr	100 yr	
Wet	9.08	11.98	10.94	12.73	18.38	-- ^(d)
Drywell	21.95	23.82	26.34	28.85	35.14	--
Silo	5.40	7.92	10.44	12.96	19.26	--
Vault	4.57	8.22	10.76	13.35	20.18	3.09 + 2.10 ^(e)
Cask	2.56	--	--	--	--	--

(a) Update of Table 9.0-1 in NUREG/CR-2210.

(b) Individually rounded to three significant figures for computational completeness and do not necessarily imply accuracy to that extent.

(c) Assumes in-compact radwaste disposal at the Hanford Site in Washington.

(d) Alternative not considered in this study.

(e) Annual surveillance and maintenance costs of \$35,000/yr would be in addition to those indicated in the table, i.e., \$2.1 million over 60 years.

The results indicate that the estimated costs for the immediate dismantlement and decontamination for unrestricted facility release (DECON) of the reference ISFSIs have increased by factors ranging from approximately 1.5 for the reference Cask ISFSI up to over 2.3 for both the reference Wet and Drywell ISFSIs between mid-1981 and 1993. The magnitude of the new cost estimates is mainly attributed to the drastic escalation in low-level waste disposal costs. The numbers reported in Table S.1 were calculated based on the in-compact radwaste disposal schedule at the U.S. Ecology facility in Washington. The decommissioning costs for ISFSIs that require less radwaste disposal did not increase as fast as those facilities that produced large volumes of radwaste over the 11.5-year escalation period.

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 Hanford Site 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 \$12,250. For in-compact waste originators, Washington also levies surcharges on top of the base rate totaling \$9.83/ft³ and a tax of 6.5%. Also in 1993, the Southeast Compact began imposing an access fee of \$220/ft³ on all eligible out-of-region waste generators to use the Barnwell Site in South Carolina. Barnwell also levies a curie surcharge of \$4,150/shipment and a tax of 2.4% on top of their base rate. These schedules provide the basis for the in-compact and out-of-compact radwaste disposal estimates.

Although manpower, energy, and equipment/supply costs increased by a factor of less than 1.5, the current in-compact radwaste burial costs are 4.46 times higher than they were in mid-1981. Out-of-compact radwaste burial costs are over 31 times higher than they were in mid-1981. For example, the in-compact radwaste disposal costs now account for nearly 60% of the total reference wet ISFSI DECON cost compared with about 35% in mid-1981. Out-of-compact radwaste disposal costs account for over 90% of the DECON budget at the same facility. These ratios vary according to the ISFSI.

The costs for the passive SAFSTOR option during both the planning/preparation and storage period have a much smaller rate of escalation, due to the absence of the volatile waste disposal cost during these stages. The preparatory cost for safe storage is estimated to have increased by a factor of about 1.5 between mid-1981 and January 1993. The annual cost of safe storage is relatively low but is estimated to have increased by a factor of 1.8, due mainly to the escalation in insurance costs.

The deferred decontamination costs at the end of the safe storage period are estimated to have increased by a factor of nearly 2.5 for the 11.5-year escalation period between mid-1978 and January 1993. These costs are comparable to the DECON costs in both magnitude and structure. Again, the largest increase is caused by waste disposal costs, which in some cases make up two-thirds of the estimated total costs compared with just 30% in 1981.

The spreadsheet system that was developed in this study uses escalation factors and provides an effective tool for future near-term cost projections for decommissioning the ISFSIs. The average annual escalation factors (log-averaged over 11.5 years) can be used for this purpose, assuming the same decommissioning approach and activities as developed in NUREG/CR-2210. However, caution is urged when applying escalation factors to costs that might behave erratically during the projection time period.

S.2 Formula for Escalating Costs to a Future Current Time

Escalation of decommissioning costs for the five different reference ISFSIs can be made from an estimate made at some previous time to a future current time using an escalation formula given in 10 CFR 50.75 (Reference 2). In this formula, shown below with minor modifications, decommissioning costs are divided into four general areas that tend to escalate similarly: (1) labor, materials and services; (2) energy and waste transportation; (3) radioactive waste disposal; and (4) taxes and insurance.

$$\text{Cost in Year X} = (\text{Adjusted Total Base Cost in Year Y}) * (AL_x + BE_x + CB_x) + \text{T\&I Costs in Year X}^1 \quad (\text{S.1})$$

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 of taxes and insurance

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

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

C = fraction of the adjusted total decommissioning cost attributable to waste burial 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.

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; other surcharges 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 in Table 10.1 of this addendum 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 Addendum to NUREG/CR-2210, the taxes and insurance costs were not evaluated.

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 could be added to the formula but would also be kept separate, because those costs have generally not been considered.

1 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 reference Independent Spent Fuel Storage Installations (ISFSI) given in NUREG/CR-2210 (Reference 1) 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," 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-2210, Reference 1) were adjusted to reflect cost escalations from mid-1981 to January 1993. The 25% contingency factor used in NUREG/CR-2210 was retained.
- Both the immediate dismantlement of the ISFSIs (DECON) and the delayed dismantlement after a 10 to 100-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-2210 are assumed to be unchanged. Information in NUREG/CR-2210 that is unchanged is not repeated in this report.
- The impacts of new packaging requirements on radioactive low-level waste (LLW) disposal costs were taken into consideration in this report.

- Because of the huge disparity in waste disposal costs, high and low estimates are provided in the tables for DECON. In-compact burial charges based on waste disposal at the Hanford Site by U.S. Ecology are included as the low estimate. Out-of-compact burial charges based on waste disposal by Barnwell in South Carolina provide the high estimate. U.S. Ecology burial charges are used to estimate SAFSTOR costs.
- The cost update was performed in an automated manner by utilizing the Lotus 3.1 spreadsheet format.
- 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-2210. Only the summary tables are included. The cross-reference of table numbers in this report to those in CR-2210 is presented as a footnote with each table and listed in Appendix A for easy comparison.

The cost update algorithm development is described in Section 2. Section 3 describes the evaluation for the cost escalations for DECON, SAFSTOR, and Deferred Decontamination for the reference Wet ISFSI. Sections 4, 5, 6, 7, 8, and 9 describe the evaluation for the cost escalations for the reference Drywell ISFSI, the reference Silo ISFSI, the reference Vault ISFSI, the reference Cask ISFSI, the Hot Cell, and the Transporter, respectively.

Section 10 discusses the applicability of the algorithm and the results of this report to future cost updates. References are listed in Section 11.

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

2 Methodology and Bases for the Cost Updates

The basic methodology and algorithm developed for updating the costs given in the original NUREG/CR-2210 are presented in Section 2.1, and the bases for the cost escalations are given in Section 2.2.

2.1 Algorithm for Cost Updates

Figure 2.1 illustrates the algorithm developed to update the cost estimates for decommissioning the ISFSIs. First, the requirements for the manpower, equipment and supplies, and various services identified in the tables in Reference 1 were reproduced in spreadsheet format. Second, the mid-1981 unit cost items were also entered

into spreadsheets: (1) the salaries for the work force; (2) the prices for various equipment, tools, and materials; and (3) the services, such as utilities, waste disposal, insurance, licensing, taxes, and reclamation of the land. Third, escalation factors for each of the cost categories were evaluated based on price index trends obtained in the most recent publications, such as the *Handy-Whitman Index of Public Utility Construction Costs* (Reference 3) and the *Monthly Energy Review* (Reference 4). 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, namely, the

Figure 2.1. Algorithm for Cost Updates for DECON

manpower cost, the equipment and supplies cost, the waste disposal cost, and the owner's expenses. 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 radioactive 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 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 the section.

Computerized spreadsheet tables allow easy adjustment to 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 its impact 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 tables, repeated from NUREG/CR-2210, include only the summary tables. Basic cost-related tables, such as disposal rate schedules, are provided in Appendix B. For example, for the reference Wet ISFSI, the updated cost estimates for DECON are summarized in Table 3.1. The cost updates for SAFSTOR (initial preparation, annual safe storage, and deferred decontamination) are summarized in Tables 3.2, 3.3, and 3.4. For the most part, 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, when the waste is disposed at the Hanford Site in Washington. The third and sixth columns list the percentage of the total labor/energy/disposal costs attributable to each cost element, for disposal at Hanford and Barnwell, respectively. The 11.5-year escalation factors, given in column 4, are

simply the ratios of the January 1993 costs to the mid-1981 costs. For the labor 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 Table 3.1. In the case of the updated costs for waste packaging, transportation, and disposal, the contemporary cost schedule from the reference disposal facility was used to calculate the January 1993 cost estimates. The fifth column shows the costs, escalated to January 1993 dollars, when the waste is disposed at the Barnwell Site in South Carolina.

2.2 Cost Estimate Updates

The cost estimate adjustments were determined by using publications containing U.S. price index trends covering the period between 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 *Handy-Whitman Index of Public Utility Construction Costs* (Reference 3), with escalation for the final year and a half using escalation rates based on the previous 10 years. The escalation factors for materials and equipment were calculated using the 1992 edition of the *Statistical Abstract of the United States* (Reference 5). The February 1993 *Monthly Energy Review Edition* (Reference 4) 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. (Reference 6). Waste disposal costs were computed based on the current *Schedule of Charges* from U.S. Ecology Inc. at Richland, Washington (Reference 7), and the Rate Schedule from Chem-Nuclear Systems, Inc. for disposal at the Barnwell Site in South Carolina (Reference 8). Tax and insurance cost estimates were updated based on escalation factors calculated in Reference 9.

2.2.1 Cost Estimate Update for Staff Labor

The 1991 *Handy-Whitman Index of Public Utility Construction Costs* (Reference 3) was used to calculate the escalation factor for the manpower costs for the planning, preparation, dismantlement, and decontamination of the

reference Wet ISFSI. First, the common labor salary/wages index averaged over the six regions in the U.S. 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 manpower costs from July 1, 1991, to January 1993, an increase of 3.0% (the average annual escalation factor) per annum was used. Therefore, the final manpower escalation factor applicable from mid-1981 to January 1993 was estimated to be 1.40. This manpower escalation was used for all of the ISFSI options.

2.2.2 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* (Reference 4).

The escalation factors for the construction machinery and equipment cost elements from mid-1981 to January 1993 were estimated to be 1.517. The escalation factor for metal-cutting tools was evaluated to be 1.705.

A special tools and equipment cost category appears in many of the summary tables. For this category, the mid-1981 dollar total was assumed to escalate over the 11.5-year period by the factor of 1.517 described above.

2.2.3 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* (Reference 5).

For the purposes of comparison, two different utility escalation factors were calculated: one based on a point-to-point ratio for the mid-1981 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 2.1. Because of extraneous circumstances (such as the peak of inflation in the 1970s 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 in Table 2.1 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. 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 the NRC's policy of full cost recovery for licensing activities.) The 1993 tax and insurance expenses were escalated according to a factor documented in Reference 8.

2.2.4 Cost Estimate Update for the Disposal of Radioactive Materials

The waste disposal costs are divided into three constituent cost categories: packaging, transportation, and burial. Cost escalation for each of the three aspects is described in detail in the following subsections. For each category, costs were not escalated according to price index information but according to contemporary cost quotes.

2.2.4.1 Estimated 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 referenced in NUREG/CR-2210. Table B.1 in Appendix B lists January 1993 prices paid by the Department of Energy for the containers at the Barnwell Site.

2.2.4.2 Estimated Costs for Waste Transportation. Waste transportation costs are based on a 500-mile trip to the LLW disposal site. The cost per mile is taken from the cost schedule provided by the Tri-State Motor Transit

Table 2.1. Escalation Factors for Energy Costs

	Pt-to-Pt 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	1.028	0.920
Composite Energy Costs Escalation Factor	0.972	1.066

Co. (Reference 6) and is summarized in Table B.2 in Appendix B. Charges for a 500-mile trip to the state of Washington were used in this reference analysis. According to Table B.2, a charge of \$2.44/mile is applicable for each truck shipment in a 500-mile trip. In addition, overweight shipments not exceeding 85,000 pounds are subject to an additional charge of \$0.21/mile for each mile traveled in a state requiring overweight permits. The State of Washington levies weight charges according to the schedule summarized in Table B.3 in Appendix B. The total weight charge in Washington for most shipments was \$0.42/mile. A flat charge of \$30 is also levied on each shipment.

2.2.4.3 Estimated Costs for Waste Burial. Because of the large discrepancy in burial costs, depending on the disposal sites and the state the waste originated in, a high and low estimate of burial costs is given. The low cost is estimated based on the U.S. Ecology *Washington Nuclear Center Schedule of Disposal Charges* for in-compact burial of radioactive material at the Hanford Site (Reference 7). The January 1993 rate schedule for the

U.S. Ecology disposal facility in Washington is summarized in Table B.4 in Appendix B. U.S. Ecology burial fees are based on the exposure rate at the surface of the container. According to Table B.4, for a package with a low surface exposure rate, the burial charge is \$28.30/ft³. There are additional fees, surcharges, and taxes that are summarized in Table B.5 in Appendix B. These total an additional \$9.83/ft³ plus 6.5% on the base charges. Further, there is a one time registration fee of \$12,250.

The high cost estimate is calculated based on the *Barnwell LLW Management Facility Rate Schedule* by Chem-Nuclear Systems, Inc., for out-of-compact burial of radioactive material (Reference 8). The January 1993 rate schedule for the Barnwell Facility is summarized in Table B.6 in Appendix B. According to Table B.6, there are four basic charges for waste burial at Barnwell. These include a base disposal charge of \$59/ft³ for standard waste, a curie surcharge of \$4,150/shipment, a Barnwell surcharge of 2.4%, and an out-of-compact access fee of \$220/ft³ for all eligible out-of-region waste generators.

3 Cost Estimate Update for the Reference Wet ISFSI

The updated cost estimates for decommissioning the reference Wet ISFSI using the DECON and SAFSTOR alternatives are presented in the following sections. As in NUREG/CR-2210, the costs are broken into two general categories. The first category covers managerial and support staff costs, which are summarized for each decommissioning alternative in Table B.7 in Appendix B. The second category involves the dedicated staff and associated costs of decommissioning, including labor, materials and supplies, rented equipment, purchased equipment, energy, license fees, insurance, and radwaste disposal. These costs are given in detail in each of the summary tables.

3.1 Cost of DECON

The total cost of immediate decontamination (DECON) for the reference Wet ISFSI in 1993, with in-compact waste disposal at the Hanford Site, including a 25% contingency allowance, is estimated to be just over \$9.0 million. This is up by a factor of 2.3 from the estimate of \$4.0 million in 1981. Waste disposal at the Hanford Site accounts for over 60% of the DECON costs, compared with only 35% in 1981. When out-of-compact disposal at the Barnwell Site is considered, the total costs climb to over \$38 million. Waste disposal accounts for over 90% of the total DECON costs in this case. The estimates for the total DECON costs are summarized in Table 3.1.

3.2 Cost of SAFSTOR

Cost estimates for the SAFSTOR option are separated into two cost categories, the costs incurred while preparing for storage and the annual costs during the safe storage period, and the costs of deferred dismantlement. These cost elements are discussed in subsequent sections.

3.2.1 Cost of Safe Storage

Table 3.2 summarizes the estimated costs of preparing for safe storage at the reference Wet ISFSI. With in-compact disposal at the Hanford Site, the total costs are estimated

to be \$3.07 million. Because the need for waste disposal during this phase is minimal (less than 2% of estimated costs), over 75% of the total estimated budget is due to labor costs. Total preparation costs increase by less than 50% from mid-1981 to 1993.

Table 3.3 summarizes the total annual safe storage costs. There is no waste disposal during this phase, so the total costs increased by only a factor of 1.8 during the 11.5-year escalation period.

3.2.2 Cost of Deferred Decontamination

Table 3.4 summarizes the estimated decontamination costs at the reference Wet ISFSI. In-compact waste disposal at the Hanford Site is the only option included. The table provides a comparison of DECON and deferring decontamination from 10 to 100 years. Due to the costs associated with waste disposal, the impact of delaying decontamination is more acute. Because of the reduction in waste volume due to radionuclide decay, the decontamination costs associated with a 10-year deferral of dismantlement decrease by a factor of 2.7 when the delay is extended to 100 years. In mid-1981, this extra deferment resulted in a decrease by a factor of only 1.8.

3.2.3 Total Cost of SAFSTOR

Table 3.5 provides a summary of the estimated costs associated with the SAFSTOR option at the reference Wet ISFSI for 10, 30, 50, and 100 years. For purposes of comparison, the DECON costs are also included. It is interesting to note that, although the DECON option is the least expensive, with a total estimated cost of around \$9.1 million, according to the table, the estimated SAFSTOR costs decrease from \$11.98 million to \$11.94 million when the safe storage period is extended from 10 to 30 years. After 30 years, the decline in disposal costs due to decay is overtaken by the cumulative labor costs, resulting in rising SAFSTOR costs.

Table 3.1. Summary of Estimated Costs of DECON for the Reference Wet ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radioactive and Contaminated Materials	1,080,255	4,184,899			26,980,710	
Radioactive Wastes	<u>23,161</u>	<u>88,232</u>			<u>546,753</u>	
Total Radwaste Disposal Costs	1,103,416	4,273,131	61.1	3.882/24.957 ^(c)	27,527,463	91.0
Dedicated Staff Labor	294,169	411,836	5.9	1.400	411,386	1.4
Support Staff Cost	1,374,472	1,924,262	27.5	1.400	1,924,262	6.4
Special Tools and Equipment	71,500	108,466	1.6	1.517	108,466	0.4
Miscellaneous Supplies	18,100	27,458	0.4	1.517	27,458	0.1
License Fees	<u>90,060</u>	<u>126,084</u>	<u>1.8</u>	<u>1.400</u>	<u>126,084</u>	<u>0.4</u>
Total Labor/Matl. Costs	1,848,301	2,598,106	37.1	1.406	2,598,106	8.6
Energy	<u>109,603</u>	<u>116,837</u>	<u>1.7</u>	1.066	<u>116,837</u>	<u>0.4</u>
Total Labor/Energy/Disposal Costs	3,061,320	6,988,074	100.0	2.283/9.879 ^(c)	30,242,406	100.0
25% Contingency	<u>765,330</u>	<u>1,747,018</u>			<u>7,560,602</u>	
Adjusted Cost w/Contingency	3,826,650	8,735,092			37,803,008	
Nuclear Insurance w/Contingency	<u>121,875</u>	<u>341,945</u>		2.806	<u>341,945</u>	
Total Wet ISFSI DECON Cost	3,948,525	9,077,037		2.298/9.661 ^(d)	38,144,952	

(a) Update of Table 9.2-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 3.2. Summary of Estimated Costs of Preparations for Safe Storage for the Reference Wet ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radioactive Materials	8,980	33,794	1.4	3.763/24.214 ^(c)	217,443	8.2
Storage of Radioactive and Contaminated Materials	11,200	23,189	0.9	2.070	23,189	0.9
Dedicated Staff Labor	190,670	266,938	10.9	1.400	266,938	10.1
License Fees	89,280	124,992	5.1	1.400	124,992	4.7
Special Tools and Equipment	67,300	96,912	3.9	1.440	96,912	3.7
Miscellaneous Supplies	88,090	126,850	5.2	1.440	126,850	4.8
Energy	25,654	27,347	1.1	1.066	27,347	1.0
Nuclear Insurance	<u>62,460</u>	<u>160,210</u>	<u>6.5</u>	2.565	<u>160,210</u>	<u>6.0</u>
Subtotal	543,634	860,232	35.0		1,043,881	39.4
Contingency (25%)	135,908	215,058			260,970	
Total Dedicated Cost for Fuel Storage Area	679,542	1,075,290			1,304,851	
Support Staff Cost ^(d)	<u>1,426,754</u>	<u>1,997,456</u>	<u>65.0</u>	1.400	1,997,456	60.5
Total Cost of Preparations for Safe Storage	2,106,296	3,072,746	100.00	1.459/1.568 ^(e)	3,302,307	100.0

(a) Update of Table 9.2-7 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) Includes a 25% contingency.

(e) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 3.3. Summary of Estimated Annual Costs of Safe Storage for the Reference Wet ISFSI^(a,b)

	Mid-1981 Costs (\$)	Escalation Factor	January 1993 Costs (\$)
<u>Labor</u>			
Inspection and Quality Assurance Verification	4,000	1.400	5,600
Secretarial	3,880	1.400	5,432
Repair	2,500	1.400	3,500
Security	6,100	1.400	8,540
Environmental and Radiological Monitoring	7,960	1.400	11,144
Inspection and Quality Assurance Verification	<u>1,000</u>	1.400	<u>1,400</u>
Total Labor Costs	25,440		35,616
<u>Other Costs</u>			
Main Building Roof Repair	1,000	1.400	1,400
Main Building Roof Replacement	1,970	1.400	2,758
Pest Control	550	1.400	770
Equipment and Supplies	420	1.517	637
Parts for Monitoring Intrusion and Fire System, Including Video Monitoring	2,000	1.517	3,034
Emergency Maintenance	1,000	1.400	1,400
Utilities	1,500	1.066	1,599
Health and Safety Inspections	780	1.400	1,092
Nuclear Liability Insurance	20,000	2.565	51,300
Total Other Costs	<u>29,220</u>		<u>63,990</u>
Subtotal	54,660		99,606
Contingency (25 %)	<u>13,665</u>		<u>24,902</u>
Total Annual Safe Storage Care Costs	68,325		124,508

(a) Update of Table 9.2-12 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

Table 3.4. Summary of Estimated Decontamination/Dismantlement Costs for the Reference Wet ISFSI^(a)

Cost Category	Decommissioning Costs in Thousands of 1993 \$				
	DECON	Dismantlement Deferred for			
		10 years	30 years	50 years	100 years
Disposal of Radioactive Materials	4,283.4	4,267.9	2,295.0	980.3	541.9
Dedicated Staff Labor	411.8	380.3	361.8	351.8	351.8
License Fees	126.1	126.1	126.1	126.1	126.1
Special Tools and Equipment	108.5	108.5	79.3	55.7	33.4
Miscellaneous Supplies	27.5	27.5	24.3	21.5	21.5
Energy	116.8	116.8	115.7	108.9	108.9
Nuclear Insurance	<u>273.6</u>	<u>60.9</u>	<u>60.9</u>	<u>54.7</u>	<u>54.7</u>
Subtotal	5,347.6	5,087.9	3,063.0	1,699.1	1,238.4
Contingency (25 %)	<u>1,336.9</u>	<u>1,272.0</u>	<u>765.7</u>	<u>424.8</u>	<u>309.6</u>
Total Cost for Fuel Storage Area	6,684.5	6,359.9	3,828.7	2,123.8	1,548.0
Support Staff Cost ^(b)	<u>2,405.3</u>	<u>1,305.0</u>	<u>1,305.0</u>	<u>1,305.0</u>	<u>1,305.0</u>
Total Deferred Dismantlement Costs	9,089.8	7,664.9	5,133.7	3,428.8	2,852.9

(a) Update of Table 9.2-13 in NUREG/CR-2210.

(b) Includes a 25 % contingency.

Table 3.5. Summary of Estimated Costs of SAFSTOR for the Reference Wet ISFSI^(a)

Years After Shutdown	SAFSTOR Decommissioning Costs in Thousands of 1993 \$				
	DECON	Preparations for Safe Storage	Storage Period	Deferred Decontamination	Total
0	9,077.0	--	0.0	--	9,077.0
10	--	3,072.7	1,245.1	7,664.9	11,982.7
30	--	3,072.7	3,735.2	5,133.7	11,941.6
50	--	3,072.7	6,225.4	3,428.8	12,726.9
100	--	3,072.7	12,450.8	2,852.9	18,376.5

(a) Update of Table 9.2-14 in NUREG/CR-2210.

4 Cost Estimate Update for the Reference Drywell ISFSI

The updated cost estimates for decommissioning the reference Drywell ISFSI via the DECON and SAFSTOR alternatives are presented in the following sections. Each alternative covers the dedicated staff and associated costs (see the summary tables), managerial and support staff costs (see Table B.7 in Appendix B), hot cell costs (Section 8), and transporter costs (Section 9).

4.1 Cost of DECON

The total cost of DECON of the reference Drywell ISFSI with in-compact waste disposal at the Hanford Site, including a 25% contingency allowance, has increased from \$9.1 million in mid-1981 to just under \$22 million in 1993. For this option, waste disposal accounts for two-thirds of the DECON costs in 1993 compared with just under 50% in mid-1981. Because of the rise in disposal rates, total labor and materials costs now account for about 26% of the budget, compared with 37.3% in 1981. When out-of-compact disposal is considered, the total estimated costs increase to over \$100 million in 1993, with about 94% of the estimated budget committed to

waste disposal. The total estimated costs for DECON of the reference drywell ISFSI are summarized in Table 4.1.

4.2 Cost of SAFSTOR

A summary of the estimated costs of SAFSTOR at the reference Drywell ISFSI is given in Table 4.2. Only in-compact disposal of the radwaste is considered in this summary. The SAFSTOR costs include the costs incurred during storage and the deferred decontamination costs. Due to the high dose rates from the contaminated drywells, even after 100 years of safe storage, the costs for radwaste disposal are the same as for DECON. Table 4.2 compares the costs for SAFSTOR associated with safe storage periods of 10, 30, 50, and 100 years. SAFSTOR costs increased by a factor of 2.28 for a 10-year period of safe storage between 1981 and 1993, from \$10.4 million to \$23.8 million. Because waste disposal costs stay constant apart from the safe storage length, the SAFSTOR costs for a 100-year period of storage only increased by a factor of 1.91, from \$18.3 million in mid-1981 to \$35.1 million in 1993.

Cost Estimate Update - Drywell ISFSI

Table 4.1. Summary of Estimated Costs of DECON for the Reference Drywell ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radwaste						
(Storage)	3,633,878	11,689,939		3.217/19.600 ^(c)	71,224,069	
(Hot Cell)	175,476	603,970			3,636,395	
(Transporter)	<u>13,971</u>	<u>49,644</u>			<u>325,128</u>	
Total Radwaste Disposal Cost	3,823,325	12,343,553	73.1	3.228/19.665	75,185,592	94.3
Dedicated Staff Labor	703,380	984,732		1.400	984,732	
Support Staff Cost	2,015,946	2,822,324		1.400	2,822,324	
Materials for Segmentation Building	18,000	27,306		1.517	27,306	
Rental of Major Equipment	161,980	271,510		1.676	271,510	
Purchase of Minor Equipment and Supplies	13,800	21,311		1.544	21,311	
Licensing Fees	<u>88,500</u>	<u>123,900</u>		<u>1.400</u>	<u>123,900</u>	
Labor/Matl. Costs						
(Storage)	3,001,606	4,251,083		1.459 ^(d)	4,251,083	
(Hot Cell)	121,242	172,643		1.424	172,643	
(Transporter)	<u>900</u>	<u>1,260</u>		<u>1.400</u>	<u>1,260</u>	
Total Labor/Matl. Costs	3,123,748	4,424,986	26.2	1.458 ^(d)	4,424,986	5.6
Energy						
(Storage)	99,164	105,709			105,709	
(Hot Cell)	<u>9,844</u>	<u>10,494</u>			<u>10,494</u>	
Total Energy Costs	109,008	116,203	<u>0.7</u>	1.066	116,203	<u>0.1</u>
Total Labor/Energy/Disposal Costs	<u>7,056,081</u>	<u>16,884,742</u>	100.0		<u>79,726,781</u>	100.0
25% Contingency	<u>1,764,020</u>	<u>4,221,186</u>			<u>19,931,695</u>	
Adjusted Cost w/Contingency	8,820,101	21,105,928			99,658,476	
Nuclear Insurance w/Contingency						
(Storage)	250,000	701,425		2.806	701,425	
(Hot Cell)	<u>52,125</u>	<u>146,248</u>			<u>146,248</u>	
Total Nuclear Insurance Costs	<u>302,125</u>	<u>847,673</u>			<u>847,673</u>	
Total Drywell DECON Costs	9,122,226	21,953,601		2.407/11.018 ^(e)	100,506,149	

(a) Update of Table 9.3-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means costs for disposal at Hanford/Barnwell.

(d) Average value, weighted by magnitudes of components.

(e) X/Y means total decommissioning costs with disposal at Hanford/Barnwell.

Table 4.2. Summary of Estimated Costs of SAFSTOR for the Reference Drywell ISFSI^(a,b)

	SAFSTOR Decommissioning Costs in 1993 \$			
	Dismantlement Deferred for			
	10 Years	30 Years	50 Years	100 Years
<u>Fuel Storage Area</u>				
Dedicated Staff Labor	1,495,669	2,397,549	3,299,429	5,554,129
Material for Segmentation Building	27,306	27,306	27,306	27,306
Rental of Major Equipment	302,165	308,165	314,165	329,165
Purchase of Minor Equipment	36,481	66,821	97,161	173,011
Licensing Fees	123,900	123,900	123,900	123,900
Energy	112,190	115,601	119,012	127,540
Nuclear Insurance	659,340	715,454	771,568	911,853
Disposal of Radwaste	<u>11,714,602</u>	<u>11,714,602</u>	<u>11,714,602</u>	<u>11,714,602</u>
Subtotal	14,471,652	15,469,397	16,467,142	18,961,505
25% Contingency	3,617,913	3,867,349	4,116,786	4,740,376
Total Costs for Fuel Storage Area	18,089,565	19,336,747	20,583,928	23,701,882
Hot Cell Costs ^(c)	1,865,336	3,130,610	4,397,852	7,565,834
Support Staff Costs ^(c)	<u>3,868,719</u>	<u>3,868,719</u>	<u>3,868,719</u>	<u>3,868,719</u>
Total Drywell SAFSTOR Costs	23,823,620	26,336,076	28,850,500	35,136,435

(a) Update of Table 9.3-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

5 Cost Estimate Update for the Reference Silo ISFSI

The updated cost estimates for decommissioning the reference Silo ISFSI via the DECON and SAFSTOR alternatives are presented in the following sections. Like the update for the reference Drywell ISFSI, included in the analysis are dedicated staff and associated costs, managerial and support staff costs, hot cell costs, and transporter costs.

5.1 Cost of DECON

The total cost of DECON of the reference Silo ISFSI with in-compact waste disposal at the Hanford Site, including a 25% contingency allowance, has increased from \$2.8 million in mid-1981 to \$5.4 million in 1993. For this option, waste disposal now accounts for almost 44% of the estimated labor/energy/disposal costs, compared with 26% in mid-1981. Support staff costs, about 73% of the dedicated budget in 1981, still account for over 55% of the total DECON costs. When out-of-compact disposal at the Barnwell Site is considered, the total estimated costs increase to over \$16 million in 1993, with over 82% committed to waste disposal. The total estimated costs of DECON for the reference Silo ISFSI are summarized in Table 5.1.

5.2 Cost of SAFSTOR

A summary of the estimated costs of SAFSTOR for the reference Silo ISFSI is shown in Table 5.2. Only in-compact disposal of the radwaste is considered in this summary. The SAFSTOR costs include those incurred during storage and the deferred decontamination costs. Like the drywells, there is no cost reduction for deferred decontamination activities at the end of the safe storage periods. Even after 100 years, the dose rates are so high that there is no reduction in the volume of contaminated material to be disposed, so the radwaste disposal costs are the same as those associated with DECON. Table 5.2 compares the costs for SAFSTOR incurred with safe storage periods of 10, 30, 50, and 100 years. SAFSTOR costs increased by a factor of 1.95 for a 10-year period of safe storage between 1981 and 1993, from \$4.05 million to \$7.9 million. Because waste disposal costs stay constant apart from the safe storage length, the SAFSTOR costs for a 100-year period of storage only increased by a factor of 1.61, from \$11.96 million in mid-1981 to \$19.26 million in 1993.

Table 5.1. Summary of Estimated Costs of DECON for the Reference Silo ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radwaste						
(Storage)	352,200	1,061,229		3.013/17.720 ^(c)	6,241,035	
(Hot Cell)	175,476	603,970			3,636,395	
(Transporter)	<u>13,971</u>	<u>49,644</u>			<u>325,128</u>	
Total Radwaste Disposal Cost	541,647	1,714,843	43.7	3.166/18.836^(c)	10,202,558	82.2
Dedicated Manpower	148,858	208,401		1.400	208,401	
Support Staff Cost	1,149,712	1,605,389		1.400	1,605,389	
Rental of Major Equipment	24,339	40,895		1.680	40,895	
Purchase of Minor Equipment and Supplies	15,300	23,210		1.517	23,210	
Licensing Fees	<u>88,500</u>	<u>123,900</u>		<u>1.400</u>	<u>123,900</u>	
Labor/Matl. Costs						
(Storage)	1,426,709	2,001,795		1.405	2,001,795	
(Hot Cell)	121,242	172,643		1.424	172,643	
(Transporter)	<u>900</u>	<u>1,260</u>		<u>1.400</u>	<u>1,260</u>	
Total Labor/Matl. Costs	1,548,851	2,175,698	55.4	1.405	2,175,698	17.5
Energy						
(Storage)	23,040	24,561			24,561	
(Hot Cell)	<u>9,844</u>	<u>10,494</u>			<u>10,494</u>	
Total Energy Costs	32,884	35,055	0.9	1.066	35,055	0.3
Total Labor/Energy/Disposal Costs	<u>2,123,382</u>	<u>3,925,596</u>	100.0	1.849/4.677^(c)	<u>12,413,311</u>	100.0
25 % Contingency	<u>530,846</u>	<u>981,399</u>			<u>3,103,328</u>	
Adjusted Cost w/Contingency	2,654,228	4,906,995			15,516,639	
Nuclear Insurance w/Contingency						
(Storage)	125,000	350,713		2.806	350,713	
(Hot Cell)	<u>52,125</u>	<u>146,248</u>			<u>146,248</u>	
Total Nuclear Insurance Costs	<u>177,125</u>	<u>496,961</u>			<u>496,961</u>	
Total Silo DECON Costs	2,831,353	5,403,956		1.909/5.656^(d)	16,013,599	

(a) Update of Table 9.4-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means costs for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 5.2 Summary of Estimated Costs of SAFSTOR at the Reference Silo ISFSI^(a,b)

	SAFSTOR Decommissioning Costs in 1993 \$			
	Dismantlement Deferred for			
	10 Years	30 Years	50 Years	100 Years
Fuel Storage Area				
Dedicated Manpower	695,279	1,597,159	2,499,039	4,753,739
Rental of Major Equipment	75,466	86,166	96,866	123,616
Purchase of Minor Equipment	39,897	70,237	100,577	176,427
Energy	28,654	32,065	35,476	44,004
License Fees	123,900	123,900	123,900	123,900
Nuclear Insurance	308,627	364,741	420,855	561,140
Disposal of Radwaste	<u>1,765,657</u>	<u>1,765,657</u>	<u>1,765,657</u>	<u>1,765,657</u>
Subtotal	3,037,480	4,039,925	5,042,370	7,548,483
25% Contingency	<u>759,370</u>	<u>1,009,981</u>	<u>1,260,592</u>	<u>1,887,121</u>
Total Dedicated Cost of Fuel Storage Area	3,796,849	5,049,906	6,302,962	9,435,604
Hot Cell Costs ^(c)	1,865,336	3,130,610	4,397,852	7,565,834
Support Staff Costs ^(c)	<u>2,262,356</u>	<u>2,262,356</u>	<u>2,262,356</u>	<u>2,262,356</u>
Total DECON Costs	7,924,541	10,442,872	12,963,171	19,263,793

(a) Update of Table 9.4-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) Includes a 25% contingency.

6 Cost Estimate Update for the Reference Vault ISFSI

The updated cost estimates for decommissioning the reference Vault ISFSI via the DECON, SAFSTOR, and ENTOMB alternatives are presented in the following sections. Each alternative covers the dedicated staff and associated costs, managerial and support staff costs, and hot cell costs.

6.1 Cost of DECON

The total cost of DECON at the reference Vault ISFSI with in-compact waste disposal at the Hanford Site, including a 25% contingency allowance, has increased by a factor of 1.7 from \$2.6 million in mid-1981 to just under \$4.6 million in 1993. Radwaste disposal for the decommissioning of the reference vault accounts for about 26% of the labor/energy/disposal costs. About 71% of the budget is committed to labor and materials; hot cell cleanup costs account for nearly a quarter of the DECON costs. When out-of-compact disposal at the Barnwell Site is considered, the total estimated costs for DECON rise to \$10.1 million in 1993. The total estimated costs of DECON for the reference Vault ISFSI are summarized in Table 6.1.

6.2 Cost of SAFSTOR

Like the cost analysis update for the reference Wet ISFSI, cost estimates for the SAFSTOR option at the reference Vault ISFSI are separated into two cost categories, the costs incurred while preparing for storage and the annual costs during the safe storage period, and the costs for deferred dismantlement following the storage period.

6.2.1 Cost of Safe Storage

Table 6.2 summarizes the estimated costs of preparing for safe storage at the reference Vault ISFSI. With in-compact disposal of the radwaste at the Hanford Site, the total preparatory costs are estimated to be just under \$3.7 million in 1993. This represents only a 45% increase in total costs compared with the mid-1981 cost of

\$2.5 million. Because the need for waste disposal during this phase is minimal (less than 1% of the estimated costs), over 80% of the total estimated budget is due to labor costs.

Table 6.3 summarizes the total annual safe storage costs. There is no waste disposal during this phase, so the total costs increase by a factor of 1.8 during the 11.5-year escalation period.

6.2.2 Cost of Deferred Decontamination

Table 6.4 summarizes the estimated decontamination costs at the reference Vault ISFSI. In-compact radwaste disposal at the Hanford Site is the only option included in this summary. This table provides a comparison of immediate decontamination (DECON) and deferring decontamination from 10 to 100 years. Because the costs associated with radwaste disposal are not proportionately as high as they were for decommissioning the reference Wet ISFSI, the impact of delaying the decontamination process is not as acute. Extending the decontamination deferment from 10 years to 100 years only drops the costs by a factor of 1.13, compared with a drop of over 1.67 for the mid-1981 cost estimate analysis.

6.2.3 Total Cost of SAFSTOR

Table 6.5 provides a summary of the estimated costs associated with the SAFSTOR option at the reference Vault ISFSI for 10, 30, 50, and 100 years of safe storage. For the purposes of comparison, the DECON costs are also included. Immediate decontamination is the most cost-effective means of decommissioning the facility, with a total cost of \$4.58 million. Preparations for SAFSTOR alone cost nearly \$3.7 million. SAFSTOR costs in 1993 range from \$8.2 million for a 10-year decontamination deferment to over \$20.1 million for a deferment of 100 years.

6.3 Cost of ENTOMB

Table 6.6 summarizes the cost estimates for the ENTOMB option, which are very similar to the costs for

Cost Estimate - Vault ISFSI

the DECON option. NUREG/CR-2210 provides an analysis explaining that, although the large decontamination effort is unnecessary during ENTOMB, the cost savings is offset by the construction of the entombment structure. However, because radwaste disposal costs in 1993 are far more expensive than construction costs, this is no longer necessarily true. With in-compact radwaste disposal at the Hanford Site, the total cost of ENTOMB rises by a factor of 1.48, from \$2.09 million in

mid-1981 to \$3.09 million in 1993. (DECON costs rose by a factor of over 1.7 to over \$4.5 million during this same period.) Out-of-compact radwaste disposal at the Barnwell Site increased total ENTOMB costs to over \$7.4 million in 1993. Much of this extra cost comes from the hot cell decontamination. There is an annual surveillance and maintenance cost of \$35,000 associated with the ENTOMB option, up from \$24,300 in mid-1981.

Table 6.1. Summary of Estimated Costs of DECON for the Reference Vault ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radwaste						
(Storage)	73,001	270,206		3.701/22.740 ^(c)	1,660,012	
(Hot Cell)	<u>175,476</u>	<u>603,970</u>			<u>3,636,395</u>	
Total Radwaste Disposal Cost	248,477	874,176	26.3	3.518/21.315 ^(c)	5,296,407	68.4
Dedicated Staff Labor	205,680	287,931		1.400	287,931	
Support Staff Cost	1,172,032	1,640,845		1.400	1,640,845	
Special Tools and Equipment	62,500	94,813		1.517	94,813	
Miscellaneous Supplies	24,500	37,167		1.517	37,167	
Licensing Fees	89,280	124,992		1.400	124,992	
Labor/Matl. Costs						
(Storage)	1,553,992	2,185,748		1.406	2,185,748	
(Hot Cell)	<u>121,242</u>	<u>172,643</u>		<u>1.424</u>	<u>172,643</u>	
Total Labor/Matl. Costs	1,675,234	2,358,391	71.0	1.407	2,358,391	30.5
Energy						
(Storage)	71,682	76,365			76,365	
(Hot Cell)	<u>9,844</u>	<u>10,494</u>			<u>10,494</u>	
Total Energy Costs	<u>81,526</u>	<u>86,859</u>	<u>2.6</u>	1.066	<u>86,859</u>	<u>1.1</u>
Total Labor/Energy/Disposal Costs	2,005,237	3,319,426	100.0	1.655/3.861 ^(c)	7,741,657	100.0
25 % Contingency	<u>501,309</u>	<u>829,857</u>			<u>1,935,414</u>	
Adjusted Cost w/Contingency	2,506,546	4,149,286			9,677,071	
Nuclear Insurance w/Contingency						
(Storage)	98,738	277,028			277,028	
(Hot Cell)	<u>52,125</u>	<u>146,248</u>			<u>146,248</u>	
Total Nuclear Insurance Costs	150,863	423,276		2.806	423,276	
Total Vault DECON Costs	2,657,409	4,572,562		1.721/3.801 ^(d)	10,100,347	

(a) Update of Table 9.5-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means costs for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 6.2. Summary of Estimated Costs of Preparations for Safe Storage for the Reference Vault ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Fuel Storage Area						
Disposal of Radioactive Materials ^(a)	1,500	5,579	0.2	3.719/22.757 ^(c)	34,136	1.1
Storage of Radioactive Materials and Contaminated Materials	2,400	8,926	0.3	3.719/22.757 ^(c)	54,617	1.7
Dedicated Staff Labor	130,938	183,314	6.2	1.400	183,314	5.7
Energy	43,483	46,353	1.6	1.066	46,353	1.4
Special Tools and Equipment	32,000	48,544	1.6	1.517	48,544	1.5
Miscellaneous Supplies	34,720	52,670	1.8	1.517	52,670	1.6
Nuclear Insurance	47,840	134,225	4.5	2.806	134,225	4.2
License Fees	<u>89,280</u>	<u>124,992</u>	<u>4.2</u>	1.400	<u>124,992</u>	<u>3.9</u>
Subtotal	382,162	604,602	20.4		678,851	21.1
Contingency (25%)	<u>95,540</u>	<u>151,151</u>			<u>169,713</u>	
Total Dedicated Cost for Fuel Storage Area	477,702	755,753			848,564	
Hot Cell Cost ^(d)	100,130	195,459	5.3	1.952/4.227 ^(c)	423,299	10.5
Support Staff Cost ^(d)	<u>1,960,708</u>	<u>2,744,992</u>	<u>74.3</u>	1.400	<u>2,744,992</u>	<u>68.3</u>
Total Cost of Preparations for Safe Storage	2,538,540	3,696,203	100.0	1.456/1.582 ^(c)	4,016,854	100.0

(a) Update of Table 9.5-7 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 6.3. Summary of Estimated Annual Costs of Safe Storage for the Reference Vault ISFSI^(a,b,c)

	Mid-1981 Estimated Annual Cost (\$)	Escalation Factor	January 1993 Estimated Annual Cost (\$)
<u>Labor</u>			
Inspection and Quality Assurance Verification	4,000	1.400	5,600
Secretarial	3,880	1.400	5,432
Repair	2,500	1.400	3,500
Security	6,100	1.400	8,540
Environmental and Radiological Monitoring	7,960	1.400	11,144
Inspection and Quality Assurance Verification	<u>1,000</u>	1.400	<u>1,400</u>
Total Labor Costs	25,440		35,616
<u>Other Costs</u>			
Main Building Roof Repair	2,180	1.400	3,307
Main Building Roof Replacement	4,290	1.400	6,508
Pest Control	500	1.400	759
Equipment and Supplies	400	1.517	607
Parts for Monitoring Intrusion and Fire System, Including Video Monitoring	2,000	1.517	3,034
Emergency Maintenance	1,000	1.400	1,400
Utilities	1,140	1.066	1,215
Health and Safety Inspections	780	1.400	1,092
Nuclear Liability Insurance	20,000	2.565	56,114
Total Other Costs	<u>32,290</u>		<u>74,036</u>
Subtotal	57,730		109,652
Contingency (25 %)	<u>14,433</u>		<u>27,413</u>
Total Annual Safe Storage Care Costs	72,163		137,064

(a) Update of Table 9.5-12 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

Table 6.4. Summary of Estimated Decontamination Costs for the Reference Vault ISFSI^(a,b)

Cost Category	Decommissioning Costs in Thousands of 1993 \$				
	DECON	Dismantlement Deferred for			
		10 years	30 years	50 years	100 years
Fuel Storage Area					
Disposal of Radioactive Materials	271.5	265.4	162.6	89.9	75.4
Dedicated Staff Labor	287.9	265.6	223.3	198.0	192.8
Energy	76.4	76.4	75.8	71.4	71.4
Special Tools and Equipment	94.8	94.8	85.4	75.9	75.9
Miscellaneous Supplies	37.2	33.5	27.9	24.9	24.9
Nuclear Insurance	221.6	46.9	46.9	42.1	42.1
License Fees	<u>125.0</u>	<u>125.0</u>	<u>125.0</u>	<u>125.0</u>	<u>125.0</u>
Subtotal	1,114.4	907.6	746.9	627.1	607.4
Contingency (25%)	<u>278.6</u>	<u>226.9</u>	<u>186.7</u>	<u>156.8</u>	<u>151.9</u>
Total Dedicated Cost for Fuel Storage	1,393.0	1,134.4	933.6	783.8	759.3
Hot Cell Costs ^(c)	1,133.0	1,035.4	1,035.4	1,035.4	1,035.4
Support Staff Cost ^(c)	<u>2,051.1</u>	<u>980.4</u>	<u>980.4</u>	<u>980.4</u>	<u>980.4</u>
Total Vault DECON Cost	4,577.0	3,150.2	2,949.4	2,799.6	2,775.1

(a) Update of Table 9.5-13 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) Includes a 25% contingency.

Table 6.5. Summary of Estimated Costs of SAFSTOR for the Reference Vault ISFSI^(a,b)

Shutdown	SAFSTOR Decommissioning Costs in Thousands of 1993 Dollars				
	DECON	SAFSTOR			Total
		Preparations for Safe Storage	Storage Period	Deferred Decontamination	
0	4,572.6	0.0	0.0	0.0	4,572.6
10	--	3,696.2	1,370.6	3,150.2	8,217.1
30	--	3,696.2	4,111.9	2,949.4	10,757.5
50	--	3,696.2	6,853.2	2,799.6	13,349.0
100	--	3,696.2	13,706.4	2,775.1	20,177.7

(a) Update of Table 9.5-14 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

Table 6.6. Summary of Estimated Costs of ENTOMB for the Reference Vault ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Fuel Storage Area						
Radioactive Waste Storage	14,740	12,626	0.5	0.857	12,626	0.2
Radioactive Waste Disposal ^(c)	5,411	18,624	0.8	3.442/20.529 ^(d)	111,082	1.9
Dedicated Staff Labor	172,814	241,939	9.8	1.400	241,939	4.1
Energy	57,974	61,800	2.5	1.066	61,800	1.0
Special Tools and Equipment	62,500	94,813	3.8	1.517	94,813	1.6
Miscellaneous Supplies	84,440	128,095	5.2	1.517	128,095	2.2
Nuclear Insurance	62,330	174,879	7.1	2.806	174,879	2.9
License Fees	<u>89,280</u>	<u>124,992</u>	<u>5.1</u>	1.400	<u>124,992</u>	<u>2.1</u>
Subtotal	549,489	857,769	34.8		950,226	16.0
Contingency (25%)	<u>137,372</u>	<u>214,442</u>			<u>237,557</u>	
Total Dedicated Cost for Fuel Storage	686,861	1,072,211			1,187,783	
Hot Cell Cost ^(e)	100,130	195,459	6.3	1.952/44.187 ^(f)	4,424,417	59.5
Support Staff Cost ^(e)	<u>1,304,021</u>	<u>1,825,629</u>	<u>59.0</u>	1.400	<u>1,825,629</u>	<u>24.5</u>
Total Entombment Cost	2,091,012	3,093,298	100.0	1,479/3.557 ^(f)	7,437,829	100.0
Annual Surveillance and Maintenance Cost	24,300	35,058		1.443	35,058	

(a) Update of Table 9.5-15 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) Includes only dry solid wastes.

(d) X/Y means escalation for disposal at Hanford/Barnwell.

(e) Includes a 25% contingency.

(f) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

7 Cost Estimate Update for the Reference Cask ISFSI

The updated cost estimate for decommissioning the reference cask ISFSI using the DECON option is presented in this section. Included in this alternative are dedicated staff and associated costs, and managerial and support staff costs. SAFSTOR is not an option for decommissioning the reference Cask ISFSI.

The total cost of DECON of the reference Cask ISFSI with in-compact radwaste disposal at the Hanford Site, including a 25% contingency allowance, has increased from

\$1.7 million in mid-1981 to just over \$2.5 million in 1993. This represents a 50% increase over the last 11.5 years. When out-of-compact radwaste disposal at the Barnwell Site is considered, the total cost of DECON rises to over \$2.9 million. Even with the most expensive radwaste disposal option, less than 10% of the total DECON budget is committed to this cost category. The total estimated costs of DECON for the reference Cask ISFSI are summarized in Table 7.1.

Table 7.1. Summary of Estimated Costs of DECON for the Reference Cask ISFSI^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radioactive Materials	19,089	94,146	4.9	4.932/22.326 ^(c)	426,178	19.0
Dedicated Worker Staff Labor	142,646	199,704	10.5	1.400	199,704	8.9
Support Staff Cost	946,968	1,320,597	69.2	1.395	1,320,597	58.9
Special Tools and Equipment	73,000	110,741	5.8	1.517	110,741	4.9
Miscellaneous Supplies	24,690	37,455	2.0	1.517	37,455	1.7
License Fees	<u>89,280</u>	<u>124,992</u>	<u>6.5</u>	<u>1.400</u>	<u>124,992</u>	<u>5.6</u>
Total Labor/Matl. Costs	1,276,584	1,793,489	98.9	1.405	2,219,667	99.0
Energy	<u>20,583</u>	<u>21,942</u>	<u>1.1</u>	1.066	<u>21,942</u>	<u>1.0</u>
Total Labor/Energy/Disposal Costs	1,316,256	1,909,577	100.0	1.451/1.703 ^(c)	2,241,609	100.0
25% Contingency	<u>329,064</u>	<u>477,394</u>			<u>560,402</u>	
Adjusted Cost w/Contingency	1,645,320	2,386,971			2,802,011	
Nuclear Insurance w/Contingency	<u>60,838</u>	<u>170,973</u>		2.810	<u>170,973</u>	
Total Cask ISFSI DECON Cost	1,706,158	2,557,944		1.499/1.743 ^(d)	2,972,983	

(a) Update of Table 9.6-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

8 Cost Estimate Update for the Hot Cell

The updated cost estimates for decommissioning the hot cell via DECON, SAFSTOR, and ENTOMB are presented here. Each alternative includes only what has been previously designated as dedicated staff and associated costs. The cost of decommissioning the hot cell, by each alternative, is included in the total decommissioning of the reference Drywell, Silo, and Vault ISFSIs.

8.1 Cost of DECON

The total cost of DECON of the hot cell with in-compact radwaste disposal at the Hanford Site, including a 25 % contingency allowance, has escalated from \$435,000 in mid-1981 to over \$1.1 million in 1993. This represents an increase in total costs by a factor of 2.6 over the 11.5-year period. This escalation is due in large part to the rise in radwaste disposal costs. When out-of-compact radwaste disposal is considered, the total estimated costs increase to almost \$5.0 million in 1993 with over 95 % of the DECON total committed to radwaste disposal. The total estimated costs of DECON for the hot cell are summarized in Table 8.1.

8.2 Cost of SAFSTOR

The cost of the preparations for safe storage and the deferred decontamination costs at the end of the safe

storage period are summarized in Table 8.2. The radwaste disposal costs for SAFSTOR are not affected by the length of decontamination deferment, because even at the end of 100 years of storage the radwaste volume to be disposed will not have been reduced.

The total cost of SAFSTOR for 10, 30, 50, and 100-year decontamination deferment periods is summarized in Table 8.3.

8.3 Cost of ENTOMB

Table 8.4 summarizes the total estimated costs of ENTOMB at the hot cell. ENTOMB costs can be broken into two categories, preparation costs and annual costs. For in-compact radwaste disposal at the Hanford Site, preparation costs are \$195,000, with 23.5 % of the total cost committed to radwaste disposal. For out-of-compact radwaste disposal at the Barnwell Site, the total increases to \$4.42 million with radwaste disposal accounting for almost 97 % of the ENTOMB preparations budget. Annual costs of ENTOMB are just over \$35,000.

Table 8.1. Summary of Estimated Costs of DECON for the Hot Cell^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1993 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1993 Estimated Cost (\$)	Percent of Total
Disposal of Radwaste	175,476	603,970	76.7	3.442/20.723 ^(c)	3,636,395	95.2
Dedicated Staff Labor	95,450	133,630	17.0	1.400	133,630	3.5
Rental of Major Equipment	15,792	23,843	3.0	1.510	23,843	0.6
Purchase of Minor Equipment and Supplies	<u>10,000</u>	<u>15,170</u>	<u>1.9</u>	<u>1.517</u>	<u>15,170</u>	<u>0.4</u>
Total Labor/Matl. Costs	121,242	172,643	21.9	1.424	172,643	4.5
Energy	<u>9,844</u>	<u>10,494</u>	<u>1.3</u>	1.066	<u>10,494</u>	<u>0.3</u>
Total Labor/Energy/Disposal Costs	306,562	787,107	100.0	2.568/12.451 ^(c)	3,819,532	100.0
25 % Contingency	<u>76,641</u>	<u>196,777</u>			<u>954,883</u>	
Adjusted Cost w/Contingency	383,203	983,884			4,774,415	
Nuclear Insurance w/Contingency	<u>52,125</u>	<u>146,248</u>		2.806	<u>146,248</u>	
Total Hot Cell ISFSI DECON Cost	435,328	1,130,132		2.596/11.303 ^(d)	4,920,663	

(a) Update of Table 9.7-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

Table 8.2. Summary of Preparations for Safe Storage and Deferred Decontamination for the Hot Cell^(a,b,c)

Item	Preparations for Safe Storage		Deferred Dismantlement	
	Hanford	Barnwell	Hanford	Barnwell
Dedicated Staff Labor	55,398	55,398	121,601	121,601
Rental of Major Equipment	8,441	8,441	19,646	19,646
Purchase of Minor Equipment and Supplies	5,158	5,158	12,096	12,096
Energy	3,765	3,765	9,035	9,035
Nuclear Insurance	46,855	46,855	96,188	96,188
Disposal of Radwaste Material	<u>36,751</u>	<u>219,023</u>	<u>569,765</u>	<u>569,765</u>
Subtotal	156,367	338,639	828,330	828,330
25% Contingency	<u>39,092</u>	<u>84,660</u>	<u>207,083</u>	<u>207,083</u>
Total Costs of Hot Cell Preparations for Safe Storage and Deferred Dismantlement	195,459	423,299	1,035,413	1,035,413

(a) Update of Table 9.7-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) January 1993 dollars.

Table 8.3. Total Estimated Costs of SAFSTOR for the Hot Cell^(a,b,c)

Item	Estimated Costs and Cost Fractions with Deferred Decontamination							
	10 years		30 years		50 years		100 years	
	Cost	Percent of Total	Cost	Percent of Total	Cost	Percent of Total	Cost	Percent of Total
Hot Cell								
Dedicated Staff Labor	627,939	42.1	1,529,819	61.1	2,431,699	69.1	4,686,399	77.4
Rental of Major Equipment	31,086	2.1	37,086	1.5	43,086	1.2	58,086	1.0
Purchase of Minor Equipment and Supplies	31,654	2.1	60,454	2.4	89,254	2.5	161,254	2.7
Energy	23,975	1.6	43,400	1.7	64,400	1.8	116,800	1.9
Nuclear Insurance	171,100	11.5	227,214	9.1	283,328	8.1	423,613	7.0
Disposal of Radwaste Material	<u>606,516</u>	<u>40.6</u>	<u>606,516</u>	<u>24.2</u>	<u>606,516</u>	<u>17.2</u>	<u>606,516</u>	<u>10.0</u>
Subtotal	1,492,269	100.0	2,504,488	100.0	3,518,282	100.0	6,052,667	100.0
25 % Contingency	<u>373,067</u>		<u>626,122</u>		<u>879,570</u>		<u>1,513,167</u>	
Total SAFSTOR Costs	1,865,336		3,130,610		4,397,852		7,565,834	

(a) Update of Table 9.7-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) January 1993 dollars.

Table 8.4. Total Estimated Costs of ENTOMB for the Hot Cell^(a,b,c)

Item	Hanford Preparations Cost	Percent of Total	Annual Cost (\$/yr)	Percent of Total	Barnwell Preparations Cost (\$)	Percent of Total
Disposal of Radwaste	36,751	23.5	0		3,419,917	96.6
Dedicated Staff Labor	55,398	35.4	22,547	80.4	55,398	1.6
Rental of Major Equipment	8,441	5.4	300	1.1	8,441	0.2
Purchase of Minor Equipment and Supplies	5,158	3.3	1,517	5.4	5,158	0.1
Energy	3,765	2.4	1,117	4.0	3,765	0.1
Nuclear Insurance	<u>46,855</u>	<u>30.0</u>	<u>2,565</u>	<u>9.1</u>	<u>46,855</u>	<u>1.3</u>
Subtotal	156,367	100.0	28,046	100.0	3,539,534	100.0
25 % Contingency	<u>39,092</u>		<u>7,012</u>		<u>884,883</u>	
Total ENTOMB Cost	195,459				4,424,417	
Annual Surveillance and Maintenance Costs ^(d)			35,058			

(a) Update of Table 9.7-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) January 1993 dollars.

9 Cost Estimate Update for the Transporter

Table 9.1 summarizes the costs incurred during decommissioning of the transporter via DECON. For in-compact disposal of the radwaste at the Hanford Site, the total estimated cost is \$63,000. Out-of-compact radwaste

disposal at the Barnwell Site increases total DECON costs to just under \$408,000. Radwaste disposal for either option accounts for over 97% of the total DECON budget.

Table 9.1. Summary of Estimated Costs of DECON for the Transporter^(a,b)

Cost Category	1981 Estimated Cost (\$)	Hanford 1983 Estimated Cost (\$)	Percent of Total	11.5-Year Escalation Factor	Barnwell 1983 Estimated Cost (\$)	Percent of Total
Disposal of Radwaste	13,971	49,644	97.5	3.553/23.272 ^(c)	325,128	99.6
Labor costs	<u>900</u>	<u>1,260</u>	<u>2.5</u>	1.400	<u>1,260</u>	<u>0.4</u>
Total Labor/Disposal Costs	14,871	50,904	100.0	3.423/21.948 ^(c)	326,388	100.0
25% Contingency	<u>3,718</u>	<u>12,726</u>			<u>81,597</u>	
Total Transporter DECON Cost	18,589	63,631		3,423/21.948 ^(d)	407,985	

(a) Update of Table 9.7-8 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) X/Y means escalation for disposal at Hanford/Barnwell.

(d) X/Y means escalation of total decommissioning costs with disposal at Hanford/Barnwell.

10 Applicability of Results to Future Cost Estimate Updates

Escalation of decommissioning costs for the types of reference fuel-cycle facilities covered in this study can be calculated from an estimate made at some previous time to a future current time using an escalation formula given in 10 CFR 50.75. In this formula, shown as Equation 10.1 below with minor modifications,¹ decommissioning costs are divided into four general areas that tend to escalate similarly: (1) labor, materials, and services; (2) energy and waste transportation; (3) radioactive waste disposal; and (4) taxes and insurance.

$$\text{Cost in Year X} = [\text{Adjusted Total Base Cost in Year Y}] \\ * [AL_x + BE_x + CB_x] \quad (10.1) \\ + \text{T\&I Costs in Year X}^{(a)}$$

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 and insurance
A = fraction of the adjusted total decommissioning cost attributable to labor, materials, and services in Year Y
B = fraction of the adjusted total decommissioning cost attributable to energy and waste transportation in Year Y
C = fraction of the adjusted total decommissioning cost attributable to waste burial 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

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

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

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, adding 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 to be used in Equation 10.1 for decommissioning the reference ISFSIs were developed from January 1993 cost estimate updates. The coefficients were calculated based on the information found in the summary tables. A set of coefficients and values are given in Table 10.1 for each decommissioning alternative for each reference ISFSI.

¹ 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 could be added to the formula but would also be kept separate, because their costs have generally not been considered.

Applicability of Results

Table 10.1. Formula Coefficients for Escalating DECON Costs for Reference Independent Spent Fuel Storage Installations

Activity	A	B	C	B _x (1993)		T&I _y ^(a)	1983 Adjusted Cost ^(a)
				Hanford	Barnwell		
Wet ISFSI	0.371	0.017	0.611	1.00	6.44	0.342	8.735
Drywell ISFSI	0.262	0.007	0.731	1.00	6.09	0.848	21.106
Silo ISFSI	0.554	0.009	0.437	1.00	5.95	0.497	5.404
Vault ISFSI	0.710	0.026	0.263	1.00	6.06	0.423	4.573
Cask ISFSI	0.939	0.011	0.049	1.00	4.53	0.171	2.558
Hot Cell	0.219	0.013	0.767	1.00	6.02	0.146	1.130
Transporter	0.025	0.000	0.975	1.00	6.55		0.064

(a) Costs are in millions of 1993 dollars and include a 25% contingency.

11 References

1. J. D. Ludwick and E. B. Moore. 1984. *Technology, Safety, and Costs of Decommissioning Reference Independent Spent Fuel Storage Installations*. NUREG/CR-2210, Pacific Northwest Laboratory, Richland, Washington.
2. 10 CFR 50.75. 1993. U.S. Nuclear Regulatory Commission, *Reporting and Recordkeeping for Decommissioning Planning*. U.S. Code of Federal Regulations.
3. Whitman, Requardt, and Associates. 1991. *The Handy-Whitman Index of Public Utility Construction Costs*. Bulletin No. 134, Baltimore, Maryland.
4. U.S. Department of Energy. February 1993. *Monthly Energy Review*. DOE/EIA-0035(93/2).
5. U.S. Department of Commerce. 1992. *Statistical Abstract of the United States*, 112th Edition. Washington, D.C.
6. Tri-State Motor Transit Co. September 1992. *Secured Transportation Services Radioactive Materials Tariff*. Supplement No. 1 to ICC TSMT 4007-C.
7. U.S. Ecology Inc., Washington Nuclear Center. Effective January 1, 1993. *Schedule of Charges, Radioactive Waste*.
8. Chem-Nuclear Systems, Inc. Effective January 1, 1993. *Barnwell Low-Level Radioactive Waste Management Facility Rate Schedule*.
9. Y. Liu and T. L. Miles. 1992. *Cost Update - Technology, Safety, and Costs of Decommissioning a Reference Uranium Hexafluoride Conversion Plant*. NUREG/CR-1757, Pacific Northwest Laboratory, Richland, Washington.

Appendix A

Table Number Cross-Reference List Between NUREG/CR-2210 and This Addendum

Appendix A

Table Number Cross-Reference List Between NUREG/CR-2210 and This Addendum

Table A.1. Table Number Cross-Reference List (between NUREG/CR-2210 and this Addendum)

No. in Current Report	Title	No. in 1981 NUREG/CR-2210
S.1	Summary of Estimated Costs of Decommissioning Alternatives for the Reference ISFSIs	9.0-1
S.2	Average Annual Escalation Factors	--
2.1	Escalation Factors for Energy Costs	--
3.1	Summary of Estimated Costs of DECON for the Reference Wet ISFSI	9.2-1
3.2	Summary of Estimated Costs of Preparations for Safe Storage for the Reference Wet ISFSI	9.2-7
3.3	Summary of Estimated Annual Costs for Safe Storage for the Reference Wet ISFSI	9.2-12
3.4	Summary of Estimated Decontamination Costs for the Reference Wet ISFSI	9.2-13
3.5	Summary of Estimated Costs of SAFSTOR for the Reference Wet ISFSI	9.2-14
4.1	Summary of Estimated Costs of DECON for the Reference Drywell ISFSI	9.3-1
4.2	Summary of Estimated Costs of SAFSTOR for the Reference Drywell ISFSI	9.3-8
5.1	Summary of Estimated Costs of DECON for the Reference Silo ISFSI	9.4-1
5.2	Summary of Estimated Costs of SAFSTOR for the Reference Silo ISFSI	9.4-8
6.1	Summary of Estimated Costs of DECON for the Reference Vault ISFSI	9.5-1
6.2	Summary of Estimated Costs of Preparations for Safe Storage for the Reference Vault ISFSI	9.5-7
6.3	Summary of Estimated Annual Costs for Safe Storage for the Reference Vault ISFSI	9.5-12
6.4	Summary of Estimated Decontamination Costs for the Reference Vault ISFSI	9.5-13
6.5	Summary of Estimated Costs of SAFSTOR for the Reference Vault ISFSI	9.5-14
6.6	Summary of Estimated Costs of ENTOMB for the Reference Vault ISFSI	9.5-15
7.1	Summary of Estimated Costs of DECON for the Reference Cask ISFSI	9.6-1
8.1	Summary of Estimated Costs of DECON for the Hot Cell	9.7-1
8.2	Summary of Preparations for Safe Storage and Deferred Decontamination for the Hot Cell	9.7-8
8.3	Total Estimated Costs of SAFSTOR for the Hot Cell	9.7-9
8.4	Total Estimated Costs of ENTOMB for the Hot Cell	9.7-16
9.1	Summary of Estimated Costs of DECON for the Transporter	9.8-1
10.1	Formula Coefficients for Escalating DECON Costs for the Independent Spent Fuel Storage Installations	--
B.1	Shipping Containers used for Wastes in this Study	B.2-1
B.2	Basic Transportation Rates	B.3-1
B.3	Additional Transportation Charges	B.3-2
B.4	U.S. Ecology Low-Level Waste Burial Costs	B.4-1
B.5	U.S. Ecology Low-Level Waste Burial Surcharges	--
B.6	Chem-Nuclear Low-Level Radioactive Waste Management Facility Rate Schedule	--
B.7	Management and Support Staff Costs of Decommissioning for the Reference ISFSIs	9.1-1

Appendix B

Containers, Transport, and Disposal Cost Schedules

Appendix B

Containers, Transport, and Disposal Cost Schedules

Table B.1. Shipping Containers Used for Wastes in This Study^(a)

Shipping Container	Mid-1981 Estimated Unit Unit Cost (\$)	January 1983 Unit Cost (\$)
208-L Steel Drum	30	25.82 ^(b)
110-L Steel Drum	20	NA
Polyethylene Drum Liner ^(c)	1	1
Fiberglassed Plywood Box (3.456m ³) ^(d)	100	NA
Fiberglassed Plywood Box	Variable	NA
Steel Box	NA	227.5/m ^{3(b)}

(a) Update of Table B.2-1 in NUREG/CR-2210.

(b) Chem-Nuclear quote.

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

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

NA = Not Applicable.

Appendix B

**Table B.2. 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 ^(c)	Column 2 ^(d)	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.

(b) Table taken from Tri-State Motor Transit Co., Docket No. MC-10937.

(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 B.3. Additional Transportation Charges When Gross Vehicle Weight Exceeds 20.41 Mg^(a,b,c)

Gross Vehicle Weight (Mg)		Base Cost (\$/mi)	Additional Surcharge (\$)	Total Charge (\$/mi)
Lower Limit	Upper Limit			
20.41	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-2210.

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

(c) From Reference 6, for the State of Washington.

Appendix B

Table B.4. Low-Level Waste Burial Costs and Surcharges at Hanford^(a,b)

U.S. Ecology
Washington Nuclear Center
Radioactive Waste Disposal
Effective January 1, 1993

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

(a) Prices shown as of January 1, 1983. Prices taken from Reference 7.

(b) Update of Table B.4-1 in NUREG/CR-2210.

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

Table B.4. (contd)

C. Minimum Disposal Charge: \$1000/shipment**D. Curle 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

Schedule C - Tax and Fee Rider

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

Table B.5. Low-Level Waste Burial Costs and Surcharges at Barnwell^(a)

Chem-Nuclear Waste Management Facility Rate Schedule January 1993	
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 Shipment	Surcharge per 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
Out of Compact Access Fee	\$220.00 per ft ³

^(a) Taken from Reference 8.

Table B.6. Management and Support Staff Costs of Decommissioning at the Reference ISFSIs^(a,b)

Position	Total Support Staff Costs in 1993 \$ for Decommissioning Alternatives at Each Type of ISFSI									
	Wet		Drywell		Silo		Vault		Cask	
	DECON ^(c)	SAFSTOR ^(d)	DECON ^(e)	SAFSTOR ^(f)	DECON ^(g)	SAFSTOR ^(h)	DECON ⁽ⁱ⁾	SAFSTOR ^(j)	ENTOMB ^(k)	DECON ^(l)
Project Manager	257,421	340,340	361,379	392,319	221,530	242,570	226,481	288,361	206,679	190,590
Decommissioning Superintendent	257,421	340,340	361,379	392,319	221,530	242,570	226,481	288,361	206,679	190,590
Health and Safety Supervisor	174,254	230,384	244,626	265,570	149,959	164,201	153,310	195,198	139,906	129,015
Contract and Accounting Specialist	131,852	176,022	186,571	203,052	112,733	126,578	115,371	148,334	104,163	95,593
Quality Assurance Supervisor	105,215	149,785	164,399	182,665	83,295	123,482	85,487	122,020	73,066	63,567
Industrial Safety Specialist	82,834	128,282	140,744	159,070	61,575	70,372	61,575	97,494	49,114	39,584
QA Engineer	84,081	126,121	136,631	153,053	64,374	74,227	65,688	103,787	54,521	46,638
Health Physicist and Shipment Specialist	126,121	169,475	180,642	197,064	107,071	117,582	109,699	142,543	98,532	89,993
Security Supervisor	112,755	162,868	176,180	195,755	89,264	101,010	91,613	130,764	78,302	68,123
Security Patrolman	45,427	68,141	73,819	83,047	34,780	39,749	35,490	59,268	29,457	25,198
Control Room Operator	57,960	88,389	96,600	108,675	43,470	50,232	44,436	68,586	36,225	29,946
Clerk and Procurement Specialist	92,165	121,853	129,385	140,463	79,315	86,848	81,087	103,242	73,998	68,237
Clerk	51,391	73,030	79,115	87,568	41,248	46,320	42,263	59,168	36,515	32,458
Secretary	124,083	169,050	180,207	197,112	104,811	115,630	107,178	140,988	95,682	87,230
Decommissioning Engineer	<u>221,283</u>	<u>292,562</u>	<u>310,647</u>	<u>337,244</u>	<u>190,431</u>	<u>208,517</u>	<u>194,686</u>	<u>247,879</u>	<u>177,665</u>	<u>163,834</u>
Subtotal	1,924,262	2,636,641	2,822,324	3,094,975	1,605,389	1,809,885	1,640,845	2,195,993	1,460,503	1,320,597
25% Contingency	<u>481,065</u>	<u>659,160</u>	<u>705,581</u>	<u>773,744</u>	<u>401,347</u>	<u>452,471</u>	<u>410,211</u>	<u>548,998</u>	<u>365,126</u>	<u>330,149</u>
Totals	2,405,327	3,295,802	3,527,905	3,868,719	2,006,736	2,262,356	2,051,056	2,744,992	1,825,629	1,650,746

(a) Update of Table 9.1-1 in NUREG/CR-2210.

(b) The number of significant figures is for computational completeness.

(c) Cost accumulation time, 25 months.

(d) Cost accumulation time, 33 months.

(e) Cost accumulation time, 35 months.

(f) Cost accumulation time, 38 months.

(g) Cost accumulation time, 21.5 months.

(h) Cost accumulation time, 23.5 months.

(i) Cost accumulation time, 22 months.

(j) Cost accumulation time, 28 months.

(k) Cost accumulation time, 20 months.

(l) Cost accumulation time, 18.5 months.

**DATE
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