Department of Energy
Savannah River Operations Office

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REPORT ON THE SAVANNAH RIVER SITE ALUMINUM-BASED SPENT NUCLEAR FUEL ALTERNATIVES COST STUDY

December 1998

EXECUTIVE SUMMARY

This report presents the relevant results from several recent analyses that were conducted to estimate the life-cycle costs of technology alternatives for the interim management and ultimate disposal of aluminum-based spent nuclear fuel (SNF) currently stored at or slated to be shipped to the Savannah River Site (SRS). The life-cycle costs of eight technology alternatives were evaluated:

- Direct Co-Disposal
- Melt and Dilute
- Reprocessing
- Press and Dilute
- Glass Material Oxidation Dissolution System (GMODS)
- Electrometallurgical Treatment
- Dissolve and Vitrify
- Plasma Arc

The initial analyses assumed new facilities (a "greenfield" approach), using privatization as the procurement approach. Later, the cost estimates were revised to consider a line item project approach and the modification and use of an existing (105L) reactor facility. Variations of the Direct Co-Disposal and Melt and Dilute alternatives were evaluated to study the cost impacts of using existing versus new (greenfield) facilities. For the Reprocessing alternative, several variations were analyzed: reprocessing using H-canyon followed by treatment of the residual SNF in either a new, reduced size Co-Disposal facility or a new, reduced size Melt and Dilute facility; and reprocessing using H-canyon followed by reprocessing in a new, smaller reprocessing facility.

It was assumed that SRS has or will receive a total of approximately 27,000 highly enriched uranium (HEU) materials test reactor equivalent (MTRE) fuel assemblies, 5,000 low enriched uranium (LEU) MTRE, and 500 HEU involute cores (e.g., High Flux Isotope Reactor cores). This represents approximately 42 MTHM of aluminum-based SNF.

Life-cycle costs were analyzed to include interim Wet Storage Costs; Transfer, Treatment, and Storage Costs (facility procurement/modification and operations costs); Fuel and Waste Processing Costs (reprocessing, high-level waste vitrification, and low-level waste processing); Repository Disposal Costs (transportation, operations, and development); and Uranium Credits. Uranium credits were estimated to range from \$110 to \$150M. However, due to the recently signed agreement between Russia and the U.S. (that calls for the potential deferment of DOE HEU sales), no value was assumed in the final cost totals. Costs were also calculated for receipt and continued wet storage (the No Action alternative), although this case does not prepare fuel for repository disposal.

Table E-1 provides a summary of the cost estimates, consistent with the most recent project policy, technology implementation, canyon utilization, and inventory assumptions. The line item approach is presented as the analyses indicated that privatization would not produce any

significant cost savings. The line item approach is also consistent with the recently approved FY 2000 start for a project to design a transfer, treatment, and storage facility.

Of the alternatives, the lowest total life-cycle costs occur when existing facilities are used. These are the Direct Co-Disposal and the Melt and Dilute alternatives. Reprocessing in H-Canyon until FY 2010, followed afterwards by direct co-disposal or melt and dilute of the residual SNF receipts, had life-cycle costs approximately $130M higher. Considering the uncertainty in the cost estimates, this indicates no significant difference in the life-cycle costs between these alternatives.

Alternative	Wet Storage and Handling	Transfer, Treatment, and Storage	Fuel and Waste Processing	Repository Disposal	Total*
Direct Co-Disposal – Greenfield	676	1,241	33	169	2,120
Direct Co-Disposal – 105L	766	919	37	169	1,890
Melt & Dilute – Greenfield	676	1,363	47	56	2,140
Melt & Dilute – 105L	766	1,073	55	56	1,950
Reprocess – Co-Disposal	655	676	610	72	2,010
Reprocess – Melt & Dilute	655	765	610	36	2,070
Reprocess (Existing/New Facility)	655	1,075	670	32	2,430
Press & Dilute	676	1,566	46	82	2,370
GMODS	676	2,065	67	198	3,010
Electrometallurgical Treatment	676	2,625	67	23	3,390
Dissolve & Vitrify	676	2,411	67	198	3,350
Plasma Arc	676	2,063	67	78	2,880
No Action**	1,650	0	78	0	1,730

*Totals rounded to $10M.
**This alternative does not produce an acceptable disposal form.

Table E-1. Summary of Life-Cycle Costs – Line Item Approach (FY 1998 $M)

Constructing a greenfield facility for the Direct Co-Disposal and Melt and Dilute alternatives results in an approximate $200M increase in life-cycle costs over those estimated for use of the existing 105L facility. The Electrometallurgical Treatment and three vitrification technologies (Plasma Arc, GMODS, and Dissolve and Vitrify) are approximately $1.0B to $1.3B higher than the other alternatives. Finally, costs for the No Action alternative were estimated to be approximately $1.7B, based on continued wet storage through FY 2035.

Several sensitivity evaluations were also conducted in conjunction with the alternatives analyses:

Reduced Receipts – Cost impacts due to a reduction in the number of receipts were calculated for the Co-Disposal, Melt and Dilute, and Reprocessing alternatives. A 25 percent reduction decreases life-cycle costs by approximately $50-150M. The decrease, however, does not result in any significant difference in relative costs between the alternatives.

Delay in Reprocessing – The impacts of delayed H-canyon availability due to its potential use for other missions were estimated. One potential mission involves the blenddown of HEU for commercial use by TVA. Another mission is the conversion of excess plutonium for use as a MOX fuel or for immobilization in HLW glass with subsequent disposal in a geologic repository. Two cases were evaluated: a delay of 2 1/2 years and a delay of 4 years. The delays result in increased life-cycle costs for the reprocessing options of approximately $150-200M.

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1. INTRODUCTION

Initial estimates of costs for the interim management and disposal of aluminum-based spent nuclear fuel (SNF) were developed during preparation of the Environmental Impact Statement (EIS) on the Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel. In conjunction with the EIS effort, the Department of Energy (DOE) established the Research Reactor Spent Nuclear Fuel Task Team (Task Team) to develop a technical strategy leading to the ultimate disposition of the existing Savannah River Site (SRS) inventory of aluminum-based SNF as well as any future receipts of aluminum-based SNF. The Task Team evaluated multiple alternatives, assessing programmatic, technical, and schedule risks, and generated life-cycle cost projections for each alternative. The eight technology alternatives evaluated were:

- Direct Co-Disposal
- Melt and Dilute
- Reprocessing
- Press and Dilute
- Glass Material Oxidation Dissolution System (GMODS)
- Electrometallurgical Treatment
- Dissolve and Vitrify
- Plasma Arc

With issuance of the Record of Decision for the Foreign Research Reactor (FRR) EIS, DOE committed to "commission or conduct an independent study of nonproliferation and other (e.g., cost and timing) implications of chemical separations of spent nuclear fuel from foreign research reactors." The Westinghouse Savannah River Company (WSRC) was tasked to provide the cost and schedule component of the study.

The WSRC cost study, completed in December 1997, provided updates to the Task Team's life-cycle cost projections. Several assumptions were revised for this study, including (1) new facilities and services were to be privatized, (2) reprocessing the SNF inventory backlog would require an additional two years (until 2010), (3) repository costs were to be revised in accordance with the current repository Viability Assessment and Total System Life Cycle Cost estimates, and (4) the technology implementation schedules should be adjusted (slipped by 3-6 years) to be consistent with the project implementation strategy. The methodology used by WSRC to conduct the alternatives cost evaluations was reviewed by the National Research Council, which found that "[t]he cost estimates in both the Task Team report and the alternative cost study appear to be sufficiently complete for comparative purposes and for selecting a small number of alternative treatment options for further consideration."

It is noted that the cost projections developed by the Research Reactor Task Team were not the first attempt to ascertain the cost impacts associated with interim storage and disposal of aluminum-based SNF. See J. F. Krupa, W.R. McDonell, and P.B. Parks, *Life-Cycle Cost Estimates for Disposal of Aluminum-Clad HEU SNF (U),* WSRC-TR-95-0180, April 20, 1995 (UCNI). Both the Task Team and the later WSRC efforts took advantage of this prior work.

In followup to the Business Plan that was developed to look at SNF dry storage, WSRC prepared an addendum to the December 1997 cost study. This addendum estimated the costs for the modification and use of an existing (105L) reactor facility versus a greenfield approach for new facilities (for the Direct Co-Disposal and Melt and Dilute alternatives). The facilities/services procurement approach was also changed from privatization to a line item project, with project start dates adjusted accordingly. The assumptions for reprocessing and high-level waste (HLW) glass costs were also revised. Finally, a 25% reduced receipts case was evaluated to provide insight into the impacts of such a scenario. Later during 1998, in response to discussions with DOE, WSRC assessed the impacts of a delay in reprocessing due to the potential reservation of H-Canyon for other missions (i.e., down blending HEU for commercial use or the conversion of plutonium to either MOX fuel or an immobilized repository disposal form). The value of uranium recovered from reprocessing was also reconsidered to account for the uranium not meeting ASTM specifications for commercial fuel and to address the recently signed agreement between Russia and the U.S. that calls for DOE consideration to defer HEU sales

This report presents the relevant results from these WSRC cost studies, consistent with the most recent project policy, technology implementation, canyon utilization, and inventory assumptions. As this is a summary report, detailed information on the technical alternatives or the cost assumptions raised in each of the abovementioned cost studies is not provided. A comparison table that briefly describes the bases used for the WSRC analyses is included as Appendix A.

The December 1997 Cost Study provides extended descriptions for each of the technical alternatives. Detailed information on the cost factors is provided in the appendices to the December 1997 cost study and the May 1998 Addendum.

2. ASSUMPTIONS

The following assumptions were used in developing the cost estimates. These assumptions are based on prior NEPA decisions for management of SNF at the Savannah River Site, National SNF Program guidance, existing SRS facility schedules, and proposed facility startup and operations.

1. Reprocessing plans are consistent with current canyon missions (e.g., the phased canyon strategy) and assume operation of H-Canyon for the processing of SNF.

2. Reprocessing of the "at risk" SNF identified in the Records of Decision for the Interim Management of Nuclear Materials (IMNM) EIS will be complete by 2001.

3. Reprocessing of the uranium and thorium metal fuels identified in the SNF Management EIS preferred alternative will occur in conjunction with implementation of the phased canyon strategy.

4. Spent nuclear fuel receipts under the Programmatic EIS and the Foreign Research Reactor EIS will occur, with schedules adjusted to reflect the most recent planning basis.

   ´. Foreign research reactor SNF receipts are underway and will continue until FY 2009.

   ´. Domestic research reactor SNF receipts are underway and will continue until FY 2035.

5. The quantities of aluminum-based SNF to be received at the SRS are those identified in the Programmatic EIS and the Foreign Research Reactor EIS, adjusted to reflect that France, Belgium, South Africa, Iran, and Pakistan will not likely participate in the FRR Program.

   ´. Foreign receipts will total approximately 12,700 aluminum-based SNF assemblies and 1,570 Materials Test Reactor Equivalents (MTRE) [approximately 0.6 MTU] of target material.

   ´. Domestic receipts will total approximately 16,200 MTREs and 540 High Flux Isotope Reactor (HFIR) cores.

Under the SNF Management EIS preferred alternative, F-Canyon would be used to reprocess the Experimental Breeder Reactor-II blanket SNF.

The uranium and thorium metal fuels identified in the SNF Management EIS are essentially the same as those identified in Table 5.2-1 of the Research Reactor Task Team Report. Hence, these fuels are sometimes referred to as the Table 5.2-1 fuels.

This represents approximately 42 MTHM of aluminum-based SNF. In contrast, the draft Savannah River Site SNF Management EIS lists a total of approximately 48 MTHM of aluminum-based SNF. The higher value included in the EIS addresses the possibility that the five countries identified above may elect to participate at a later date.

6. Under the reduced inventory case, it is assumed that reductions will be taken across-the-board, i.e., equally split between HEU and LEU MTRE.

7. New transfer/treatment facilities (including a modified 105L facility) are assumed to be operational in FY 2006.

8. The treated SNF (Direct Co-Disposal, Melt and Dilute, and Press and Dilute alternatives) will be stored in standardized co-disposal canisters (nominally 17" OD x 120" length). The HLW from the reprocessing and vitrification alternatives will be stored in Defense Waste Processing Facility (DWPF) type canisters (nominally 24" OD x 120" length).

9. Concrete pad storage is assumed for interim storage of SNF co-disposal canisters pending shipment to the repository. This option provides flexibility in that storage capacity can be procured incrementally and be tied more closely with actual receipts.

10. With the exception of the No Action alternative, the material forms produced by each alternative will be acceptable for repository disposal. Repository studies underway by the National SNF Program will aid in establishing the final parameters for the direct disposal and dilution options. Currently, the permissible enrichments are:

    - For the Direct Co-Disposal alternative: 14.4 Kg U-235 (for 93% BOL enrichment) or 43 Kg U-235 (for 19.5% BOL enrichment).
    - For the Melt and Dilute alternative, the HEU is to be diluted to 5% U-235.
    - For the Press and Dilute alternative, the dilution will be to 2% U-235.

11. Shipments to the geologic repository will begin in 2015, at a rate of 140 SNF co-disposal canisters per year.

3. TECHNOLOGY ALTERNATIVES

The following briefly describes the technology alternatives. Detailed information on the technical alternatives is provided in the December 1997 cost study.

3.1. Direct Co-Disposal – Greenfield

Under this alternative, the SNF would be packaged in standardized repository co-disposal canisters (nominally 17" OD x 120" length) with only minimal treatment (i.e., cropping). A new facility would be constructed with startup in FY 2006. The SNF will initially be received, cropped, and interim stored in the 105L disassembly basin or the Receiving Basin for Offsite Fuel (RBOF). When the new Transfer and Storage Facility (TSF) is available, the SNF will be received at the TSF and packaged in the standardized co-disposal canisters. The canisters would be inerted and sealed (welded), and then placed in pad type cask storage pending shipment to the repository. Characterization requirements are assumed to be minimal. At the repository, an SNF co-disposal canister would be loaded into a repository waste package along with five HLW glass canisters. The disposition flowsheet for this alternative is shown in Figure 3-1.

Figure 3-1. Direct Co-Disposal Disposition Flowsheet

3.2. Direct Co-Disposal – 105L

This alternative is technically similar to the direct co-disposal greenfield alternative, except that SNF treatment would occur in the 105L reactor process area rather than in a new facility. Modifications to the 105L facility would be needed. Also, due to use of the 105L facility, it is assumed that the site SNF would be consolidated into the 105L disassembly basin by FY 2006 (allowing early de-inventory of RBOF). Wet operations within the 105L disassembly basin would extend into FY 2014. After FY 2014, shipping casks would continue to be received at the 105L facility, but the SNF would be placed in short term lag storage pending its packaging for repository disposal.

3.3. Melt and Dilute – Greenfield

Under this concept, the SNF would be melted and isotopically diluted to less than 20% U-235 in a new facility. The depleted uranium and additional aluminum (needed to create a low temperature eutectic mixture) are assumed to come from SRS stocks. The melt would be cast in small disks (currently envisioned to be approximately 15" diameter by 4" high), with the disks then stacked in standardized repository co-disposal canisters (nominally 17" OD x 120" length). The canisters would then be inerted, sealed (welded), and stored in pad type cask storage pending shipment to the repository. At the repository, an SNF melt and dilute canister would be loaded into a repository waste package along with five HLW glass canisters. The disposition flowsheet for this alternative is shown in Figure 3-2.

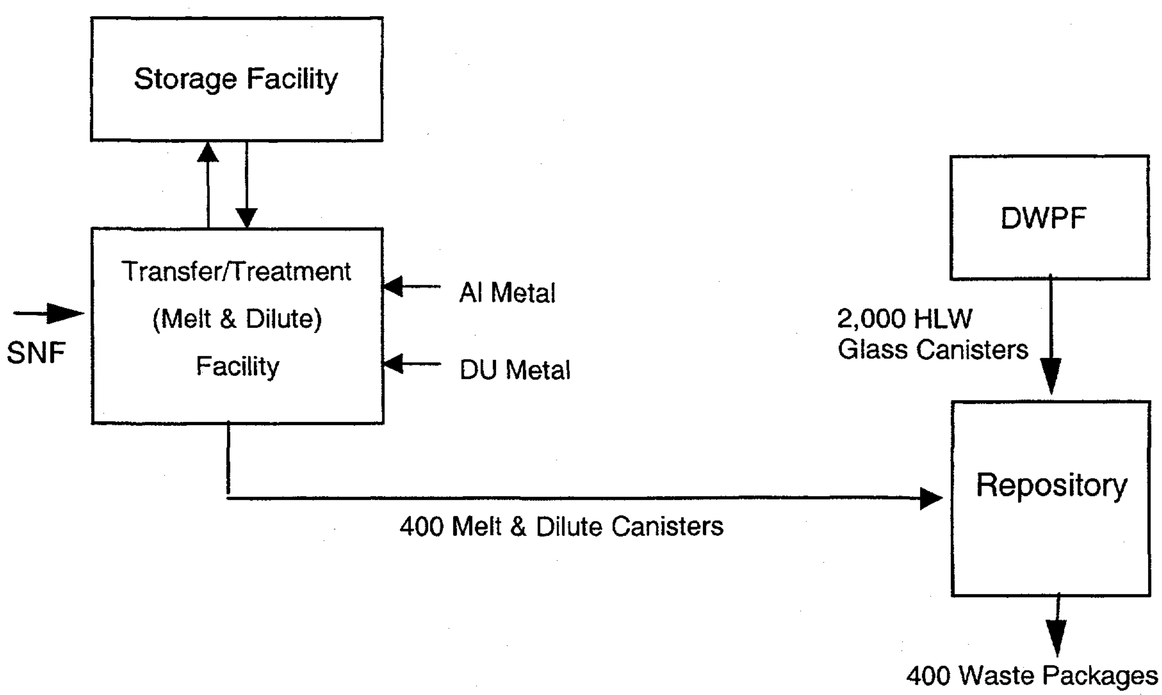

Figure 3-2. Melt and Dilute Disposition Flowsheet

3.4. Melt and Dilute – 105L

This alternative is technically similar to the melt and dilute greenfield alternative, except that SNF treatment would occur in the 105L reactor process area rather than in a new facility. Modifications to the 105L facility would be needed. Facility schedules are similar to those assumed for the Direct Co-Disposal – 105L alternative.

3.5. Reprocess, Followed by Direct Co-Disposal

Under this scenario, reprocessing would occur in H-Canyon until the backlog in SNF inventory is gone. Transfer of the aluminum-based SNF from INEEL to SRS is assumed to be accelerated, with shipments occurring between FY 2000 and FY 2005. Cessation of reprocessing in H-Canyon is assumed in FY 2010, following completion of the FRR program. A small (greenfield) receipt, packaging and storage facility (direct co-disposal technology) would be built and used after FY 2010 to manage the residual SNF receipts.

Recovered uranium would be diluted to 5% U-235, making it non-weapons capable and available for commercial use. The HLW would be sent to the tank farms to eventually be converted into saltstone and HLW glass. After FY 2010, the residual SNF would be placed in standardized co-disposal canisters and stored pending shipment to the repository. At the repository, the SNF and HLW glass canisters would be loaded into repository waste packages similar to the other alternatives. The disposition flowsheet for this alternative is shown in Figure 3-3.

This acceleration in shipping schedules requires additional transportation casks and wet basin manpower. See Section 4.1.

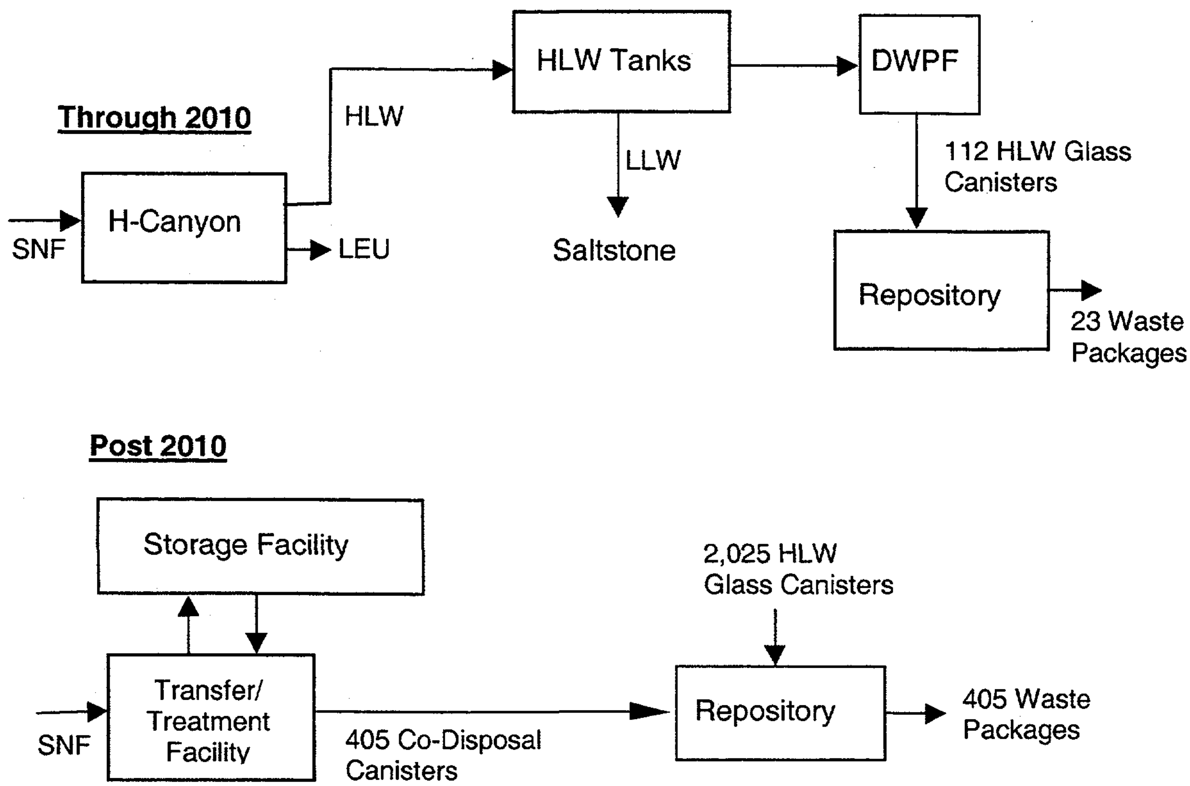

Figure 3-3. Reprocessing Followed by Co-Disposal Disposition Flowsheet

3.6. Reprocess, Followed by Melt and Dilute

This concept is similar to the prior alternative, except that a small melt and dilute (greenfield) facility would be built (rather than a direct co-disposal facility) for treating the residual SNF receipts after FY 2010. The disposition flowsheet for this alternative is shown in Figure 3-4.

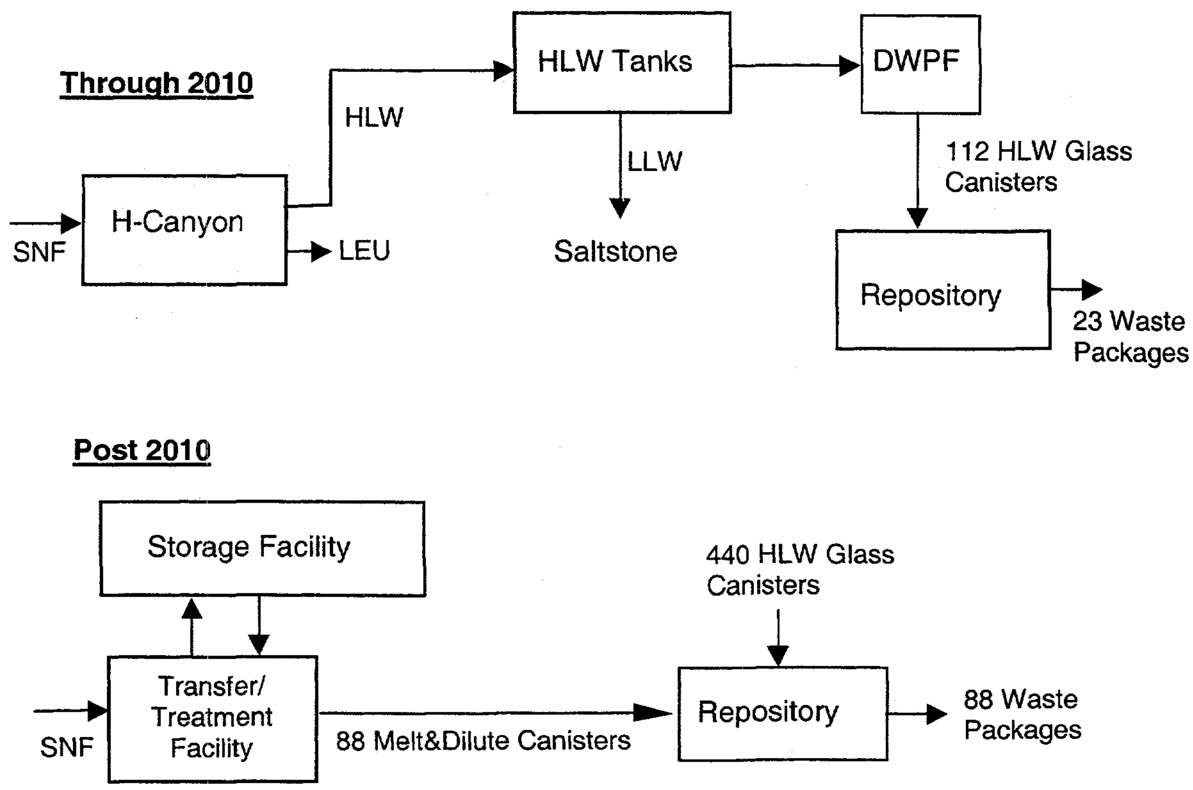

Figure 3-4. Reprocessing Followed by Melt and Dilute Disposition Flowsheet

3.7. Reprocess in H-Canyon, Followed by Reprocessing in New, Smaller Facility

This concept is similar to the prior reprocessing alternatives, except that a small receipt, dissolution, recovery and waste vitrification (greenfield) facility would be used after FY 2010 to treat the residual SNF receipts. The costs associated with using DWPF after FY 2010 to vitrify the small quantity of HLW (resulting from the residual SNF receipts) were considered excessive; consequently a small, new vitrification capability is assumed for this alternative. The disposition flowsheet for this alternative is shown in Figure 3-5.

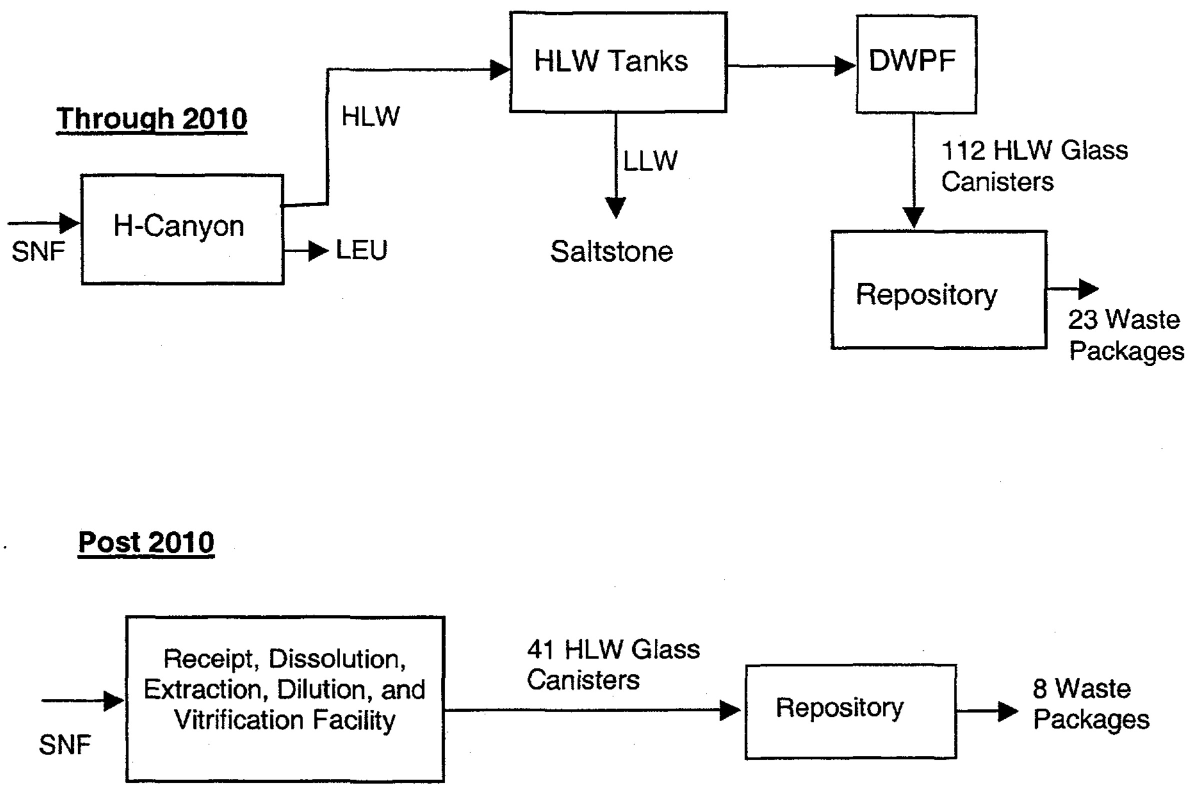

Figure 3-5. Reprocessing in H Canyon, Followed by Reprocessing in a New, Small Facility Disposition Flowsheet

3.8. Press and Dilute

Under this concept, a new facility would be built, with startup in FY 2006. The endfittings from the SNF assemblies would be removed and the fuel plates compacted along with depleted uranium to form a SNF product having an effective enrichment of 2% U-235. These compacts would then be stacked in standardized repository co-disposal canisters (nominally 17" OD x 120" length). The canisters would then be inerted, sealed (welded), and stored in pad type cask storage pending shipment to the repository. At the repository, an SNF press and dilute canister would be loaded into a repository waste package along with five HLW glass canisters. The disposition flowsheet for this alternative is shown in Figure 3-6.

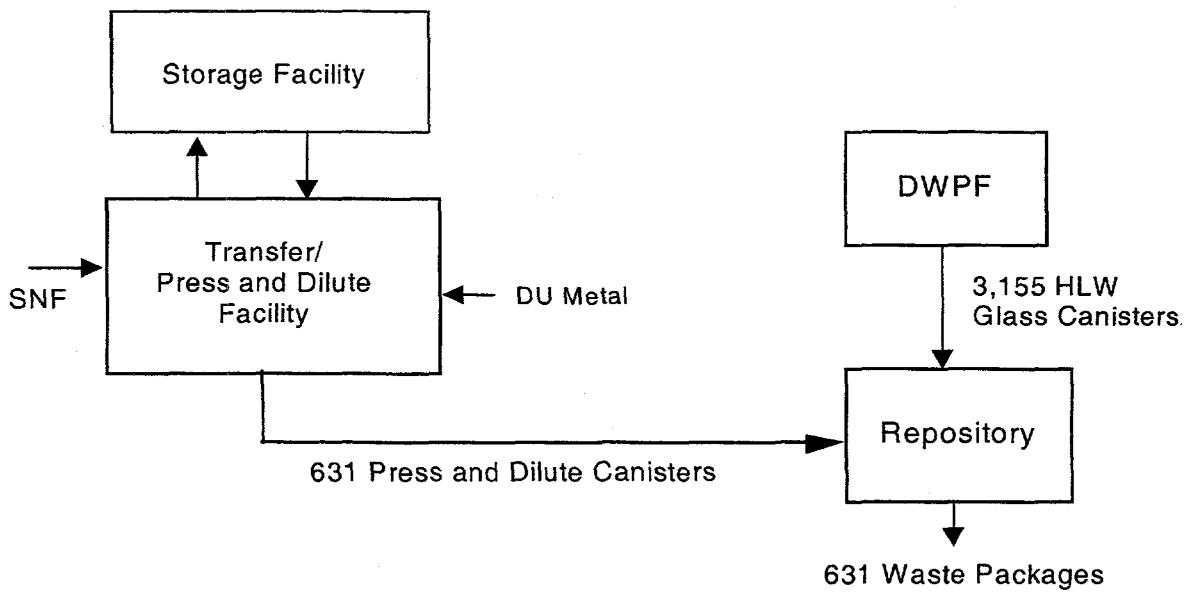

Figure 3-6. Press and Dilute Disposition Flowsheet

Note that press and dilute technology provides criticality protection to some extent, but not nonproliferation protection. The HEU remains easily separable.

3.9. Electrometallurgical Treatment

The electrometallurgical treatment technology is one of four advanced treatment technologies for which cost estimates were prepared. A FY 2011 startup date was assumed for these four alternatives due to the developmental nature of the technologies

For the electrometallurgical treatment alternative, the SNF will be initially received, cropped and interim stored in RBOF and the 105L disassembly basin. When the new treatment facility is available, the SNF will be received and cropped in that facility. In the electrorefiner, first pure aluminum, then pure uranium are recovered in sequential electrometallurgical processes. The aluminum is recast to remove adhering salt and disposed of as low level waste. Uranium is remelted to remove adhering salt and depleted uranium metal is added to make 5% U-235 ingots which have no proliferation potential. Fission products from the cells, salt, and traps are recovered, combined, and converted into glass forms suitable for repository disposal. The remaining higher actinides, lanthanides and noble metals are oxidized in a furnace and combined with the waste glass, which is poured into standardized DWPF type HLW canisters. The glass canisters would then be stored pending shipment to the repository. At the repository, the glass canisters would be loaded into repository waste packages similar to the other alternatives. The disposition flowsheet for this alternative is shown in Figure 3-7.

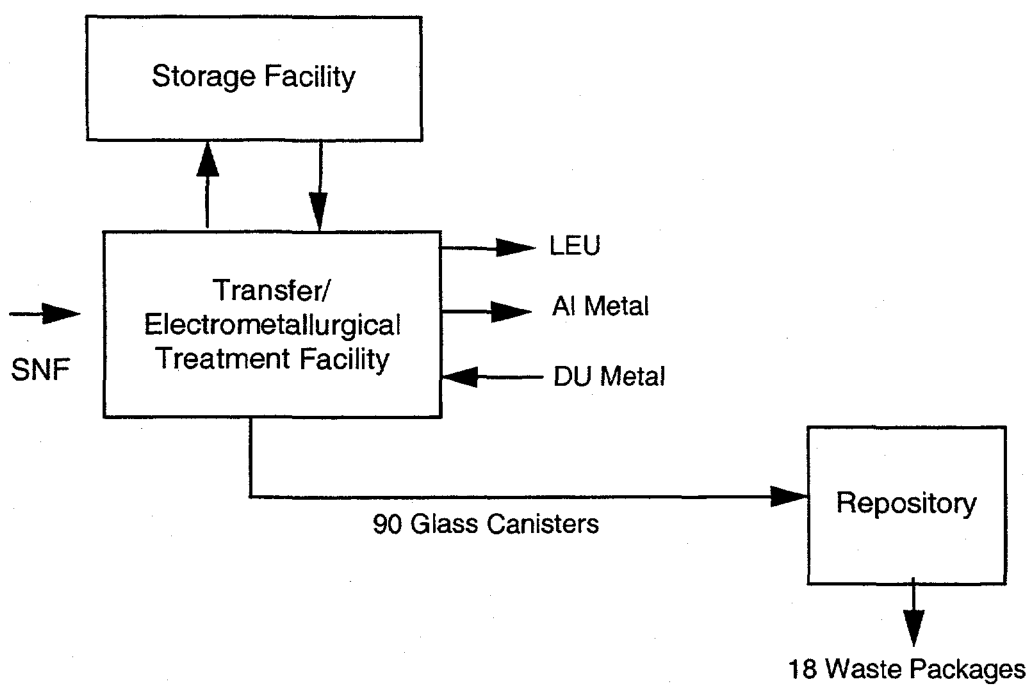

Figure 3-7. Electrometallurgical Treatment Disposition Flowsheet

3.10. Glass Material Oxidation Dissolution System

The concept is similar to the prior alternative, except that the Glass Material Oxidation Dissolution System (GMODS) treatment technology would be used to treat the SNF. A batch process is used in which the SNF and depleted uranium are combined (to yield a 5% enrichment) in a glass melter. Lead dioxide is added to convert the metals to oxides and glass frit is added to make glass The glass is poured into standardized DWPF type canisters and stored pending shipment to the repository. At the repository, five GMODS glass canisters would be loaded into each repository waste package. The disposition flowsheet for this alternative is shown in Figure 3-8.

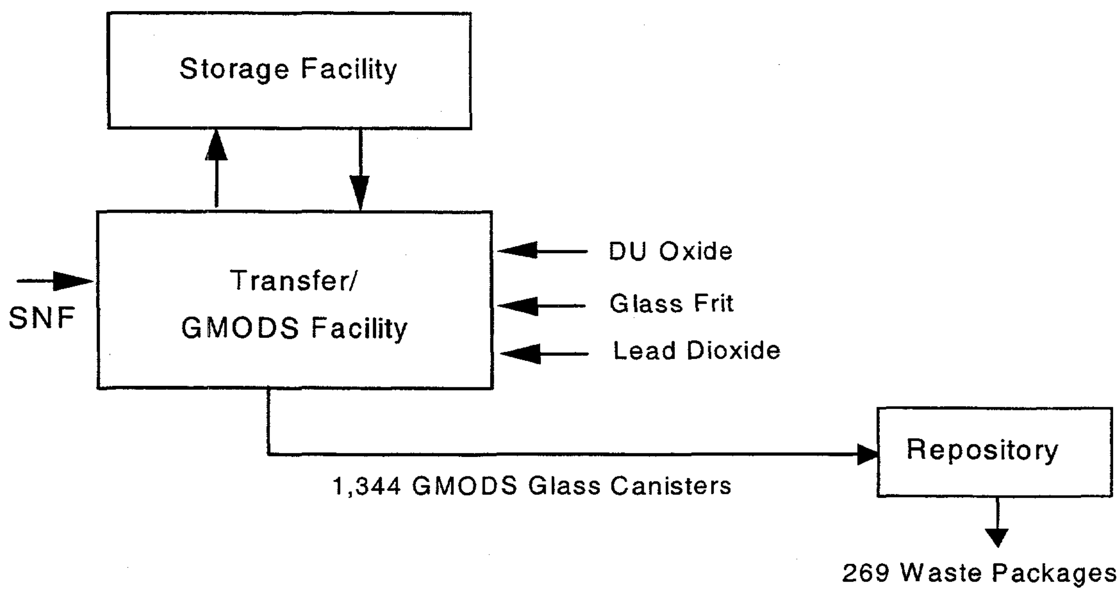

Figure 3-8. GMODS Disposition Flowsheet

3.11. Dissolve and Vitrify

Under this concept the SNF would be dissolved in mercury catalyzed nitric acid, diluted to a 5% U-235 enrichment by adding depleted uranium, and vitrified. The glass is poured into standardized DWPF type canisters and stored pending shipment to the repository. The disposition flowsheet for this alternative is shown in Figure 3-9.

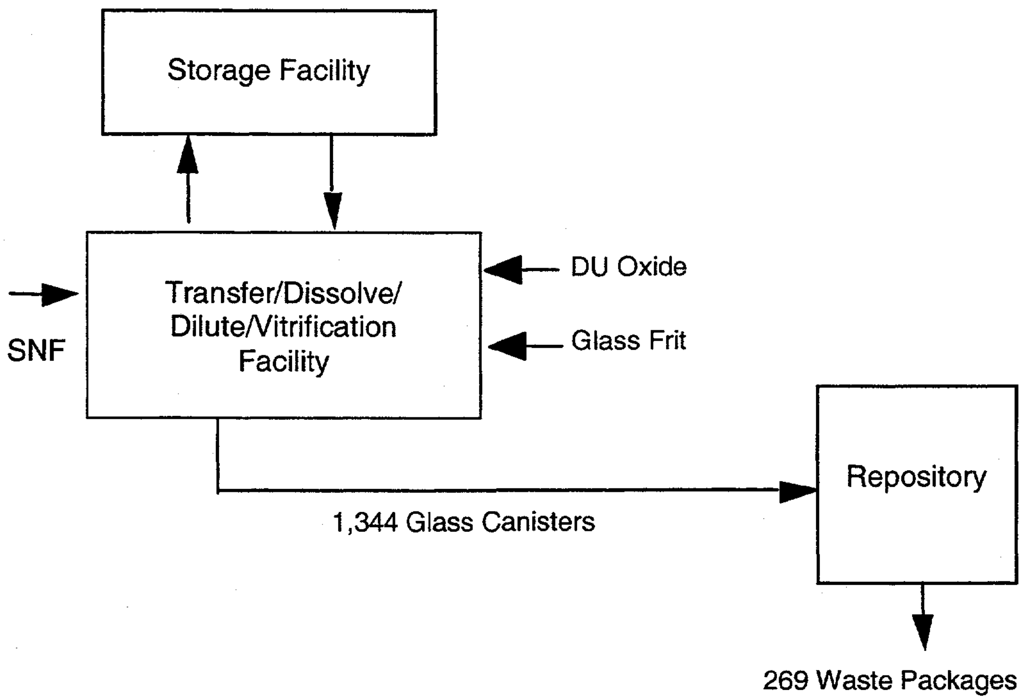

Figure 3-9. Dissolve and Vitrify Disposition Flowsheet

3.12. Plasma Arc

In the plasma arc treatment process, the SNF is oxidized, combined with low value materials (i.e., contaminated soil) along with depleted uranium to reduce the enrichment to 5% U-235, and converted to a vitreous ceramic. It is assumed that the vitreous ceramic waste form would be placed in standardized DWPF type canisters and stored pending shipment to the repository. For this alternative, it was assumed that four ceramic canisters would be loaded into each repository waste package. The disposition flowsheet for this alternative is shown in Figure 3-10.

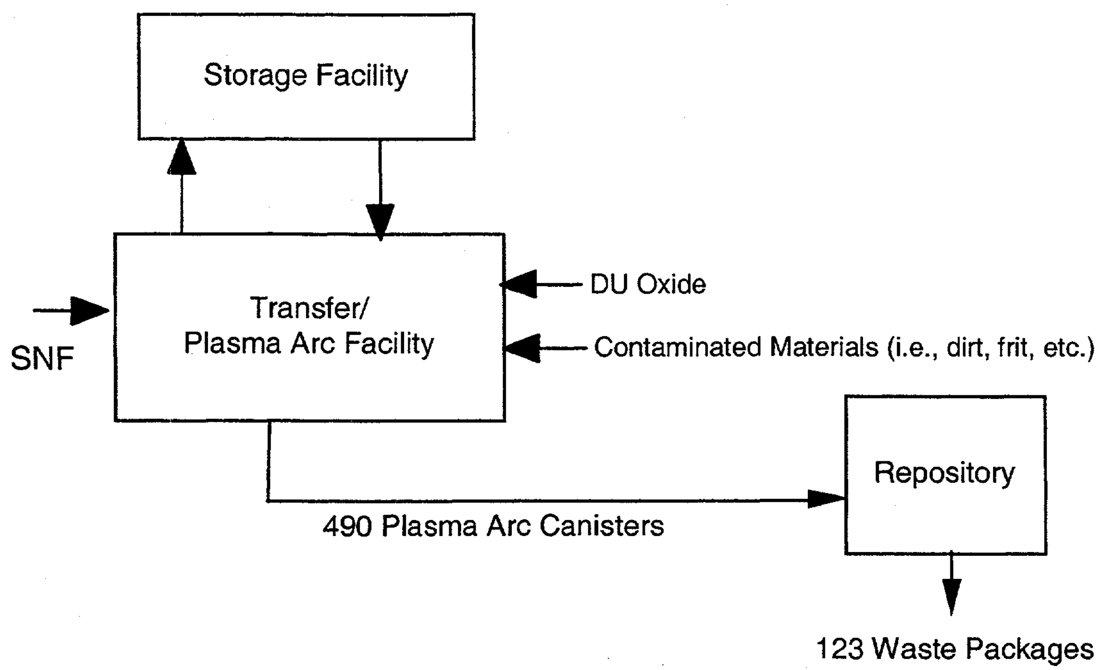

Figure 3-10. Plasma Arc Disposition Flowsheet

3.13. No Action

Under the No Action alternative, SNF will continue to be received and stored in both RBOF and the 105L disassembly basin through the planning period (FY 2035). This alternative does not produce a product form suitable for repository disposal.

4. COST FACTORS

The following briefly describes the cost factors used in developing the life-cycle cost estimates. Detailed information on the cost factors is provided in the appendices to the December 1997 cost study and the May 1998 Addendum.

The life-cycle costs were developed in constant FY 1998 dollars, with the cost analysis beginning in FY 1998 and ending in FY 2037. SNF receipts and treatment were assumed to occur through FY 2035. Facility deactivation and decommissioning activities associated with the non-reprocessing alternatives were assumed to occur in FY 2036 and FY 2037.

4.1. Wet Storage and Handling

Wet storage costs were taken from the FY 1998 Integrated Spent Fuel Management Plan. These costs are fully burdened and include some activities in the facilities associated with the basins which are not directly attributable to SNF management, e.g. moderator storage, resin regeneration, etc. Excluding these non-SNF activities would reduce wet basin costs by at least 10 percent. Any reduction, however, would not have a significant impact on the relative rankings for the alternatives.

As the reprocessing alternatives assume accelerated receipt of the aluminum-based SNF from INEEL, \$6M a year was added to the operations costs (\$3M each to RBOF and the 105L disassembly basin) to reflect additional fuel and cask handling costs for these alternatives. \$7M was also added to the reprocessing cases for a one time purchase of additional offsite shipping casks (to facilitate receipt acceleration).

Wet storage costs for the cases with treatment facilities located in the 105L facility reflect early shutdown of RBOF (FY 2006) and use of the 105L disassembly basin for receipt and intermediate storage. Reduced receipts cases reflect reduced storage times as appropriate for each case.

4.2. Transfer, Treatment, and Storage

Facility costs were taken from the Preliminary Conceptual Designs (PCDs) generated for the recent Business Plan developed to review the cost of M&O vs. privatization approaches for procurement of treatment and storage services. As with the Research Reactor Task Team effort, equipment lists were developed based on those presented in three INEEL waste management cost studies,, and a WSRC aluminum-based SNF cost study. Costs were escalated from FY 1992 to FY 1998 dollars using appropriate Chemical Engineering indices for Buildings and Equipment (10.42% and 11.29%, respectively). Estimates of building and equipment costs were developed for each technology based upon the number of standardized canisters and storage casks needed for interim management and repository disposal.

The impact of discounting \$ was evaluated and determined not to change the relative ranking of the alternatives.

Operations costs were based on similar methodology as used for the INEEL studies, i.e., maintenance materials at 7% of installed equipment, operational materials at 4% of installed equipment, and utilities at 3% of installed equipment for 15 shift/week operations. Estimates of the number of operations personnel needed for each technology were made by WSRC Spent Fuel Storage Division personnel. As new facilities were assumed to be sized specifically for SNF transfer/treatment, a 21 shift/week, around-the-clock operations effort was assumed. For the alternatives that used reprocessing in the existing H-Canyon, five shift operations were assumed due to large capacity of the facility and its use for missions other than aluminum-based SNF treatment.

Table 4-1 provides the results from this assessment.

Technology	Operator	Operator Support	Mainte-nance	Direct	Support	Area Support	Admini-strative	Totals
Direct Co-Disposal	95	12	68	45	100	15	40	375
Melt and Dilute	125	15	77	55	120	15	40	447
Reprocess* – Co-Disposal	17	5	32	17	40	7	20	138
Reprocess* – Melt & Dilute	24	8	40	22	51	8	22	175
Reprocess*	29	10	52	29	64	14	34	232
Press & Dilute	125	15	77	55	134	13	47	466
GMODS	153	18	88	65	147	18	49	538
Electrometallurgy	241	29	138	91	231	29	77	836
Dissolve & Vitrify	175	21	136	67	168	20	56	643
Plasma Arc	153	18	88	65	147	18	49	538

* Five shift operation assumed

Table 4-1. Personnel Estimates

4.2.1. IAEA Implementation Impact

The cost impact for subjecting the TSF to International Atomic Energy Agency (IAEA) oversight was estimated at $338K for the initial setup and $140K annually thereafter. Since these costs are relatively insignificant, they are assumed to be covered within the capital contingency and operating cost estimates.

4.2.2. Nuclear Regulatory Commission Licensing Impact

Preliminary estimates were made of the cost impact due to potential Nuclear Regulatory Commission (NRC) oversight over a new treatment/storage facility. The initial licensing submittal and review are estimated to cost approximately $2-3M. Annual fees thereafter are estimated at $282K per year. Since the current planning basis is that the facility will be built to NRC standards but not licensed, these costs are not factored into the estimate.

4.3. Fuel and Waste Processing

Incremental costs for reprocessing SNF in H-Canyon were calculated assuming implementation of the

Phased Canyon Strategy that was approved by the Secretary of Energy. Under this strategy both F- and H-Canyons will be operating to stabilize nuclear materials at the SRS in response to the Defense Nuclear Facilities Safety Board (DNFSB) recommendation 94-1. Processing relatively limited quantities of SNF during the DNFSB 94-1 time period would not significantly increase the overall cost of the nuclear material stabilization work. The allocated costs to process SNF have been estimated to be less than $6 million. Similarly, DNFSB 94-1 stabilization program costs would not be significantly reduced if SNF were not included in the Phased Canyon Strategy.

It was assumed that processing of SNF in conjunction with the Phased Canyon strategy would be complete by FY 2001 and that H-Canyon would be used for SNF processing after that time. The reprocessing scenario costs are based on the assumption that SNF processing in H-Canyon could begin in FY 2001. However, if a proposed HEU blend-down program is undertaken (or plutonium conversion to either MOX fuel or an immobilized repository disposal form), then H-Canyon would not be available for processing SNF until sometime between FY 2003 and FY 2005 (see section 5.2). For the reprocessing alternatives, operations in H-Canyon were assumed to continue until FY 2010, followed then by facility deactivation.

Costs for capital improvements to the F- and H-Canyons were also considered. The total costs for upgrading the exhaust systems for both canyons are estimated to be about $55 million. However, these costs would not increase the life-cycle costs of reprocessing SNF since they have already been allocated and the project will be completed regardless of whether SNF is processed.

The latest High-Level Waste System Plan was used to estimate costs for operating the waste tanks, DWPF, the Saltstone Facility, and the Glass Waste Storage Building.

Low-level waste (LLW) costs are included. A cost of $1400/m^3 was used, based on direction provided in the SRS EIS data book. With the exception of the reprocessing alternatives, LLW costs were estimated in a range of $35M to $65M. LLW costs for the reprocessing alternatives were higher at approximately $90-100M.

4.4. Repository Disposal

Research Reactor Task Team estimates for the repository costs (transportation and emplacement) were revised to reflect the current approach for cost allocation, transportation and packaging being developed for the repository 1998 Viability Assessment and Total System Life Cycle Cost estimate.

4.5. Uranium Credits

Initial estimates of the potential credit for recovered uranium used a value of $1000/kg (solution or metal) for 5% U-235 per DOE's Office of Materials Disposition documentation for excess HEU disposition. This valuation was later reduced to account for the recovered uranium not meeting

The SNF that could be processed during the DNFSB 94-1 stabilization program is the material identified in Table 5.2-1 of the Research Reactor Task Team Report.

ASTM specifications for commercial fuel use. Based on this later valuation, WSRC calculated a potential uranium credit of approximately $110M for the two reprocessing cases that called for cessation of reprocessing after FY 2010 (reprocessing followed by direct co-disposal, or reprocessing followed by melt and dilute). Assuming reprocessing of all aluminum-based SNF through FY 2035 yields a higher value: approximately $150M.

The recently signed agreement between Russia and the U.S. (that calls for potential deferment of DOE uranium sales for up to 10 years) raises the possibility that no value may be obtained for the recovered uranium. Hence, uranium credits for the reprocessing alternatives are not included in the life-cycle cost totals.

Indeed, costs may increase due to the need for uranium storage.

5. SUMMARY OF RESULTS

The relevant results from the technology alternatives cost studies are presented in Table 5-1. The assumptions used to arrive at these results are consistent with the most recent canyon utilization and project planning bases. Results are presented for a line item project approach and reflect the expectation that the value of recovered uranium will be zero.

Of the alternatives, the lowest total life-cycle costs occur when existing facilities are used. These are the Direct Co-Disposal and the Melt and Dilute alternatives. Reprocessing in H-Canyon until FY 2010, followed afterwards by direct co-disposal or melt and dilute of the residual SNF receipts, has life-cycle costs approximately $130M higher. Considering the uncertainty in the cost estimates, this indicates no significant difference in the life-cycle costs between these alternatives.

Constructing a greenfield facility for both the Direct Co-Disposal and Melt and Dilute alternatives results in an approximate $200M increase in life-cycle costs over those estimated for use of the existing 105L facility. The Electrometallurgical Treatment and three vitrification technologies (Plasma Arc, GMODS, and Dissolve and Vitrify) are approximately $1.0B to $1.3B higher than the other alternatives. Finally, costs for the No Action alternative were estimated to be approximately $1.7B, based on continued wet storage through FY 2035.

Alternative	Wet Storage and Handling	Transfer, Treatment, and Storage	Fuel and Waste Processing	Repository Disposal	Total*
Direct Co-Disposal – Greenfield	676	1,241	33	169	2,120
Direct Co-Disposal – 105L	766	919	37	169	1,890
Melt & Dilute – Greenfield	676	1,363	47	56	2,140
Melt & Dilute – 105L	766	1,073	55	56	1,950
Reprocess – Co-Disposal	655	676	610	72	2,010
Reprocess – Melt & Dilute	655	765	610	36	2,070
Reprocess (Existing/New Facility)	655	1,075	670	32	2,430
Press & Dilute	676	1,566	46	82	2,370
GMODS	676	2,065	67	198	3,010
Electrometallurgical Treatment	676	2,625	67	23	3,390
Dissolve & Vitrify	676	2,411	67	198	3,350
Plasma Arc	676	2,063	67	78	2,880
No Action**	1,650	0	78	0	1,730

*Totals rounded to $10M.

***This alternative does not produce an acceptable disposal form.*

Table 5-1. Summary of Life-Cycle Costs – Line Item Approach (FY 1998 $M)

5.1. Reduced Receipts

Cost impacts due to a reduction in the number of receipts were evaluated for the Direct Co-Disposal, Melt and Dilute, and Reprocessing alternatives. A 25 percent reduction decreases life-cycle costs by approximately $50-150M. The decrease, however, does not result in any significant difference in relative costs between the alternatives. Summaries of the life-cycle costs are shown in Table 5-2.

Alternative	Wet Storage and Handling	Transfer, Treatment, and Storage	Fuel and Waste Processing	Repository Disposal	Total*
Direct Co-Disposal – Greenfield	684	1,197	0	124	2,000
Direct Co-Disposal – 105L	760	928	0	124	1,810
Melt & Dilute – Greenfield	684	1,325	0	33	2,040
Melt & Dilute – 105L	760	1,101	0	33	1,890
Reprocess – Co-Disposal	685	712	433	56	1,890
Reprocess – Melt & Dilute	685	813	433	28	1,960
Reprocess	685	1,139	477	26	2,330

*Totals rounded to $10M.

Table 5-2. Summary of Life-Cycle Costs for the Reduced Receipts Case (FY 1998 $M)

5.2. Delay in H-Canyon Availability

The impact of delayed H-Canyon availability was evaluated for the reprocessing cases. One of the missions being considered is the use of H-Canyon to blend-down HEU to 5% for its use in commercial reactors. Another is the use of H-Canyon for conversion of excess plutonium to either MOX fuel or an immobilized repository disposal form. Two cases were evaluated: (1) a delay of 2 1/2 years for HEU alloy blend-down and (2) a delay of 4 years for a combination of HEU alloy and metal blend-down. The delays result in increased life-cycle costs for the reprocessing options of approximately $150-200M. Summary totals are shown in Table 5-3.

Alternative	Life-Cycle Costs w/o Delay	Life-Cycle Costs w/ 2-1/2 yr Delay	Life-Cycle Costs w/ 4 yr Delay
Reprocess – Co-Disposal	2,010	2,220	2,240
Reprocess – Melt & Dilute	2,070	2,270	2,280
Reprocess	2,430	2,590	2,610

Table 5-3. Impact on Life-Cycle Costs Due to Delay in Reprocessing (FY 1998 $M)

The reduced receipts sensitivity analysis was performed prior to the consideration of LLW costs within the fuel and waste processing cost factor. Including LLW costs does not change the relative ranking of the alternatives.

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APPENDIX A

Analysis Bases Used in SNF Technology Alternatives Cost Study

Study	Cost Study, Revision 1 (December, 1997)	Cost Study, Revision 1 Addendum 1 (May 1998)	Sensitivity Analyses (October 1998)
Purpose	Support EIS and Non-proliferation Study	Analysis of selected cases for M&O line item basis; Evaluate reduced receipts	Support EIS --all technologies recalculated for M&O line item projects; Evaluate impact of delay in H-canyon availability on reprocessing costs
Schedule	FY 2006 start for Co-Disposal, Melt & Dilute; FY 2011 start for advanced technologies	FY 2006 start for Co-Disposal, Melt & Dilute; FY 2011 start for advanced technologies	FY 2006 start for all technologies
Financing Basis	Privatization project	M&O line item project	M&O line item project
Facility Design Basis	Preliminary Conceptual Designs (PCDs) for greenfield facilities, plus Research Reactor Task Team report for equipment and space for advanced technologies	PCDs for greenfield and 105L facilities, plus Research Reactor Task Team report for reprocessing in small facility	PCDs for greenfield and 105L facilities, plus Research Reactor Task Team report for advanced technologies
Fuel Receipts	SNF Management EIS planning basis	SNF Management EIS planning basis; plus 25% reduction	SNF Management EIS planning basis

Reprocessing Cost Basis	D&D starts immediately after shutdown	D&D starts immediately after shutdown	D&D delayed due to use of H-canyon for other missions
Number of Repository Co-disposal Canisters: • **Direct Co-Disposal** • **Melt & Dilute**	 1,415 337	 1,400 400	 1,400 400
Low-Level Waste Costs	Not analyzed	Not analyzed	Estimated from EIS data book input
Uranium Credit	$1000/kg at 5% U-235	$15.00*Xh/g U (Note 1)	$14.95*Xh/g U (Note 1)

Note 1. Xh = enrichment value of the assay.