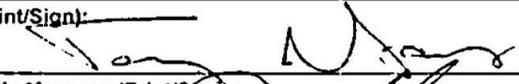


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# Hanford Single-Shell Tank Waste Retrieval Process

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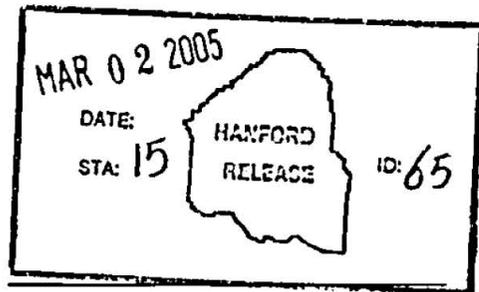
Key Words: limits of technology, waste volume limit, exception request

Abstract: This document discusses the decision-making process used by the DOE Office of River Protection to determine completion of waste retrieval for individual SSTs at the Hanford Site with respect to allowable waste residuals.

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# HANFORD SINGLE-SHELL TANK WASTE RETRIEVAL PROCESS

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**LIST OF TERMS**

ALARA	as low as reasonably achievable
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HFFACO	<i>Hanford Federal Facility Agreement and Consent Order</i>
ORP	Office of River Protection
SST	single-shell tank
WMA	Waste Management Area

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**1.0 INTRODUCTION**

The U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed a comprehensive cleanup and compliance agreement (*Hanford Federal Facility Agreement and Consent Order* ([HFFACO]) (Ecology et al. 1989) in 1989 for the Hanford Site in south-central Washington State. The HFFACO, also known as the Tri-Party Agreement, is a legally enforceable agreement for achieving compliance with the *Comprehensive Environmental Response Compensation and Liability Act of 1989* remedial action provisions and with the *Resource Conservation and Recovery Act of 1976* treatment, storage, and disposal unit regulations and corrective action provisions.

HFFACO Milestone series M-45 requires DOE to retrieve, "...as much tank waste as technically possible...", which establishes quantitative objectives for the maximum volume of waste that can be left in each single-shell tank (SST), and establishes a process in HFFACO Appendix H for variance from the numerical objectives if they cannot be met for any specific tank. Appendix H also requires DOE to "...interface with the U.S. Nuclear Regulatory Commission, and reach formal agreement on the retrieval and closure actions for single-shell tanks with respect to allowable waste residuals in the tank and soil column." Appendix H also requires DOE to "review relevant license issues" if DOE seeks a variance to the M-45 numerical objectives for a specific SST.

In addition to the HFFACO, DOE O 435.1, *Radioactive Waste Management*, and its associated manual and guides also include requirements and guidance for managing these wastes. The Field Element Manager is responsible for ensuring as low as reasonably achievable (ALARA) principles for radiation protection are incorporated in the conduct of radioactive waste management activities. ALARA is the approach to radiation protection to manage and control exposures (both individual and collective) to the workforce and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable (10 CFR 835.2, "Definitions").

SST waste is classified as mixed waste that contains both a radioactive component and hazardous (nonradioactive) component. Thus, SST waste retrieval actions are conducted in accordance with the requirements in the HFFACO, which governs the management of the hazardous waste components and DOE O 435.1, which governs the management of the radioactive waste components. Both the HFFACO and DOE O 435.1 recognize that 100% removal of the tank waste may not be achievable.

This document discusses the decision-making process used by the DOE Office of River Protection (ORP) to determine completion of waste retrieval for individual SSTs at the Hanford Site with respect to allowable waste residuals (see Appendix A for the SST C-106 tank retrieval process).

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**2.0 TANK WASTE RETRIEVAL PROCESS**

The SST waste retrieval process is based on the HFFACO Appendix H – Single-Shell Tank Retrieval Criteria Procedure (see Figure 1), modified to consider the radioactive component of the tank waste residuals. The Appendix H procedure consists of a series of steps that: (a) establish numerical criteria for the allowable residual waste volume following completion of retrieval (Figure 1, Steps 1-5); and (b) provide a process to determine if the numerical criteria are met, on a tank-by-tank basis, and the course of action to be followed if the criteria are not met (Figure 1, Steps 6-14). The end result of the Appendix H procedure is a determination that waste retrieval on a given SST is complete.

In order to satisfactorily address the DOE O 435.1 requirements pertaining to the radioactive component of the residual waste, it is necessary to amplify the Appendix H procedure to include: (a) an analysis of the predicted radiological impacts of leaving the residual waste in place against radiological performance objectives; and (b) an evaluation of the costs of retrieving additional waste and the resulting risk reduction.

The decision-making process for determining waste retrieval is presented in Figure 2 and includes the following steps:

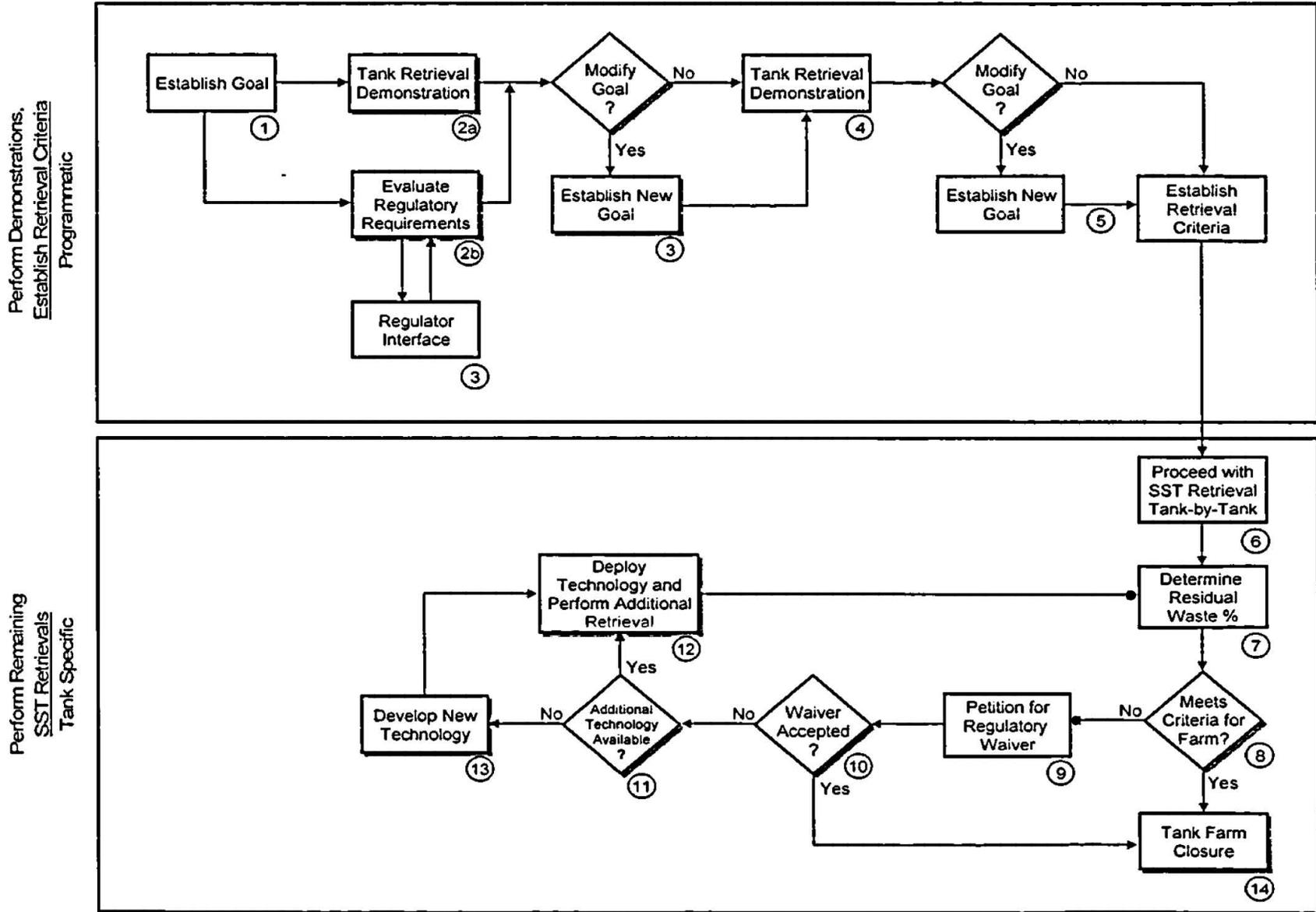
**1. Retrieve Waste to Limits of Technology**

The limits of retrieval technology can be determined by trending retrieval performance data against the number of retrieval batches completed. As the retrieval performance efficiency decreases with every retrieval batch completed, eventually a point is reached where the retrieval system no longer effectively removes waste. This relationship is illustrated in Figure 3.

**2. Determine if Residual Waste Volume Limit is Met**

The HFFACO waste retrieval goal is based on a post-retrieval maximum residual limit of 99% of the total waste in the SSTs, which results in an average residual waste volume goal of 360  $\text{ft}^3$  in the 100-series tanks and 30  $\text{ft}^3$  in the 200-series tanks. The post-retrieval volume measurement is performed using a method developed through an approved data quality objective process.

Figure 1. Process for Assessing Percentage of Waste Retrieved from Waste Retrieval Operations. (Adapted from HFFACO, Appendix H)



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**3. Submit Exception Request**

If DOE determines the retrieval goal is not achieved for a given SST after the limits of technology has been reached, HFFACO Appendix H allows DOE to submit a request for exception to Ecology and the EPA. The request shall include, as a minimum, the following information:

- The reason DOE does not believe the retrieval criteria can be met.
- The schedule, using existing technology, to complete retrieval to the criteria - if possible.
- The potential for future retrieval technology developments that could achieve the criteria, including estimated schedules and costs for development and deployment.
- The volume of waste proposed to be left in place, and it's chemical and radiological characteristics.
- Expected impacts to human health and the environment if the residual waste is left in place.
- Additional information as required by EPA and/or Ecology.

**4. Approve/Reject Exception Request**

EPA and Ecology will either approve the exception to the criteria, in which case retrieval will be considered complete for the tanks in question, or they will deny the request. If the request is denied, DOE must continue to attempt to retrieve the tank wastes until the criteria is met for the tank.

**5. Evaluate/Select Additional Waste Retrieval Technology**

DOE evaluates alternate technologies to determine the feasibility of removing additional waste. Current retrieval technologies that may be deployed include modified sluicing, the mobile retrieval system, vacuum retrieval, and acid dissolution. If additional technologies are available, then one or more technologies will be selected and waste retrieval resumed. If additional technologies are not available, then new technologies may be developed and deployed.

**6. Evaluate Risk/Dose Reduction and Cost of Additional Retrieval**

DOE performs an analysis of the predicted human health impacts resulting from the residual waste if it were left in place. The results of the analysis are compared against relevant radiological performance objectives. Additionally, alternative retrieval technologies are evaluated to determine how much more waste can possibly be removed and the cost to deploy those technologies.

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## 7. Determine if Additional Waste Retrieval is Warranted (Radiological Sufficiency)

DOE evaluates the marginal dose reduction against the marginal cost of developing new technology to achieve additional residual retrieval (see Figure 4). DOE will determine whether the potential incremental dose/risk reduction attained from additional retrieval is warranted by the additional cost incurred.

## 8. Complete SST Retrieval

Retrieval on a given SST is complete when the following conditions are satisfied:

- The limits of retrieval technology have been reached; or
- The numerical criteria for residual waste volume are met, or an exception request to the criteria has been approved by Ecology and the EPA; and
- DOE has determined additional waste retrieval is not warranted and the predicted radiological impacts resulting from leaving the residual waste in place are acceptable.

Figure 2. Single-Shell Tank Retrieval Criteria Evaluation Process.

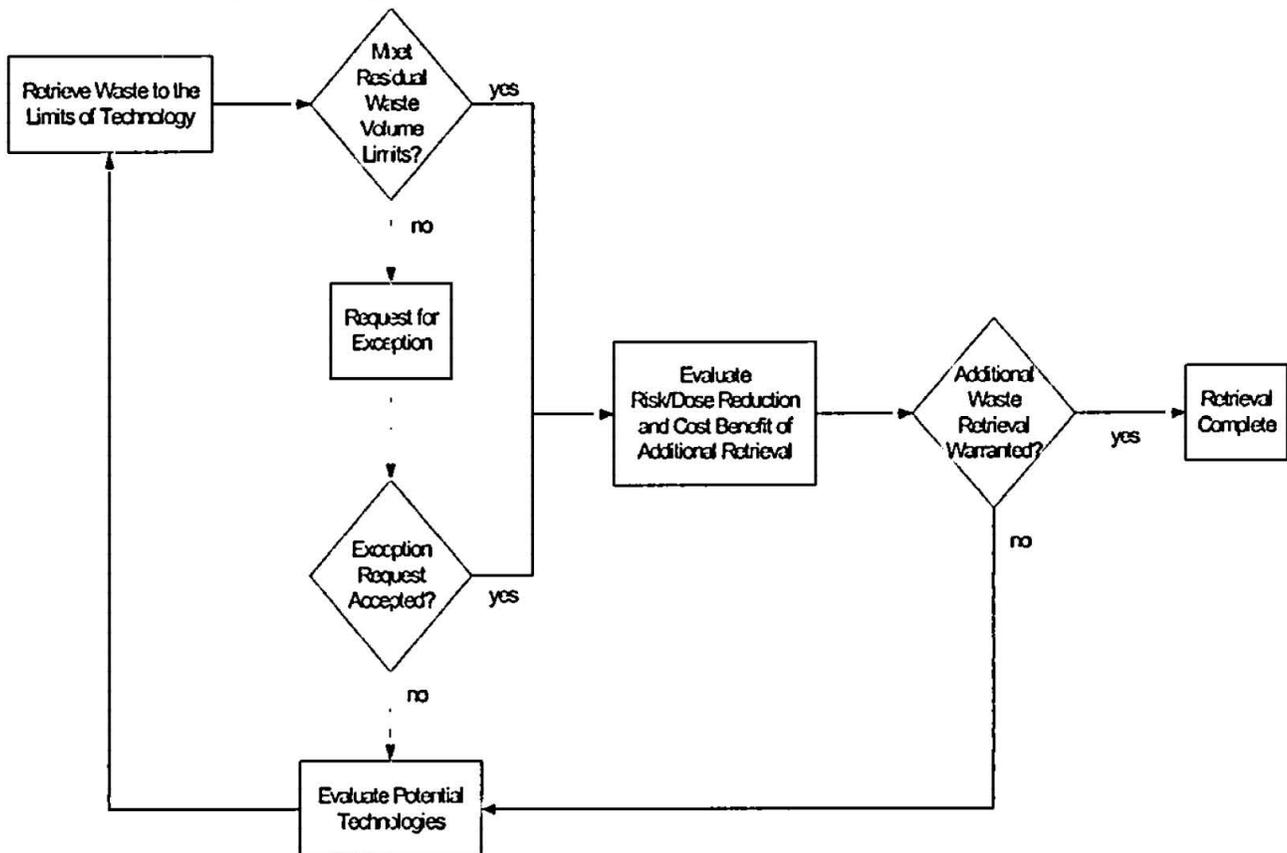


Figure 3. Generic Retrieval Technology Effectiveness.

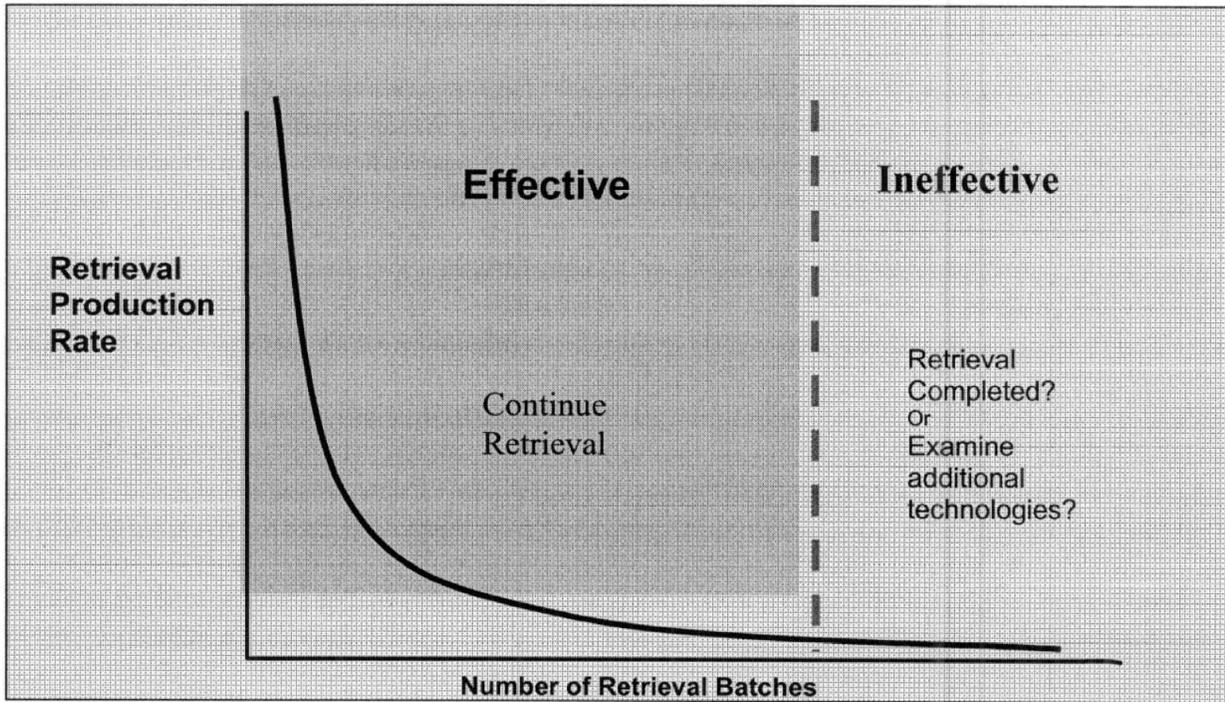
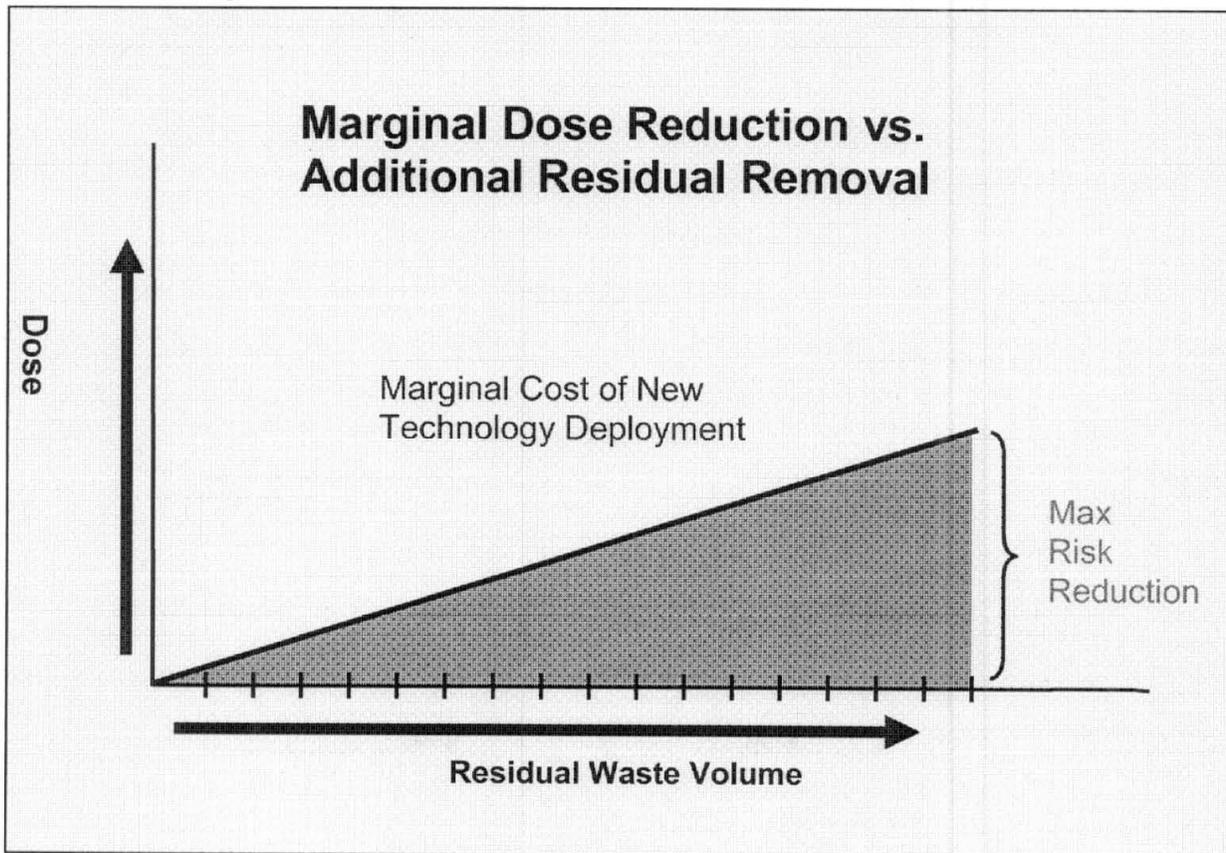


Figure 4. Dose Reduction vs. Additional Residual Waste Removal.



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**3.0 FINDINGS AND DETERMINATION**

Both HFFACO and DOE O 435.1 recognize that removing 100% of the tank waste may not be achievable. To determine completion of waste retrieval for SSTs with respect to allowable waste residuals, ORP must analyze the predicted radiological impacts of leaving the residual waste in place against radiological performance objectives and evaluate the costs of retaining additional waste and the resulting risk reduction.

Finally, ORP must evaluate alternate technologies to determine the feasibility of removing additional waste and the impacts to human health and the environment if the residual waste is left in place.

**4.0 REFERENCES**

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, Public Law 96-150, 94 Stat. 2767, Title 26, 42 USC 9601 et seq.

DOE O 435.1, 1997, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, State of Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

*Resource Conservation and Recovery Act of 1976*, Public Law 94-580, 90 Stat. 2795, 42 USC 6901, et seq.

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## APPENDIX A

APPLICATION OF TANK RETRIEVAL PROCESS  
TO SINGLE-SHELL TANK C-106

DOE has applied the tank waste retrieval process to SST 241-C-106 (SST C-106) in the following documents:

- RPP-20110, *Stage I Retrieval Data Report for Single-Shell Tank 241-C-106*
- RPP-20577, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*
- RPP-20658, *Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval for Single-Shell Tank 241-C-106.*

Built in 1944, SST C-106 stored mixed wastes resulting from reactor fuel reprocessing. SST C-106 is located in the south end of the 200 East Area on the Hanford Site and has a maximum design capacity of 530,000 gal. The tank was removed from active service in November 1979. The highest volume of waste in the tank was approximately 230,000 gal of plutonium/uranium extraction first-cycle waste sludge. Until 1998, the tank continued to receive 5,000 gal/month of water for evaporative cooling.

Initial retrieval began in 1998 and lasted through 1999 using high-pressure sluicing nozzles. Waste was retrieved by pumping to the limit of "standard" sluicing technology. DOE developed a variant to the standard sluicing technology (referred to as modified sluicing) and combined this technology with acid additions to "condition" the residue in August 2003. A number of acids/mixes were reviewed and oxalic acid was selected. The oxalic acid washing method was used until acid dissolution was determined to be ineffective. Retrieval of SST C-106 was stopped in December 2003 based on determining that the limits of these technologies had been reached. Displacement measurements and video mapping were conducted to verify final residual volume and sampling of residual contents was conducted. Figure A-1 shows the estimated residual waste volume following the various retrieval campaigns of SST C-106.

The modified sluicing removal efficiency curve for SST C-106 is shown in Figure A-2. As the figure illustrates, the limit of technology for modified sluicing was reached after four retrieval campaigns.

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Figure A-1. SST C-106 Retrieval Volume Reduction.

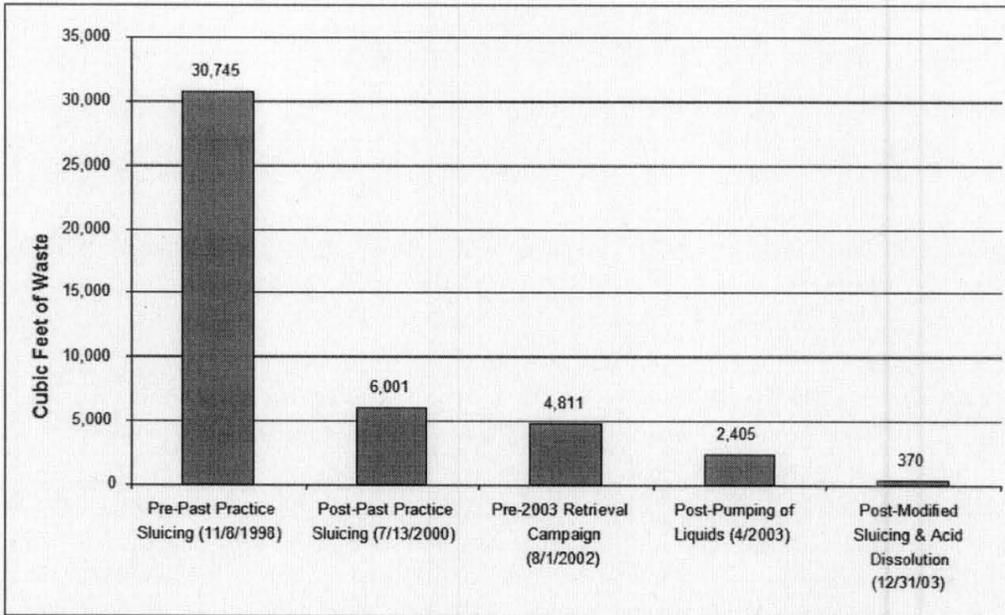
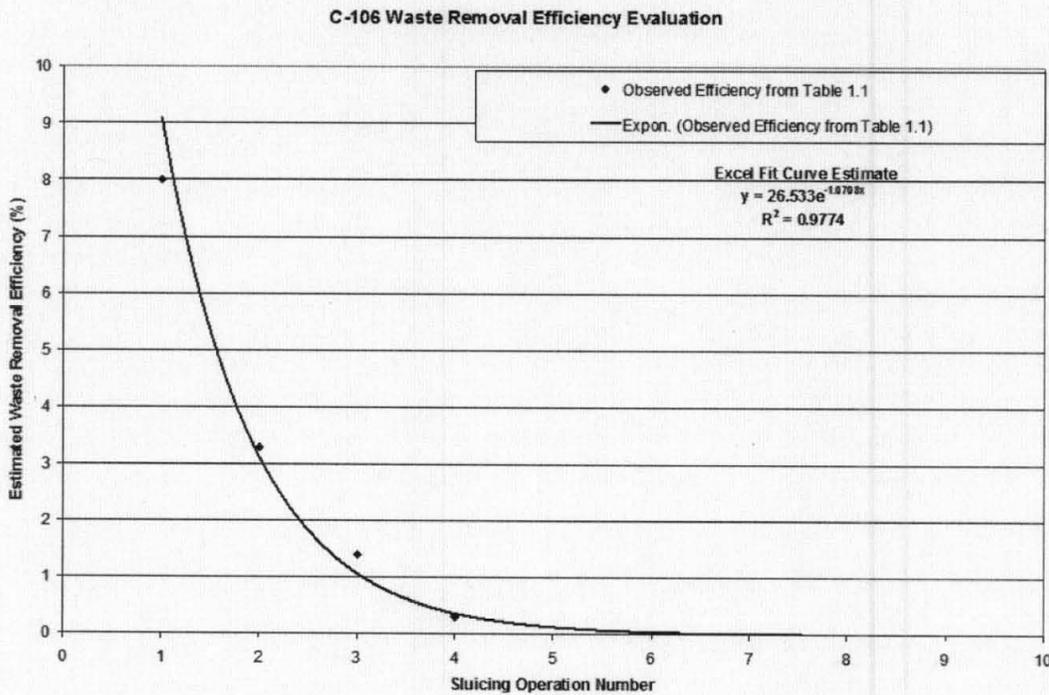


Figure A-2. Estimated Waste Removal Efficiency for Modified Sluicing.



The retrieval of SST C-106 resulted in a 99% reduction in radiological inventory from 10.1 million Ci pre-retrieval in 1996 to 0.14 million Ci in 2004.

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The radiological removal efficiency of the SST C-106 retrieval campaign for the modified sluicing technology was confirmed based on the post-retrieval sample results shown in Table A-1.

Table A-1. Post-Retrieval Sample Results.

Description	Curie (Ci)	Percent (%)	Comment
Total curies	136,700	--	--
<sup>90</sup> Sr/ <sup>90</sup> Y	132,200	96.7	Low mobility, short half life.
<sup>99</sup> Tc	0.165	1.2 E-04	--
<sup>129</sup> I	0.00063	4.6 E-07	--
<sup>137</sup> Cs/ <sup>137</sup> Ba	2,830	2.1	--
TRU	96	0.07	Plutonium and Americium
Total mass of residual waste	15,900 Kg	--	--
Chrome (+6)	3.76 Kg	0.024 of total mass	--

Note:

TRU = transuranic.

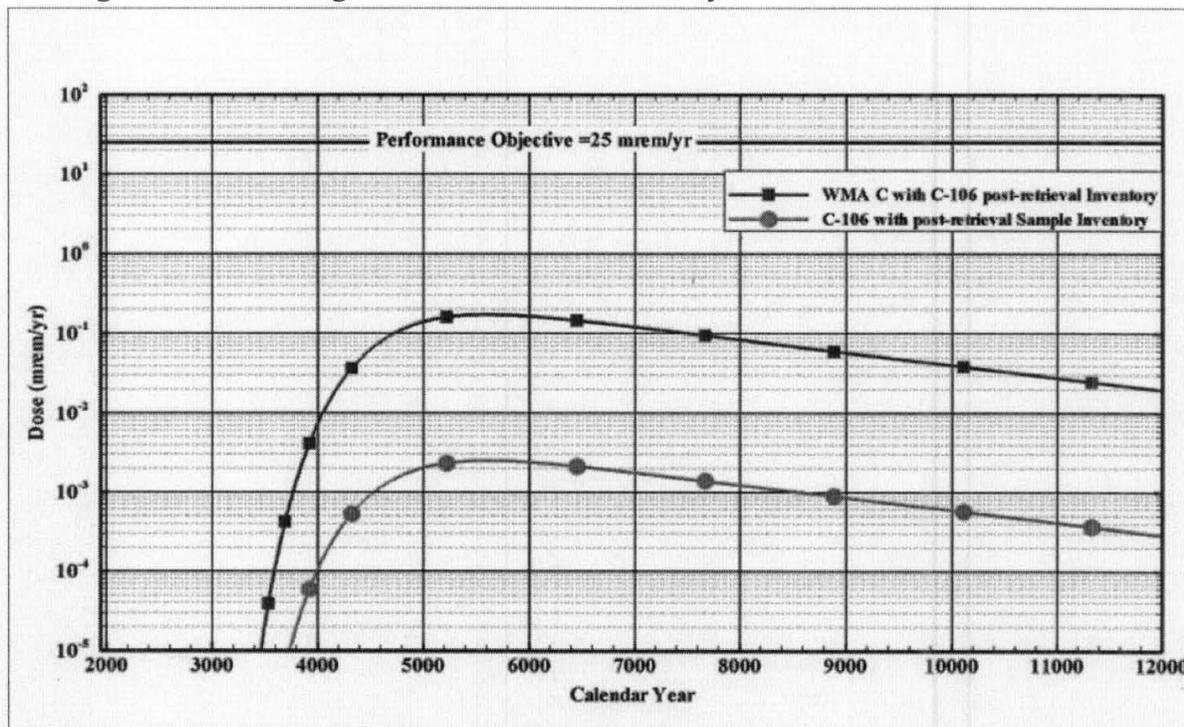
#### A.1 RISK REDUCTION PERFORMANCE METRICS OF WASTE MANAGEMENT AREA C AND SST C-106

SST C-106 is located within Waste Management Area (WMA) C, which includes 11 other 100-series tanks and four 200-series tanks. The performance objective for all pathways dose is 25 mrem/yr and is determined at the fence line of WMA C. Based on the assumption that only the volume goals are achieved in the WMA C tanks (360 ft<sup>3</sup> for 100-series tanks and 30 ft<sup>3</sup> for the 200-series tanks) it has been determined that the resulting dose for all pathways is 0.17 mrem/yr for WMA C. The post-retrieval dose for SST C-106 tank residual is 0.0025 mrem/yr. Figure A-3 illustrates dose rates for all pathways over time.

The performance objective for residential and industrial drinking water dose is 4 mrem/yr. For these performance metrics, WMA C produces a dose of 0.09 mrem/yr and 0.03 mrem/yr, respectively. The post-retrieval dose for SST C-106 is 0.0015 mrem/yr and 0.00052 mrem/yr, respectively.

EPA has established that the groundwater concentration of <sup>99</sup>Tc is not to exceed 900 pCi/L. The WMA C tank residuals (assuming 360 ft<sup>3</sup> and 30 ft<sup>3</sup>) is 63 pCi/L and the post-retrieval SST C-106 tank residual is 1.3 pCi/L.

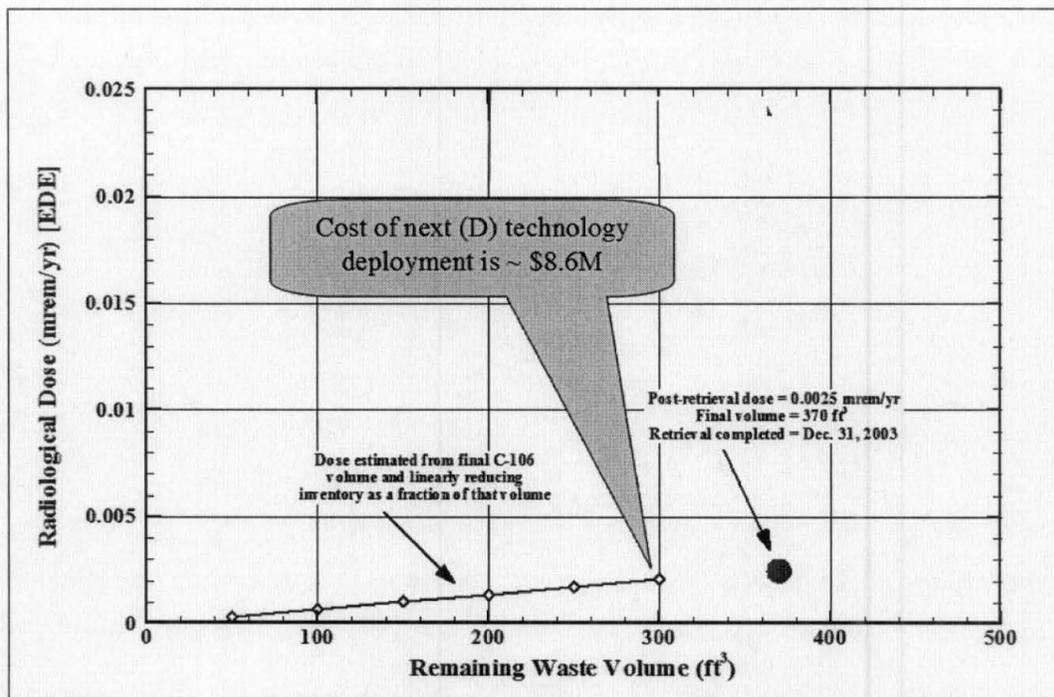
Figure A-3. Radiological Dose for the All-Pathways Farmer at WMA C Fence Line.



DOE has determined, based on the retrieval efficiency and the reduction in risk achieved, that the deployment of the next available technology for further residual waste retrieval from SST C-106 is not justified. The cost of deployment of the next technology is approximately \$8.6 million and does not significantly reduce the radiological dose from the residual waste that would remain. This cost does not include operational costs for the additional residual waste removal. Figure A-4 shows the relationship between cost of additional retrieval/residual waste removal and radiological dose reduction.

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Figure A-4. All Pathways Farmer at the WMA Fence Line  
(Performance Objective = 25 mrem/yr).



### A.3 CROSS WALK WITH APPROACH

Waste was retrieved from SST C-106 by pumping to the limit of “standard” sluicing technology. DOE combined this technology with acid additions to “condition” the residue and the limit of technology for modified sluicing was reached after five retrieval campaigns.

DOE has determined that the deployment of the next available technology for further residual waste retrieval from SSC C-106 is not justified.

### A.2 REFERENCES

RPP-20110, 2004, *Stage I Retrieval Data Report for Single-Shell Tank 24-C-106*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20577, 2004, *Stage II Retrieval Data Report for Single-Shell Tank 241-C-106*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-20658, 2004, *Basis for Exception to the Hanford Federal Facility Agreement and Consent Order Waste Retrieval Criteria for Single-Shell Tank 241-C-106*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.