Conf-950216--151

WHC-SA-2623-FP

Tank Waste Remediation System: An Update

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

WHC-SA-2623-FP

Tank Waste Remediation System: An Update

W. T. Alumkal
H. Babad
G. L. Dunford
J. O. Honeyman
D. D. Wodrich

Date Published
February 1995

To Be Presented at
Waste Management '95
Tucson, Arizona
February 26-March 2, 1995

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse Hanford Company P.O Box 1970 Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

TANK WASTE REMEDIATION SYSTEM: AN UPDATE

William T. Alumkal
Harry Babad
Gary L. Dunford
James O. Honeyman
Donald D. Wodrich

Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352
(509) 376-7411

ABSTRACT

The U.S. Department of Energy's Hanford Site, located in southeastern Washington State, contains the largest amount and the most diverse collection of highly radioactive waste in the United States. High-level radioactive waste has been stored at the Hanford Site in large, underground tanks since 1944. Approximately 217,000 m^3 (57 Mgal) of caustic liquids, slurries, saltcakes, and sludges have accumulated in 177 tanks. In addition, significant amounts of ^{90}Sr and ^{137}Cs were removed from the tank waste, converted to salts, doubly encapsulated in metal containers, and stored in water basins.

The Tank Waste Remediation System Program was established by the U. S. Department of Energy in 1991 to safely manage and immobilize these wastes in anticipation of permanent disposal of the high-level waste fraction in a geologic repository. Since 1991, significant progress has been made in resolving waste tank safety issues, upgrading Tank Farm facilities and operations, and developing a new strategy for retrieving, treating, and immobilizing the waste for disposal.

This page intentionally left blank.

INTRODUCTION

The U.S. Department of Energy's (DOE) Hanford Site, located in southeastern Washington State, contains the largest amount and the most diverse collection of highly radioactive waste in the United States. The Tank Waste Remediation System (TWRS) program was established in 1991 to safely store, treat, and dispose of those wastes. This paper provides an update on the progress of the TWRS program.

BACKGROUND

High-level radioactive waste (HLW) has been stored at the Hanford Site in large underground storage tanks since 1944. Approximately 217,000 m^3 (57 Mgal) of waste have accumulated in 177 tanks. These caustic wastes consist of different chemicals, including liquids, slurries, saltcakes, and sludges.

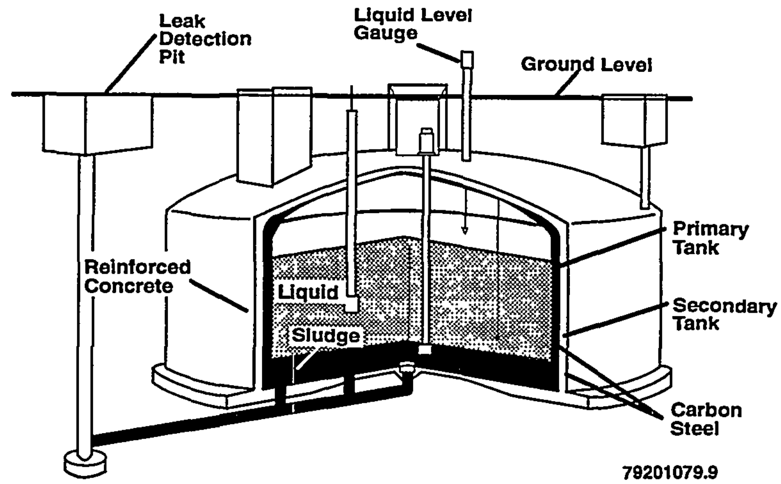
The radioactive waste stored in these tanks came from different sources, including: 1) three plutonium and uranium recovery processes from approximately 100,000 metric tons uranium (Mtu) of irradiated fuel; 2) three radionuclide recovery processes from waste; and 3) miscellaneous sources (e.g., laboratories and reactor decontamination solutions). These wastes were then concentrated and mixed in order to minimize the number of storage tanks required. The neutralized wastes include sodium nitrate/nitrite, sodium hydroxide, sodium aluminate, sodium phosphate, the hydrous oxides of iron, chrome, and other transition metals, large amounts of organics, and approximately 250 MCi of radionuclides.

The wastes are stored in 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs). The SSTs are made of reinforced concrete with a carbon-steel liner and can hold 208 m^3 (55,000 gal) to 3,800 m^3 (1 Mgal) of radioactive waste. The DSTs consist of a carbon steel tank within a steel-lined concrete tank, and have a nominal capacity of 3,800 m^3 (1 Mgal), as shown in Figure 1. Of the SSTs, 67 have leaked or are suspected to have leaked a total of approximately 3,800 m^3 (1 Mgal).

No waste has been added to the SSTs since 1980. The pumpable liquids are being removed from the SSTs and are being sent to DSTs, so that the remaining waste is mostly sludge and saltcake. There is no evidence to suggest that any of the DSTs have leaked.

In addition to the waste stored in the tanks, significant amounts of ^{90}Sr and ^{137}Cs were removed from the tank waste, converted to salts, doubly encapsulated in metal containers, and stored in water basins. There are approximately 1,900 6.7-cm (2.6-in.)-diameter x 52-cm (20.5-in.)-long capsules containing approximately 160 MCi total.

Figure 1. Double-Shell Tank.



TWRS PROGRAM DESCRIPTION AND STATUS

The Tank Waste Remediation System's mission is "to store, treat, and immobilize highly radioactive Hanford Site waste in an environmentally sound, safe, and cost-effective manner." Systems Engineering techniques are being applied to TWRS to establish functions and requirements, to identify all its relationships to other programs, and to evaluate alternatives for accomplishing the TWRS mission. This systematic, disciplined, and documented approach is an effective way to manage this large, complex Hanford Site waste management program, which will require many years to complete.

A technical strategy for storing, treating and disposing of the tank waste has been developed, and the strategy has been agreed upon through extensive interaction with the public, other public interest groups, and regulatory agencies. This strategy is shown in Figure 2 and described in the following sections.

TANK FARM OPERATIONS

Newly generated wastes continue to be received in the double-shell waste tanks, and approximately 4 million gallons of liquid waste are yet to be pumped from the SSTs to the DSTs to reduce the risks of leaks. Continuous surveillance and monitoring of the 177 underground tanks is necessary to ensure the waste is safely stored. Significant progress has

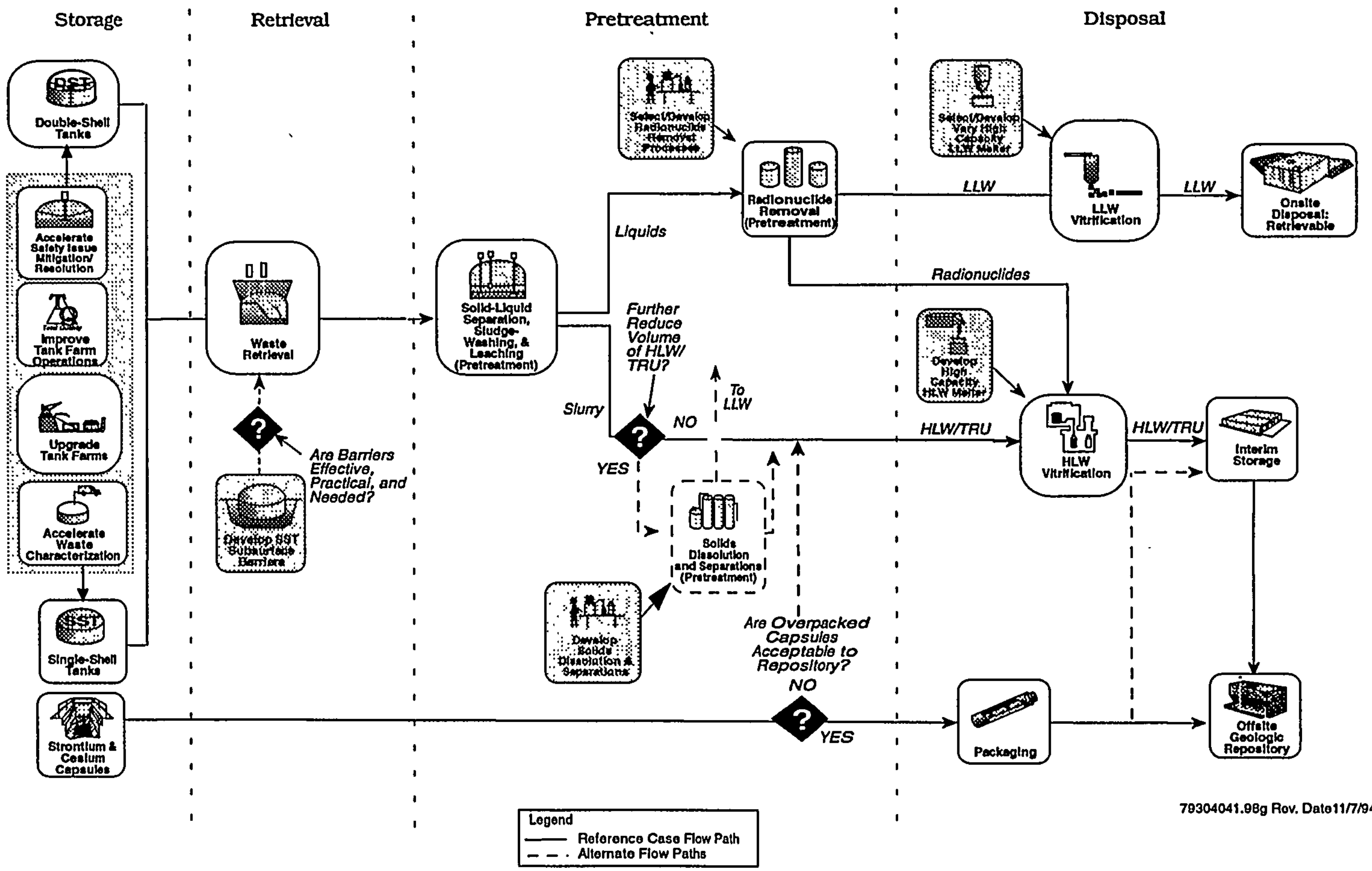


Figure 2. Hanford Tank Waste Remediation System Strategy.

been made in the past year on improving tank farm operations to increase safety and cost effectiveness.

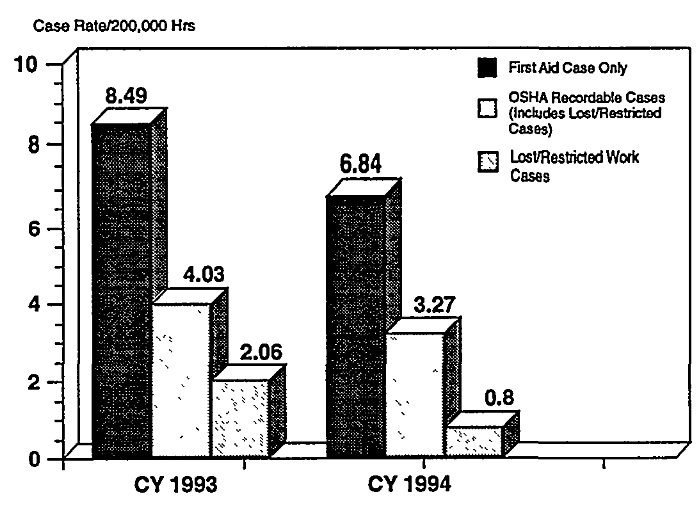
Safety statistics have improved in all categories, as shown in Figure 3. The number of lost and restricted work case injuries decreased by more than 60% and the total number of days lost was reduced by 75%. During this same time period, the maintenance productivity increased 50% and the backlog of corrective maintenance work was at an all-time low.

The 242-A Evaporator was restarted, and recovered more than 19,000 m^3 (5 Mgal) of DST space during two processing campaigns. The lessons learned and implemented from Campaign 94-1 made Campaign 94-2 even more successful. No safety incidents or personnel contaminations occurred during Campaign 94-2, and only one administrative-based occurrence report was issued. The Campaign 94-2 maintenance outage was completed 30% faster than scheduled, production targets were exceeded, and the overall campaign was completed well ahead of schedule.

The SST pumping program, for the first time since the early 1980's, was actively removing liquid waste from 6 SSTs at one time. More than 760 m^3 (200 Kgal) of waste was transferred to DSTs during the year. This included pumping two tanks that were "assumed leakers."

The plan is to continue improving tank farm operations to increase productivity and keep the workplace safe.

Figure 3. TWRS Injury/Illness Case Rate Strategy.



TANK FARM UPGRADES

Many of the Hanford Site facilities and much of the equipment at the tank farms are 40 to 50 years old and have not been well maintained. Upgrading the tank farms is a high priority, because the tank farms will continue to provide interim waste storage for many years until disposal of the waste can be achieved. Upgrades include: new safety analyses; replacing old instrumentation, equipment, and ventilation systems; constructing new waste transfer lines; removing obsolete contaminated equipment; and removing contaminated soil.

SAFETY ISSUE RESOLUTION

The highest TWRS program priority is resolution of waste tank safety issues. The safety issues of primary importance are summarized below.

- **Flammable gas concentrations in 25 tanks (SSTs and DSTs).** The flammable gas tanks safety issue involves the potential release of flammable gases in concentrations above the lower flammability limit. The worst tank, 101-SY, has been successfully mitigated with a mixing pump. The pump is operated up to three times a week to mix the waste and release gas.

  Hydrogen monitors are being installed on all 25 flammable gas tanks. A better understanding of the physical properties of the tanks will be gained using a retained gas sampler, a viscometer, and void fraction devices. The void fraction test instrument has been successfully demonstrated in tank 101-SY. This monitoring data will be used, along with knowledge acquired during the process, to determine if any tanks other than 101-SY require active mitigation for safe storage. Documentation to close the 101-SY Unreviewed Safety Question was submitted in 1994.

- **Potentially explosive mixtures of sodium nickel ferrocyanide and sodium nitrate and nitrite in 18 tanks.** In certain concentrations, these chemicals are known to react exothermally at high temperatures. Extensive testing of waste samples and simulants, along with temperature measurements and modelling, suggests that these wastes are safe and can continue to be safely stored for many years. Six of the original Ferrocyanide Watch List tanks have been removed from the Watch List based on records that showed no ferrocyanide had been added to these tanks. (Watch List tanks are those that the Secretary of the DOE reports on to Congress because of potential safety concerns.) The understanding and evaluation of this safety issue have progressed to the point that the Ferrocyanide Unreviewed Safety Question was closed in 1994.

- **The potential for exothermic nitrate-nitrite organic chemical reactions in SSTs.** The organic tanks safety issue involves the potential for uncontrolled exothermic reactions of organic chemicals and nitrates/nitrites and for vapors from semi-volatile organics entrained in waste to exceed the flammability limits (Sederburg and Reddick 1994).

Recent laboratory tests showed that fuel concentrations and temperatures required to support propagating exothermic reactions are comparable to those for ferrocyanide. Ten tanks that received organic complexants were added to the Organic Tanks Watch List following a review of sampling data and waste transfer records (Toth et al. 1994, Hanlon 1994). Vapor sampling and safety analyses were completed and formed the basis for closing the Unreviewed Safety Question concerning flammability of the floating organic layer in tank 103-C (Postma et al. 1994).

- **Mitigation of worker safety concerns resulting from the random release of fugitive noxious vapors from passively ventilated SSTs.** These vapors have a strong odor and, on occasion, have made some workers ill. A health and safety plan that includes appropriate sampling/respiratory requirements has been implemented.

- **High-heat load in SST 241-C-106 requiring periodic addition of water to provide evaporative cooling.** Because many of the SSTs have leaked, attempts are underway to remove as much liquid from them as possible. Currently, the liquid cannot be removed from tank 241-C-106 because the tank would overheat, potentially damaging its structural integrity. Therefore, plans are underway to remove the waste from this tank, and a project has begun to provide the facilities and equipment to start sluicing the waste from this tank in 1996.

WASTE CHARACTERIZATION

Waste characterization data must meet the needs of safety, waste treatment, and disposal program elements. The waste core sampling equipment is being improved and additional systems have been placed in service. Additional analytical laboratory hot cells are under construction, faster and more accurate analytical methods and instruments are being developed, and the laboratory data management system is being upgraded. In response to Defense Nuclear Facility Safety Board Recommendation 93-5, waste sampling and characterization for safety issue identification and resolution will be accelerated. This acceleration includes screening all single-shell tanks over the next three years to determine if any other tanks have safety concerns that may require resolution.

WASTE RETRIEVAL

Waste will be retrieved from all the tanks for treatment, immobilization, and disposal; the waste in some safety issue tanks may be retrieved in order to resolve the safety issues. Hydraulic sluicing has been the method used to retrieve waste from underground radioactive waste tanks at the Hanford Site and elsewhere. While sluicing is the preferred method of waste retrieval, it may not be acceptable in single-shell tanks that leak, and it may not remove some of the hard sludges. A robotic, long-reach arm with an assortment of tools is being developed to solve these problems. Design of the first SST sluicing system (for tank 241-C-106) is in progress. Subsurface containment barriers, which could be installed around and beneath the leaking tanks, are also being considered.

WASTE PRETREATMENT

The waste retrieved from the tanks will be separated into two fractions so that most of the radionuclides, and only a small part of the waste volume, are in the HLW fraction. The HLW will be vitrified and shipped offsite for disposal in a geologic repository. The bulk of the chemicals, and only a small amount of radionuclides, would be in the low-level waste stream that will be vitrified and disposed of near the surface onsite. The strategy is to use proven separations technology, to the fullest extent possible. More advanced separations technologies will be developed, but will only be implemented if needed to achieve the required level of radionuclide removal or an acceptably small volume of HLW. The pretreatment processes will include:

- Solid-liquid separation, and sludge washing and leaching, with the soluble liquid fraction destined to be the low-level waste stream. A sludge settling test in tank 241-AZ-101 was initiated.

- Radionuclide removal from the soluble liquid fraction to assure the waste can be categorized as low-level waste. Ion exchange processes are planned to remove ^{137}Cs and possibly ^{90}Sr, which will be routed to the HLW stream. Removal processes for long-lived mobile radionuclides (e.g., ^{99}Tc) will be developed as a contingency.

- Enhanced sludge washing, leaching, and blending to minimize the amount of high-level waste.

- Technology development for selective sludge dissolution and advanced radionuclides separation processes, continued as a contingency. These technologies may be needed if the amount of vitrified HLW to be produced is not acceptable to the repository or if there is an economic reason to reduce the amount of glass.

- Organic destruction process development, continued as a contingency for resolution of waste tank safety issues or, if needed, to achieve radionuclide separation.

LOW-LEVEL WASTE IMMOBILIZATION

The low-level waste will be vitrified and disposed of onsite near the surface, in a retrievable form. The existing grout immobilization process and the disposal system will be maintained as a contingency for freeing up DST space if required. The low-level waste vitrification facility will have a capacity of approximately 100 tons of glass per day. Standard glass industry melter technology may be adapted for this application, and the radiation level of the waste stream should be low enough to allow minimal shielding. Some melter tests have been conducted, and an aggressive program of waste form development and vendor melter tests must be carried out to meet the Tri-Party Agreement (Ecology 1994). Neither the final vitrified waste form (large monoliths or small pieces) nor the disposal container have been selected.

HIGH-LEVEL WASTE VITRIFICATION

Vitrification as borosilicate glass is generally accepted as the method that will be used to immobilize high-level waste. The TWRS strategy is to provide a high-level vitrification capacity that will be able to vitrify all of the high-level waste in 20 years. This will require a melter capacity of approximately 15 tons per day. A high-capacity melter development program is being conducted. A stirred melter and a high-temperature melter are being acquired for testing. The number and size of melters that will be installed in the HLW vitrification facility will depend upon the results of the development program.

The waste container capacity and configuration will be optimized considering such factors as the vitrification plant, interim storage, and the geologic repository. This may include a larger HLW "package" (e.g., 10-m^3 container) to reduce the cost of disposal at the repository.

INTERIM HLW STORAGE

HLW containers will require onsite storage for many years until a geologic repository is ready to accept them.

^{137}Cs AND ^{90}Sr CAPSULES

The ^{137}Cs and ^{90}Sr capsules will be stored until they can be packaged and shipped to the geologic repository for disposal. Overpacking multiple capsules in a canister is the reference plan. If the overpacked capsules do not meet repository acceptance criteria, the ^{137}Cs and ^{90}Sr capsules will have to be processed and vitrified with other HLW.

SCHEDULE

The schedule for carrying out the TWRS program includes: 1) completing retrieval of all SST waste by 2018; 2) closing all SST farms by 2024; and 3) completing all waste vitrification by 2028. The major milestones embodied in a recently approved amendment to the Tri-Party Agreement (Ecology 1994) are listed in Table 1.

CONCLUSION

The Hanford Site TWRS program is a large, complex program that will require many years to complete. Acquiring the funding and stakeholder commitment to conduct this program will require a national consensus that this work is necessary and is being done in a cost-effective manner. In order to significantly decrease the budget requirements, an ongoing process is in place for review of options from single processing lines to commercialization. Privatization of selected processing units could reduce the funding needs even more. We must continue to review each option's level of risk while achieving the program objectives with significantly fewer dollars. It is imperative to work safely, protect the public, seek the best technology, and use national expertise in planning and conducting the TWRS program.

The DOE is committed to an open, responsive policy and encourages public participation in Hanford Site cleanup discussions. The Hanford Site has been selected as a place to test the Clinton administration's thrust to "reinvent government." This designation is particularly appropriate because cleaning up the Hanford Site is estimated to cost tens of billions of dollars.

Table 1. TWRS Major Milestones.

Milestone	Date
• Mitigate/Resolve Tank Safety Issues	9/2001
• Complete Single-Shell Tank (SST) Interim Stabilization	9/2000
• Provide Additional Double-Shell Waste Tanks • Perform Double-Shell Tank Space Evaluation	12/1998 9/1994 (annually thereafter)
• Complete Tank Farm Upgrades	6/2005
• Characterize Tank Waste - Issue Tank Characterization Reports for all SSTs and DSTs (177)	9/1999
• Complete Closure of All Single-Shell Tank Farms - Complete Evaluation and Testing of Subsurface Barriers - Initiate Full-Scale Demonstration of Waste Retrieval - Initiate Tank Waste Retrieval from One SST - Complete Waste Retrieval from All SSTs	9/2024 9/1997 10/1997 12/2003 9/2018
• Complete Pretreatment Processing of Waste - Start Construction of LLW Pretreatment Facility - Start Hot Operation of LLW Pretreatment Facility - Start Hot Operation of HLW Pretreatment Facility	12/2028 11/1998 12/2004 6/2008
• Complete Vitrification of High-Level Waste - Initiate Construction of HLW Vitrification Facility - Initiate Hot Operation of HLW Vitrification Facility	12/2028 6/2002 12/2009
• Complete Vitrification of Low-Level Tank Waste - Select Reference Melter - Initiate Construction of LLW Vitrification Facility - Initiate Hot Operation of LLW Vitrification Facility	12/2028 6/1996 12/1997 6/2005

NOTE: See Part 1, Amendment 4 of the Tri-Party Agreement (Ecology 1994) for a description of these milestones and the many additional sub-tier milestones.

REFERENCES

Ecology, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Hanlon, B. M., 1994, *Waste Tank Report for October 31, 1994*, WHC-EP-0182-79, Westinghouse Hanford Company, Richland, Washington.

Postma, A. K., J. E. Meacham, G. S. Barney, G. L. Borsheim, R. J. Cash, M. D. Crippen, D. R. Dickinson, J. M. Grigsby, D. W. Jeppson, M. Kummerer, J. M. McLaren, C. S. Simmons and B. C. Simpson, 1994, *Ferrocyanide Safety Program: Safety Criteria for Ferrocyanide Watch List Tanks*, WHC-EP-0691, Westinghouse Hanford Company, Richland, Washington.

Sederburg, J. P. and J. A. Reddick, 1994, *TBP and Diluent Mass Balances in the Purex Plant at Hanford 1955-1991*, WHC-MR-0483, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Toth, J. J., P. J. Heasler, C. C. Willingham, and P. D. Whitney, 1994, *Organic Carbon in Hanford Single-Shell Tank Waste*, PNL-9434, Pacific Northwest Laboratory, Richland, Washington.

DISTRIBUTION

Number of Copies

OFFSITE

2	U.S. Department of Energy EM-36, Trevion II Washington, DC 20585	
	J. Tseng	
	S. Cowan	

ONSITE

17	U.S. Department of Energy- Richland Operations Office	
	C. P. Bader	S7-51
	S. T. Burnum	S7-53
	R. E. Gerton	S7-54
	L. Erickson (5)	S7-53
	J. E. Kinzer (5)	S7-50
	D. D. Wodrich	S7-50
2	Pacific Northwest Laboratory	
	G. H. Beeman	S7-71
	B. M. Johnson	K9-70
21	Westinghouse Hanford Company	
	W. T. Alumkal	S7-85
	H. Babad (6)	S7-30
	G. L. Dunford (5)	S7-84
	L. F. Ermold	S7-84
	J. O. Honeyman	S7-81
	J. L. Lee	R2-50
	M. A. Payne	S7-14
	A. M. Umek	S7-81
	R. D. Wojtasek	S7-84
	Central Files	L8-04
	OSTI (2)	L8-07