Tanks Focus Area

Multiyear Program Plan FY96-FY98

July 1995
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Executive Summary

The U.S. Department of Energy (DOE) faces a major tank remediation problem with approximately 330 tanks storing over 380,000 m^3 of high-level waste and transuranic waste across the DOE system. Most of the tanks have significantly exceeded their life spans. Seventy-nine tanks across the DOE system (most at Hanford) are known or assumed to have leaked. Some of the tank contents are potentially explosive. These tanks must be remediated and made safe. However, regulatory drivers are more ambitious than baseline technologies and budgets will support.

Before FY95, responsibility for remediating DOE's tanks and for developing supporting technologies for that effort was spread across multiple organizations and sites within the DOE system. During FY95, DOE's Office of Environmental Restoration and Waste Management (EM) funded approximately $120 million of tank technology development. Only about 20% of that work was clearly integrated. To increase integration and realize greater benefit from its technology development budget, DOE issued a call for proposals on approaches for transitioning tank technology development from a site-based effort to a national focus (April 1, 1994). A team of seven contractors and national laboratories responded to that call and were awarded responsibility for implementing the new focused approach for tanks. In this effort, Pacific Northwest Laboratory serves as the lead of the technical team composed of Idaho National Engineering Laboratory (INEL), Los Alamos National Laboratory, *Oak* Ridge National Laboratory, Sandia National Laboratories, Westinghouse Savannah River Company, and Westinghouse Hanford Company. DOE's Richland Operations Office serves as the lead field office and administrator of this team.

The Tanks Focus Area (TFA) Implementation Team began operation in October 1994. The team manages, coordinates, and leverages technology development to provide integrated solutions to remediate problems that will accelerate safe and cost-effective cleanup and closure of DOE's national tank system. Successful solutions will reduce technical, programmatic, or environmental. safety, and health risk and reduce the overall cost of tank remediation.

The TFA is responsible for technology development to support DOE's four major tank sites at the Hanford Site, INEL. *Oak* Ridge, and Savannah River Site. Its technical scope covers the major functions that comprise a complete tank remediation system: safety, characterization, retrieval, pretreatment, immobilization, and closure. The TFA integrates program activities across all organizations that fund tank technology development within EM. including the Offices of Waste Management (EM-30), Environmental Restoration (EM-40), and Technology Development (EM-50). In the future, the TFA will integrate activities across and beyond the DOE system.

The TFA's immediate challenge has been to deliver, within 1 year, a technology program that is

- applicable - addresses users' needs and can be implemented within budget, schedule, and regulatory constraints

- integrated - leverages relevant activities across **EM-30,** EM-40, and **EM-50** and, later, across and beyond the **DOE** system
- acceptable - has broad involvement of key stakeholders and incorporates expertise from outside the laboratory system (e.g., from industry and universities)
- accountable - performs within budget and on schedule and produces a clear benefit.

At the same time, the technologies provided by this program must

- reduce the technical risks that jeopardize baseline tank remediation performance requirements
- reduce the programmatic risks that 1) jeopardize the sites' ability to comply with regulatory or stakeholder drivers that are not formalized in baseline plans or **2)** limit the site's ability to change their baselines in response to budget cuts
- reduce environmental, safety, and health risks involving environmental, worker, or public safety issues associated with managing or remediating tanks
- significantly reduce the overall cost of tank remediation.

The **TFA** is responding to this challenge by pursuing **a** phased management and technical strategy. The program will initially focus on technologies that can be rapidly deployed or meet near-term needs at multiple sites under multiple possible baselines (e.g., privatization). This involves, in large part, completing DOE investments in technologies that are ready to be demonstrated and can be successfully deployed. As these technologies are demonstrated and transitioned to users, the program will shift to focus on less mature technical initiatives that offer potentially greater payoffs.

Concurrently, the TFA will ensure that the EM tank technology budget is fully leveraged or coordinated so that organizations doing similar work integrate their scopes and budgets to realize greater benefit. (Leveraged work does this formally, linking technical task plans or activity data sheets across organizations. Coordinated work does this informally, acknowledging the relevance of related tasks by sharing data and/or facilities.) Ensuring that the work is leveraged or coordinated will be initially accomplished by aggressively coordinating tank technology activities across EM, shifting to a more fully leveraged program by FY97.

In FY95, the TFA developed the organizational and technical basis for a nationally integrated technology program. The TFA Implementation Plan presents the organizational framework for that program. The multiyear program plan (MYPP) **(TFA** 1995a) documents the recommended 3-year technical program and describes the path forward for its implementation.

The process for defining the technical program presented in this MYPP involved four major steps (see Figure ES.1):

- needs assessment - The Implementation Team collected tank technology needs from the four tank waste sites, organized them into a needs breakdown structure that maps onto the sites' work breakdown structures, and evaluated them to identify high-impact multisite needs suitable for the focus of a national technology program. The sites were involved in the data collection, and the results were validated by the site tank programs and field offices. The process and results are documented in the ***TFA Site Needs Data Assessment*** report (TFA 1995b).

- program definition - The Implementation Team used the information resulting from the needs assessment to develop 22 technical elements that will solve the core problems related to tank remediation (Table ES.1). These technical elements comprise the core of the TFA technical programs and are presented in the MYPP (TFA 1995a).

- scope selection - The Implementation Team selected specific activities to be addressed within each technical element and defined deliverables and an appropriate schedule. This information comprises the TFA FY96 program execution guidance and forms the basis of the TFA FY96 work plan.

- team selection and activity planning - The Implementation Team will form groups of users, producers, and developers who will further define and then perform the technical tasks for each technical element. This activity will complete the TFA FY96 work plan and produce the required test, regulatory, and stakeholder plans for the program.

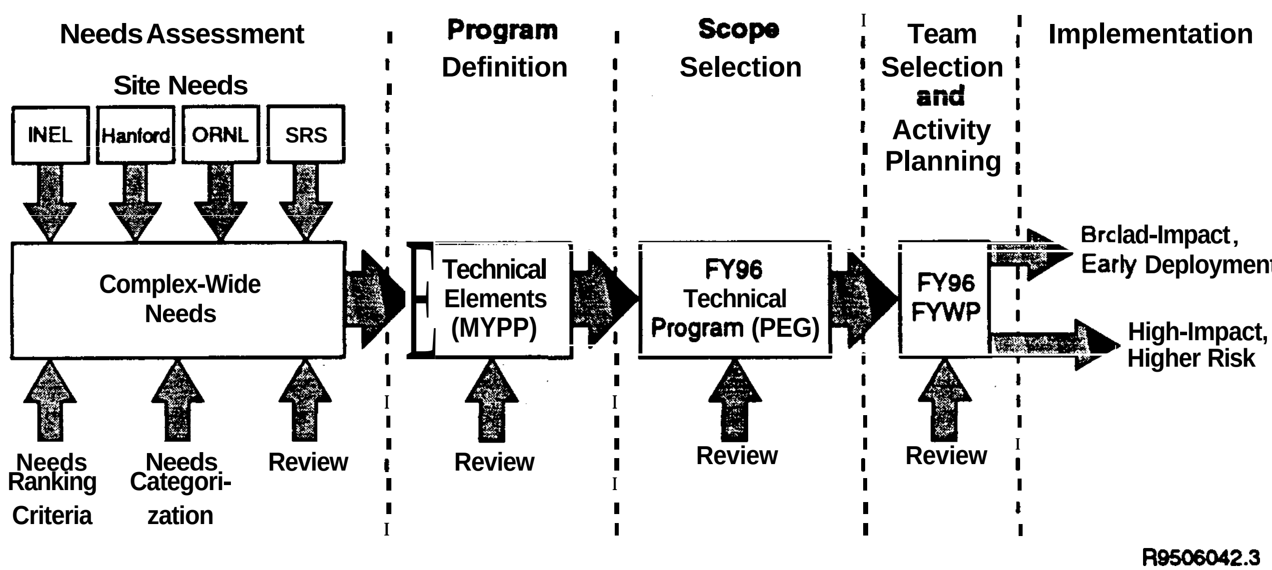

Figure ES.1. TFA Program Development

Each of these steps has been or will be reviewed for both programmatic and technical validity. To ensure programmatic viability and facilitate eventual deployment, the TFA is guided by a User Steering Group comprised of senior managers of the site tank remediation programs. The User Steering Group has reviewed and validated the TFA needs assessment and the selection of high-impact needs and has endorsed the MYPP (TFA 1995a). To ensure technical validity, a TFA Technical Review Group, comprised of technical experts from national laboratories and universities, reviews the TFA technical program. To facilitate integration across EM and beyond, the TFA is led by senior DOE managers of EM-30, EM-40, and EM-50.

As intended, the program described in the MYPP (TFA 1995a) is generally focused on solutions that are planned for deployment within site baselines in 1 to 3 years. These near-term solutions emphasize relatively mature technologies, many of which have been developed by EM for several years but may not have received the national, focused attention that this program will provide. The solutions are primarily aimed at reducing technical risk and offer enhancements to or fill gaps in current site baselines.

Technologies that offer early and relatively certain site benefits and are directly integrated with site programs and budgets include the following:

- Advanced Hot-Cell Analytical Technology - This technology is part of a package of technologies being developed as a “rapid response” to Defense Nuclear Facilities Safety Board demands for more effective characterization of Hanford tanks. It will provide immediate benefit to Hanford by providing laser abalation/mass spectrometry and Raman spectroscopy scanning for high-level waste molecular analysis (required to design processing flowsheets), near infrared scanning for moisture (a safety concern), and gamma/beta scanning. In addition to providing an early win at Hanford for faster and more representative characterization data and potentially reducing characterization costs by about $20 million, the technologies have other potential applications.

- Deployment Systems - A light-duty utility arm is being developed to provide an in-tank multipositioning capability for surveying tank structures, characterizing tank waste, and enabling small-scale retrieval. This technology provides the platform for deploying a range of instruments in tanks and will demonstrate the feasibility of larger-scale mechanical retrieval. It will be demonstrated and deployed for separate missions at Hanford, INEL, and Oak Ridge during FY96 and FY97.

- Retrieval Process Development - High- and medium-pressure jets are being developed and demonstrated in tanks at INEL and Oak Ridge in FY96 to remove the difficult tank waste heels at these sites. This process provides an alternate waste removal technology that is particularly effective for hard-to-remove sludges from tanks with integrity problems, including tanks that leak or have difficult to manage hardware. The jets will provide immediate benefit to INEL and Oak Ridge, supporting the Tank Heel Removal Project and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-driven Gunite Tank Treatability Study, respectively, and offers potential retrieval benefits at Hanford.

- Alkaline Cesium Removal - The FY96 cesium removal demonstration at *Oak* Ridge will provide critical data on the most cost-effective sorbents to use within different flowsheets. The data will support key processing decisions related to selecting ionexchange sorbents (at *Oak* Ridge), in-tank precipitation alternatives (at Savannah River Site), and baseline cesium removal processes (at Hanford).

- Waste Processing and Tank Closure Demonstration - A Savannah River Site *tank* will be cleaned and closed, with demonstrations testing alternate retrieval and closure technologies planned over 3 years (FY96-FY98). The demonstrations will provide valuable data and. potentially, readily deployed retrieval alternatives to Savannah River Site, supporting key decisions related to baseline retrieval options and potentially accelerated schedules. The demonstration will also benefit Hanford, Oak Ridge, and INEL where current retrieval technologies are also too costly and potentially ineffective against regulatory requirements for closure.

While focused on near-term baseline needs, the **TFA** has initiated higher payoff investments that have longer lead times and mid-term investments that are targeted at reducing technical, programmatic, and safety risks at the sites.

Investments that offer particularly significant life-cycle cost savings with relatively significant risk include caustic recycle methods and evaluation of concepts for moving away from centralized, large-scale processing to more focused facilities and processes. Additional cost-saving investments include process monitoring and control; alkaline strontium, technetium, and transuranic waste removal; acidic cesium, strontium, transuranic, and technetium removal; evaporators for waste concentration and water balance; processes for managing effluents; consolidation of glass process controls; and vitrification of ion-exchange resins.

Investments that are primarily targeted at reducing technical risks that jeopardize site baseline remediation requirements include sludge wash/caustic leach, solid-liquid separations technology. and continuous emission monitoring (melter selection). Investments driven by site programmatic risks (budget and regulatory demands) include in situ characterization and sampling technology, retrieval enhancements, and evaluation of alternate forms for low-level waste. Investment in reducing environmental, safety, and health risk include tank leak detection and monitoring technology.

Taken together, the full set of technical elements offers a portfolio of emerging tank remediation technologies that balances near-term baseline needs with longer term high-payoff alternatives, early wins with higher risk solutions, and risk reduction with cost savings.

Each technical element is directly associated with multiple other technical activities funded by EM-30, EM-40, or EM-50. FY95 activities that may be leveraged or coordinated in FY96 have been identified and will be integrated into this plan as EM-30 and EM-40 complete their FY96 planning process. Table ES.2 shows the estimated EM-30, EM-40, and EM-50 funding for each of the technical elements. Details are provided in Section 4 of the MYPP.

In FY96, the **TFA** strategy will be to continue the process of integrating site technology and crosscutting activities with a program that maintains a national perspective. The **TFA** will ensure that at least **80%** of the **EM** tank technology budget that is not directed at site-specific problems is fully leveraged or coordinated. The goal is to use the high-impact needs presented in the ***TFA Site Needs Data Assessment*** and the program presented in the MYPP to identify high-impact multisite activities that could be more efficiently performed through aggressive leveraging or coordination. Figure **ES.2** illustrates the envisioned concept for this integrating and focusing role in relation to site-specific and system-wide tank remediation.

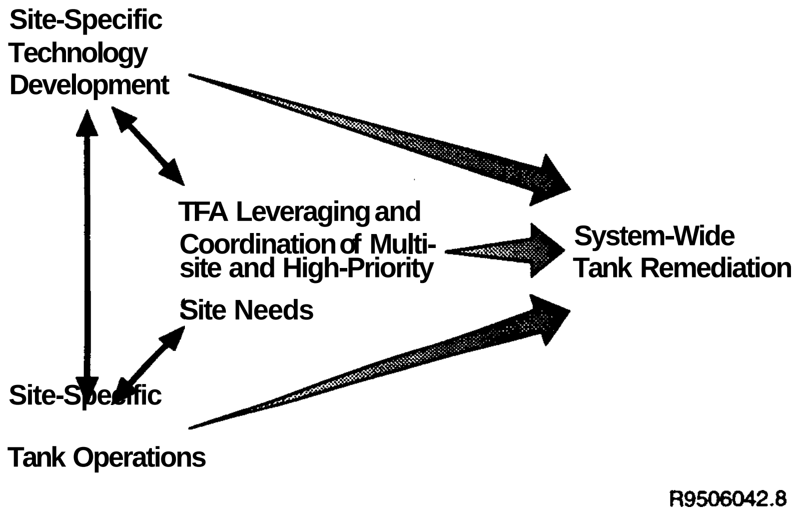

Figure ES.2. TFA Scope

References

Tanks Focus Area **(TFA).** 1995a. ***Multiyear Program Plan FY96-FY98.*** PNL-10650, Pacific Northwest Laboratory, Richland, Washington.

Tanks Focus Area (TFA). 1995b. ***TFA Sire Needs Data Assessment.*** Pacific Northwest Laboratory, Richland, Washington.

Table ES.l. Summary of TFA Technical Program

Technical Element	Problem Statement
Tank Leak Detection and Monitoring	In-tank leak detection methods are inadequate for measuring waste leaks during hydraulic retrieval operations that might insult the environment and possibly threaten public health. External methods need to be demonstrated that will provide early warning of tank leaks. This element reduces ES&H risk and will enhance current baselines at Hanford, Oak Ridge, and SRS.
Advanced Hot Cell Analytical Technology	The current baseline for characterization of sludges in the Hanford waste tanks would require that over 400 full-length core samples be obtained and analyzed in 19-in. segments over a 3-year time period. That approach will not provide the data expected to be required for remediation process design on time. More practically, projected budgets will not support it. Scanning technologies are needed to meet regulatory and DNFSB requirements within budget. This element reduces programmatic risk associated with DNFSB requirements and offers an early win at Hanford with indirect benefits to applications in the Mixed-Waste Focus Area.
In Situ Characterization	Retrieving one full-length core from tank waste can cost up to $400K. The average cost to conduct a complete suite of physical and chemical analyses on the core is about $350K and can take up to *200* days to complete. Development of in situ sensors and a deployment platform is needed to provide rheology data to augment coring operations at Hanford and, where possible, take the place of coring and hot cell analyses. This element reduces cost and will enhance current baselines at Hanford and INEL.
Process Monitoring and Control	On-line process analyzers will reduce the technical risk associated with waste processing. They are needed to: monitor corrosion inhibitors and rates, minimize the amount of liquid LLW created during HLW sludge washing, increase the feed rate to HLW glass melters, and reduce the risk of producing out-of-specification HLW and LLW forms. This element reduces technical risk and will enhance current baselines at Hanford, INEL, Oak Ridge, and SRS.
Sampling - Waste and Tank	Regulations require that target levels of waste removal be met before HLW tanks can be fully remediated and closed. Sites are currently unable to effectively sample the bottom of the tank and tank walls. This element reduces ES&H risk associated with DNFSB and tank closure requirements, enhancing the *Oak* Ridge baseline.
Deployment Systems	Sites are currently unable to inspect or confirm the inner environment and structural integrity of tanks, characterize waste at multiple locations, or retrieve and clean out waste "heels" at the bottom of tanks. Improved Characterization, inspection, and retrieval concepts could be realized with the addition of a single multifunction deployment system. This element reduces technical risk and will enhance baselines at Hanford, INEL, *Oak* Ridge, and SRS.

Table ES.l. (contd)

Technical Element	Problem Statement
Enhancements to Present Retrieval Processes	Baseline retrieval process technologies used at Hanford (past practice sluicing), Oak Ridge (past practice sluicing), and SRS (mixer pumps) have shortcomings that could be improved upon with modest investments in the application of existing industry technologies (such as mining and petrochemical). Even small investments in these site baseline technologies could result in savings of hundreds of millions of dollars. Specific problems include the following: • Mixer pumps have 1) leaking seals that add too much water to the tanks, 2) high life-cycle costs, and 3) limited ability to mobilize hard waste heels. • Past practice sluicing 1) is unable to mobilize heel wastes, 2) creates excessively dilute waste streams, and 3) can cause problems when used on leaking tanks. This element reduces technical risk and offers a cost-saving enhancement to current baselines at Hanford, INEL, Oak Ridge, and SRS.
Retrieval Process Development	Past practice sluicing, while effective, is still associated with large risk in terms of heel removal and leaking tanks; waste heels are difficult and costly to remove and require large volumes of water and acid cleaning. In addition, all of the waste cannot be removed using past practices. This element reduces programmatic risk and will enhance current baselines at Hanford, INEL, Oak Ridge, and SRS.
Acidic Cs/Sr/TRU/Tc Removal	The current baseline at INEL calls for the acidic supernate to be disposed of as Class A LLW. However, available separations methods do not remove the cesium, strontium, technetium, and TRU required for that classification. This element reduces technical risk and fills a gap in current baselines at Hanford and INEL.
Alkaline Cs Removal	Classification of alkaline supernate at Hanford, Oak Ridge, and SRS as either Class A or Class C determines how the waste will be treated and stored. Cesium removal is necessary to 1) permit the supernate to be processed, immobilized, and disposed of as a Class A LLW and 2) reduce worker exposure, improve safety, and allow for decreased facility costs. Available separations methods have not been proven and comparative data on the most-effective sorbents do not exist. This element reduces technical risk in currtnt baselines at Hanford and Oak Ridge and offers an alternative to the baseline at SRS.

Table ES.l. (contd)

Technical Element	Problem Statement
Alkaline Sr/TRU/Tc Removal	Because of the presence of strontium, technetium, and TRU, supernate cannot be processed, immobilized, and disposed of as Class A LLW. Technetium removal is potentially important because of its long half-life and mobility. Available separations methods have not been proven. This element offers a significant cost-reducing enhancement to current baselines at Hanford, Oak Ridge, and SRS.
Caustic Recycle	Significant sodium hydroxide must be added to sluice and leach sludges, which could increase the LLW volume by 18%. The added sodium also puts added requirements on the immobilization system. If caustic can be cleaned for release, the amount of LLW to be immobilized is reduced by 90%. This element offers a significant cost-reducing alternative to current baselines at Hanford and SRS.
Manage Process Effluents	The construction of new tank farms is not likely. Nevertheless, processing tank waste generates large amounts of liquid, solid, and gaseous effluents that must be treated and disposed of at all sites. Tank farms are still receiving wastes. All four sites have some D&D activities that add to the amount of wastes being stored. Secondary liquid wastes are recycled to the tanks. This element offers a cost-saving enhancement to current baselines at Hanford, INEL, Oak Ridge, and SRS.
Sludge WashlCaustic Leach	The majority of tank waste at Hanford, Oak Ridge, and SRS is stored in high caustic sludge that contains sodium and aluminum. The sodium and aluminum content of the sludge increases the number of HLW logs to be processed, as do components such as phosphate and chromate. This element offers cost savings, fills a gap in current baselines at Hanford and Oak Ridge, and may enhance the baseline at SRS.
Solid-Liquid Separations Test Equipment Development and Transfer	After the separation and washing process, colloidal materials and small particles may remain in the supernate and could cause downstream processing failures. TRU materials and strontium tend to attach to small particles and are difficult to process as supernate. This element offers a cost-reducing enhancement and reduces technical and programmatic risk at Hanford, INEL, Oak Ridge, and SRS.
Waste Concentration/Water Balance	Retrieval and pretreatment operations add large amounts of water to the waste, which must be removed for some pretreatment operations and for immobilization feed. The size and complexity of the LLW and HLW processes depend on the amount of excess water in the feed. Evaporator prohlems include fouling and vapor. This element offers a cost-saving early win at Oak Ridge with possible applications at other tank sites.

Table ES.1. (contd)

Technical Element	Problem Statement
Form for Immobilization of LLW	Three of the tank sites have selected grout as the LLW form, and one has selected glass. Sufficient funds will probably not be available for a DWPF-type immobilization facility in the foreseeable future. This element reduces programmatic risk associated with probable hudget cuts and resulting changes in baseline agreements and will provide the basis for selecting alternatives to current baselines.
Melter Selection	More specific criteria, more timely data, and input from other programs are needed to improve the efficiency and reduce the risks of melter technology selection. This element reduces the technical risks at Hanford, INEL, Oak Ridge, and SRS associated with current baselines or privatization.
Vitrification of Ion-Exchange Resins	An appropriate process for vitrifying ion-exchange resins is needed. This element offers a significant cost-reducing alternative to tank remediation at Hanford, Oak Ridge, and SRS.
Consolidation of Glass Process Controls Development	Hanford, INEL, and SRS efforts on glass process controls development are duplicative. This element offers a sensible cost-saving enhancement to system-wide tank remediation.
Focused Facilities and Processes	Sufficient funds will probably not be available for large central processing facilities in the foreseeable future. Budget and stakeholder pressures to initiate remediation may prevent the traditional "one-size-fits-all" approach to tank remediation. This element reduces fiscal year costs and programmatic risks associated with current baselines at Hanford, INEL, Oak Ridge, and SRS and explores an alternative step-wise approach to remediation that favors smaller facilities tailored to groups of tanks with similar waste characteristics.
Waste Retrieval and Tank Closure Demonshation	DOE has little experience in actually closing a *tank.* There are no technical data establishing tank closure standards at each site to help sites and regulators determine the degree to which each tank must be remediated prior to stabilizing and closing that tank. This element reduces technical risk and offers a cost-reducing early win at SRS with benefits to Hanford, INEL, and Oak Ridge.

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Table ES.2. Recommended Technical Program Budget

Needs Breakdown Structure Reference	Technical Element	FY95 Budget, $K[a]					FY% Requested Budget, $K[a]					FY97 Requested Budget, $K[a]					FY98 Requested Budget, $K[a]					Total
		EM-SO Tanks	EM-SO X[b]	EM-30 Hanford	EM-30 Others	EM-40	EM-SO Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 others	EM-40	EM-SO Tanks	EM-SO X[b]	EM-30 Hanford	EM-30 Others	EM-40	EM-SO Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 Others	EM-40	
Manage Tank Waste: Safely Store wastes	Tank Leak Detection and Monitoring	625	300	250			600	270	1,000			450		1,000								4,495
Manage Tank Waste: Characterize Tank System	Advanced Hot Cell Analytical Technology	350		865			1,310		2,650			1,000		1.850			450		750			9,225
	In Situ Characterization	790		1,420			710		1.500			450		1.400			250		500			8,020
	Process Monitoring and Control						5 0 0					750					750					2,000
	Sampling - Waste and Tank						300					500					750					1,550
Process Waste: Retrieve Wastes	Deployment System	4.215		1.530	2.112	1.420	6.560		3.250	1,408	2,500	4,000					4,000					31,005
	Enhancements to Present Retrieval Processes			1.235	403	870	700		9,190	1,205		700		7,580			1,000		3,700			26,583
	Retrieval Process Development	3,500		2,670	1,790	2,000	2.865		8,570	1,400		2,500		4,010	600		2,500		10,600	2,400		45,405
Process Waste: Pretreat Wastes	Acidic Cs/Sr/TRU/Tc Removal	434	1,750		1,770		550	1,500		500		550	1,500		1,000		600					10,154
	Alkaline Cs Removal	1,467	1,550	1,872	868		2,500	1,000	899	1,730		1,500	500	1,080	500		1,500					16,966
	Alkaline Sr/TRU/Tc Removal	1,601	1,525	3,984	689		300	1,000	2,504			500	800	1,560			300					14,763
	Caustic Recycle		970				600	1,000				1,000	500				2,000					6,070
	Manage Process Effluents						300	500				600	500				1,350					3,250
	Sludge Wash/Caustic Leach		1,725	5,696	3,944	100	1,000	1,500	6,000	3,147	500	1,000	1,250	2,750		2,000	1,500					32,112
	Solid-Liquid Separations Test Equipment Development and Transfer	300		2,016	1,235		800	600	1,905	1,050	500	1,400	600	1,905	1,200	500	1,500					15,511
	Waste Concentration/Water Balance	1,100			980		350			400		350			400		200					3,780
Process Waste: Select Waste Forms for LLW	Form for Immobilization of LLW	400		1,700	4.191		900		950	3,402	500	400		950	1,375	1,000	800		350		1,000	17,918
	Melter Selection	150	50	25.198	97		60	50														25,605
	Vitrification of Ion-Exchange Resins	200		1.879			800		2,525			1,000		1,915			1,000		2,730			12,049
Process Waste: Select Waste Form for HLW	Consolidation of Glass Process Controls Development	300	200	1,720	3.228		100	200	2,630	3,387		300	200	2,220			300		1,020			15,805
	Focused Facilities and Processes						300					1,650					5,000					6,950
System Closure: Determine Performance Criteria for Tank Facility Stabilization and Closure	Waste Retrieval and Tank Closure Demonstration	100			200		1,450			645	2,500	1,900			500		2,000			500		9,795
Total		15.542	8.070	52.035	21,507	4.390	23,555	7,620	44,573	18,274	6,500	22,500	5,850	28,220	5,575	3,500	27,750	-	19,650	2,900	1,000	319,011

(a) Bares for funding estimates: EM-50 Tanks estimated from ongoing projects plus TFA estimates of ongoing work; all other estimates were provided by the applicable program management as of January 1995. These estimates are subject to change as the programs change
(b) EM-50 X = EM-50 crosscutting programs.

All funding estimates are for planning purposes only and are not official funding information.

Contents

Figures

Tables

Section 1 - Introduction

The Tanks Focus Area (TFA) Multiyear Program Plan (MYPP) presents the recommended TFA technical program. The recommendation covers a 3-year funding outlook (FY96-FY98), with an emphasis on FY96 and FY97. In addition to defining the recommended program (Section 2), this document also describes the processes used to develop the program (Section 3), the implementation strategy for the program (Section 4), the references used to write this report (Section 5), data on the U.S. Department of Energy (DOE) tank site baselines (Appendix A), details on baseline assumptions and the technical elements (Appendix B), and a glossary (Appendix C).

1.1 Background

DOE faces a major tank remediation problem. Approximately 330 tanks are used to store over 380,000 m^3 of high-level waste (HLW) and transuranic (TRU) waste across the DOE system. Most have significantly exceeded their life spans. Seventy-nine tanks across the DOE system (most at Hanford) are known or assumed to have leaked. In addition, some of the tank contents are potentially explosive. These tanks must be remediated and made safe. However, regulatory drivers are more ambitious than baseline technologies and budgets will support.

The tanks are located at the four major DOE tank sites: Richland, Washington; Idaho Falls, Idaho; Oak Ridge, Tennessee; and Savannah River, South Carolina. The tank waste exists in different forms, and the constituents vary across the sites and across the tanks at each site. Some tanks contain chemicals that generate gas or high amounts of heat and are potentially explosive. The tanks also differ in structure, construction, and capacity. The technical risks of remediation are complicated by programmatic, institutional, and regulatory issues that also vary across the sites.

DOE's Office of Environmental Restoration and Waste Management (EM) has an estimated FY95 budget of about $120 million for technology development to remediate tank waste. This money is funded out of 11 organizations and supports about 350 separate activities addressing a variety of problems across the four tank sites.

The TFA estimates that 35% of the EM tank technology budget is specific to (and required for) site baselines and will likely add little benefit to other sites. Approximately 5% of the EM budget addresses problems that are either low priority to the sites, have already become irrelevant with changing site baselines, are duplicative, or are unlikely to produce practical solutions. The remaining 60% is focused on activities that have potential benefit across sites and may be refocused (40%) or are already leveraged (20%) to increase their benefit to the system. Figure 1.1 shows this distribution graphically.[a]

(a) **These estimates are based on preliminary judgments by the TFA Technical Team using data supplied by the sites in January 1995. The database is not complete, and these preliminary judgments need to be further assessed before this assessment is used to support specific decisions.**

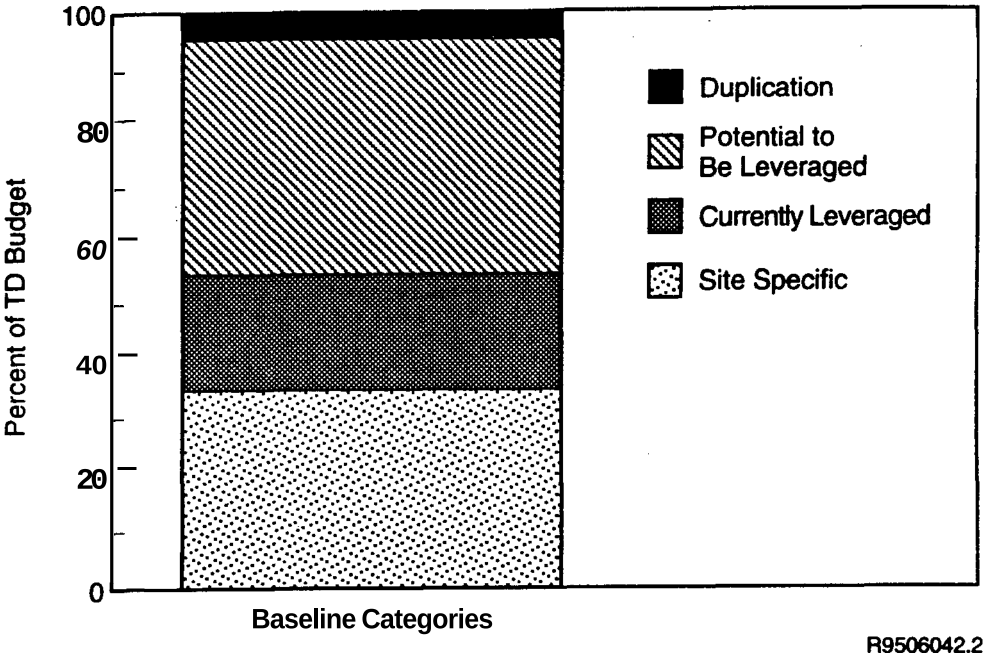

Figure 1.1. Distribution of EM FY95 Tank Technology Development Budget

1.2 New Approach to Technology Development

Before FY95, responsibility for remediating DOE's tanks and for developing supporting technologies was spread across multiple organizations and sites within the DOE system. In January 1994, DOE issued an action plan establishing a new approach for solving complex remediation problems, including the HLW and TRU waste tank problem. On April 1, 1994, DOE issued a call for proposals on approaches for transitioning tank technology development from a site-based effort to one with a national focus.

A team of seven contractors and national laboratories responded to the call for proposals and were awarded responsibility for implementing the new approach for tanks. In this effort, Pacific Northwest Laboratory (PNL) serves as the lead technical organization of the TFA Implementation Team. This team is composed of Idaho National Engineering Laboratory (INEL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Sandia National Laboratories (SNL), Westinghouse Savannah River Company (WSRC), and Westinghouse Hanford Company (WHC). DOE's Richland Operations Office (RL) serves as the lead field office and administrator of this team. The Implementation Team is guided by a User Steering Group (USG) comprised of senior managers of the site tank remediation programs. The technical program is reviewed by the TFA Technical Review Group (TFA-TRG), which is comprised of technical experts from the national laboratories and universities.

The TFA began operation in October 1994. Its mission is to provide integrated solutions that will accelerate safe and cost-effective cleanup and closure of DOE's national tank system. Successful solutions will reduce technical, programmatic, or environmental, safety, and health (ES&H) risk and reduce the overall cost of tank remediation.

The TFA is responsible for technology development to support DOE's four major tank sites at the Hanford Site, **INEL,** Oak Ridge, and Savannah River Site (SRS). Its technical scope covers the major functions that comprise a complete tank remediation system: safety, characterization, retrieval, pre-treatment, immobilization, and closure. The TFA integrates program activities across all organizations that fund tank technology development within EM, including the Offices of Waste Management (EM-30), Environmental Restoration (EM-40), and Technology Development **(EM-50).** In the future, the TFA will integrate activities across and beyond the DOE system.

The TFA's immediate challenge has been to deliver, within 1 year, a technology program that is

- applicable - addresses users' needs and can be implemented within budget, schedule, and regulatory constraints
- integrated - leverages relevant activities across **EM-30,** EM-40, and **EM-50** and, later, across and beyond the DOE system
- acceptable - has broad involvement of key stakeholders and incorporates expertise from outside the laboratory system (e.g., from industry and universities)
- accountable - performs within budget and on schedule and produces a clear benefit.

At the same time, the technologies provided by this program must

- reduce the technical risks that jeopardize baseline tank remediation performance requirements
- reduce the programmatic risks that 1) jeopardize the sites' ability to comply with regulatory or stakeholder drivers that are not formalized in baseline plans or 2) limit the site's ability to change their baselines in response to budget cuts
- reduce ES&H risks involving environmental, worker, or public safety issues associated with managing or remediating tanks
- significantly reduce the overall cost of **tank** remediation.

1.3 Organization of MYPP

The MYPP consists of the following sections. Section **2** provides a program overview and describes the baseline recommendation. The baseline recommendation consists of **22** technical elements. The technical elements were developed by the TFA Technical Team based on data gathered during the needs assessment and program definition stages of the process and have been reviewed by the USG and TFA-TRG. The technical elements address the broad-impact multisite needs, they describe the technical problem underlying each need, and they map a path to resolve the technology development components of that problem. Each technical element also contains FY96-FY98 budget and scope projections.

Detailed schedules and performance indicators will be presented in the TFA **FY96** work plan. Section 3 provides an overview of the processes used to develop and implement the baseline recommendation: site needs assessment, TFA program definition, scope selection, and team development. Section **4** describes the impact of the implementation strategy for the program. Section 5 lists the references used in writing this report.

Several appendices are attached to this document. Appendix A describes DOE's baseline approach to remediating each site's tank waste as well as the site costs and risks associated with the remediation baselines. Appendix B consists of a summary of the current baseline technical and programmatic assumptions and more detailed descriptions of the recommended technical elements. Each description includes a problem statement, path to solution, technical issues, **FY96-FY98** scope, benefits of the technology, and funding information. Appendix C contains a list of acronyms and abbreviations and a glossary of terms used in this document.

Larger tables for each section of this **MYPP** are provided at the end of each section. Other figures and tables are placed after they are called out in the text.

Section 2 - TFA Technical Program

This section describes the assumptions and recommendations for a nationwide tank technology program that addresses high-impact multisite needs associated with DOE's baseline approach for remediating and closing tanks. It provides an overview of the program, including tables that summarize the technical elements of the program (with their problems, solution paths, and deliverables) and the recommended program budget.

2.1 TFA Technical Program Overview

In FY95, the TFA developed the organizational and technical basis for a nationally integrated technology program. The TFA Implementation Plan presents the organizational framework for that program. This MYPP documents the recommended technical program and describes the path forward for its implementation.

The technical elements were developed from the information resulting from the needs assessment (see Section 3) and defined to meet the fundamental DOE remediation objectives of reducing technical, programmatic, or ES&H risks and reducing the overall cost of remediation. The selection of technical elements and distribution of funding support a balance of "early wins" that may be delivered in 1 to **3** years to address immediate uncertainties in site baselines, "enhancements" that provide ways to significantly enhance remediation baselines by reducing costs and risks over the remediation life cycle, and "longer termhigh-payoff solutions" that provide alternatives to the baseline technical approach.

Table 2.1 summarizes the technical elements of the TFA program; the technical element titles, summaries of the problem statement and primary benefit, path to solution, and deliverables are given. The technical elements are listed by the following major needs structure categories breakdown: manage tank waste, process waste, and system closure. More detailed descriptions of the technical elements are given in Appendix B.

The technical elements support a program that is responsive to high-impact tank remediation needs, either because of their urgency to a single site or their multisite benefit. The TFA assumes that **EM-30** and EM-40 programs will continue to respond to high-priority problems at the sites that have little or no benefit to the broader system. However, the TFA will remain cognizant of tank technology needs and activities across the system and will provide data relevant to processing system-wide requirements and conditions so that technical solutions applicable at one site will benefit others.

The requested budget for the TFA-managed technical program is $23.6 million[(a)] for FY96 and **$24.3** million for FY97 (see Table **2.2).** These figures are $75.7 million and $58.3 million, respectively, when activities in the crosscutting and Hanford programs are integrated. The fully coordinated

(a) TFA management *costs* of approximately *$5* million will be outlined in the FY96 work plan.

budget for the recommended program, including **EM-30, EM-40**, and **EM-50** funding, is **$100.5** million for FY96 and $67.4 million for FY97. These figures reflect currently requested crosscutting and site-specific program budgets for activities that are either directly leveraged,") strongly coordinated,@" or potentially leveraged[c] with the focused multisite program.

No recommendations are provided at this time regarding the scope of currently funded EM tank-related technical activities beyond the focus of this program. In addition, no effort has yet been made to integrate activities beyond EM, including basic research conducted within the Office of Energy Research that is relevant to the recommended program. Further integration will occur during the latter part of FY95 and in FY96.

2.2 Technical Program

The **TFA** is pursuing a phased management and technical strategy. The program will initially focus on technologies that can be rapidly deployed or meet near-term needs at multiple sites under multiple possible baselines (e.g., privatization). **As** these technologies are demonstrated and transitioned to users, the program will shift to focus on technical initiatives that offer greater payoffs with somewhat greater risk.

The program presented here is therefore focused on solutions that are planned for deployment **within** site baselines in 1 to **3** years. These near-term solutions emphasize relatively mature technologies, many of which have been developed by **EM** for several years but may not have received the national, focused attention that this program will provide. The solutions are primarily aimed at reducing technical risk and offer enhancements to or fill gaps in current site baselines.

Technologies that offer early and relatively certain site payoffs include the following:

- Advanced Hot-Cell Analytical Technology - This technology is part of a package of technologies being developed as a "rapid response" to Defense Nuclear Facilities Safety Board **(DNFSB)** demands for more effective characterization of Hanford tanks. It will provide immediate benefit to Hanford by providing laser abalation/mass spectrometry and Raman spectroscopy scanning for **HLW** molecular analysis (required to design processing flowsheets), near infrared scanning for moisture (a safety concern), and gamma/beta scanning. In addition to providing an early win at Hanford for faster and more representative characterization data and potentially reducing characterization costs by about **$20** million, the technologies have potential applications to other EM remediation problems (e.g., mixed waste).

- Deployment Systems - **A** lightduty utility arm is being developed to provide an in-tank multipositioning capability for surveying tank structures, characterizing tank waste, and enabling small-scale retrieval. This technology provides the platform for deploying a range of

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(a) Directly Leveraged - Budgets, scope, and schedule have been integrated in existing technical task plans or activity data **sheets.**

(b) Strongly Coordinated - Scopes are dependent on data **provided under related technical task plans or activity data sheets.**

***(c)* Potentially Leveraged - Scopes are related, and there may be an opportunity for further leveraging.**

instruments in tanks and will demonstrate the feasibility of larger-scale mechanical retrieval. It will be demonstrated and deployed for separate missions at Hanford, INEL, and Oak Ridge during **FY96** and **FY97**.

- Retrieval Process Development - High- and medium-pressurejets are being developed and demonstrated in tanks at INEL and Oak Ridge in **FY96** to remove the difficult tank waste heels at these sites. This process provides an alternate waste removal technology that is particularly effective for hard-to-remove sludges from tanks with integrity problems, including tanks that leak or have difficult to manage hardware. The jets will provide immediate benefit to INEL and Oak Ridge, supporting the Tank Heel Removal Project and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-driven Gunite Tank Treatability Study, respectively, and offers potential retrieval benefits at Hanford.

- Alkaline Cesium Removal - The **FY96** cesium removal demonstration at Oak Ridge will provide critical data on the most cost-effective sorbents **to** use within different flowsheets. The data will support key processing decisions related to selecting ionexchange sorbents (at Oak Ridge), in-tank precipitation alternatives (at SRS), and baseline cesium removal processes (at Hanford).

- Waste Processing and Tank Closure Demonstration - **A** SRS tank will be cleaned and closed, with demonstrations testing alternate retrieval and closure technologies planned over 3 years (FY96-FY98). The demonstrations will provide valuable data and, potentially, readily deployed retrieval alternatives to SRS, supporting key decisions related to baseline retrieval options and potentially accelerated schedules. The demonstration will also benefit Hanford, Oak Ridge, and INEL where current retrieval technologies are also too costly and potentially ineffective against regulatory requirements for closure.

While focused on near-term baseline needs, the TFA has initiated higher payoff investments that have longer lead times and mid-term investments that are targeted at reducing technical. programmatic, and safety risks at the sites.

Investments that offer particularly significant life-cycle cost savings with relatively significant **risk** include caustic recycle methods and evaluation of concepts for moving away from centralized, large-scale processing to more focused facilities and processes. Additional cost-saving investments include process monitoring and control; alkaline strontium. technetium, and transuranic waste removal; acidic cesium, strontium, TRU, and technetium removal; evaporators for waste concentration and water balance; processes for managing effluents; consolidation of glass process controls; and vitrification of ion-exchange resins.

Investments that are primarily targeted at reducing technical risks that jeopardize site baseline remediation requirements include sludge wash/caustic leach, solid-liquid separations technology, and continuous emission monitoring (melter selection). Investments driven by site programmatic risks (budget and regulatory demands) include in situ characterization and sampling technology, retrieval enhancements, and evaluation of alternate forms for LLW. Investment in reducing ES&H risk include tank leak detection and monitoring technology.

Taken together, the full set of technical elements offers a portfolio of emerging tank remediation technologies that balances near-term baseline needs with longer term high-payoff alternatives, early wins with higher risk solutions, and risk reduction with cost savings.

Each technical element is directly associated with multiple other technical activities funded by **EM-30, EM-40**, or **EM-50. FY95** activities that may be leveraged or coordinated **in FY96** have been identified and will be integrated into this plan **as EM-30** and **EM-40** complete their **FY96** planning process. Table **2.2** shows the estimated **EM-30, EM-40,** and **EM-50** funding for each of the technical elements. Section **4** provides additional detail of this integration.

In **FY96**, the TFA strategy will be to continue the process of integrating site technology and crosscutting activities with a program that maintains a national perspective. The **TFA** will ensure that at least 80% of the EM tank technology budget that is not directed at site-specific problems is fully leveraged or coordinated. The goal is to use the high-impact needs presented in the ***TFA Site Needs Data Assessment*** and the program presented in this **MYPP** to identify high-impact multisite activities that could be more efficiently performed through aggressive leveraging or coordination.

2.3 Assumptions for the MYPP

The **TFA** made programmatic and technical assumptions about tank waste remediation when developing the recommended technical program. General programmatic assumptions are shown below; technical assumptions are provided in Appendix **B** (Table **B.**1).

- Tri-Party Agreement, Federal Facility Agreements, and DOE-state agreements will be honored as currently written.

- Accepted tank closure scenarios involving retrieval and treatment of the majority of the tank waste will not change.

- EM **FY96** commitments to Congress for tank-related technology demonstrations will be honored (these primarily involve characterization, retrieval, and cesium removal demonstrations).

Within these boundary conditions, this **MYPP** supports alternative remediation baselines including privatization and significant site remediation budget reductions.

Table **2.1.** Scope of Recommended TFA Technical Program

Technical Element	Problem Statement	Path to Solution	**FY96-FY98 Scope**
Tank Leak Detection and Monitoring	In-tank leak detection methods are inadequate for measuring waste leaks during hydraulic retrieval operations that might insult the environment and possibly threaten public health. External methods need to he demonstrated that will provide early warning of tank leaks. This element reduces ES&H risk and will enhance current baselines at Hanford, Oak Ridge, and Savannah River.	Develop in situ monitors that signal safety concerns and provide data for making tank waste retrieval decisions. Demonstrate ability to rapidly and cheaply install ERT prohes using CP method. Test ERT technique in cold facility at Hanford. Move from successful cold test to an actual HLW tank during retrieval.	- Identify candidate HLW tanks for ERT demonstration. - Install plastic dry wells and ERT technology in cold test facility. - Monitor for leaks during retrieval campaign. - Validate cost and rapidity of emplacement of ERT electrodes with CP technique in cold tests. - Baseline ERT to actual tank farm environment. - Conduct ERT demonstration test **on** tank during retrieval operations. - Develop protocols for use and purpose of LDM data during retrieval operations.
Advanced Hot Cell Analytical Technology (AHCAT)	The current haseline for characterization of sludges in Hanford waste tanks would require that over **400** full-length core samples be obtained and analyzed in **19-in. seg**ments over a 3-year time period. That approach will not provide the data expected to be required for remediation process design **on** time. More practically, projected budgets will not support it. Scanning technologies are needed to meet regulatory and Defense Nuclear Facilities Safety Board (DNFSB) requirements within budget. This element reduces programmatic risk associated with DNFSB requirements and offers an early win at Hanford with indirect benefits from applications to other EM problems (e.g., the Mixed-Waste Focus Area).	Develop remote analytical scanning technologies to reduce the cost and time to characterize extruded cores from tank wastes. Complete the AHCAT program for the Hanford Site HLW tank cores, which will develop, demonstrate, and deploy the laser ablationlmass spectrometer, near infrared probe, Raman spectroscopy prohe, and a β/γ probe for elemental, moisture, chemical, and β/γ analysis, respectively, into a routine hot cell application for scanning cores.	- Deploy core scanning technologies **for** routine use **in** the Hanford Site hot cells to reduce cost and time to characterize extruded cores from tank waste.

Table 2.1. (contd)

Technical Element	Problem Statement	Path to Solution	FY96-FY98 Scope
In Situ Characterization	Retrieving one full-length core from tank waste can cost up to $400K. The average cost to conduct a complete suite of physical and chemical analyses on the core is about $350K and can take up to 200 days to complete. Development of in situ sensors and a deployment platform is needed to provide rheology data to augment coring operations at Hanford and, where possihle, take the place of coring and hot cell analyses. This element reduces cost and will enhance current baselines at Hanford and INEL.	Complete development of Raman sensor for integration with standard rheology sensor package in CP. Cold field test Raman sensor with 35-ton push force to check integrity of sapphire window. Test chemical and radiation hardness of sensor in gamma test facility. Deploy CP in real tank waste.	- Develop and cold test Raman probe sensor package on CP for operation in Hanford tanks to augment coring operations. - Deploy cone penetrometer with integrated sensor package including Raman probe for scanning molecular species in situ at Hanford. - Develop and cold test physical properties end effectors (minilab) for deployment on LDUA at INEL in FY97.
Process Monitoring and Control	On-line process analyzers will reduce the technical risk associated with waste processing. They are needed to minimize the amount of liquid LLW created during HLW sludge washing, increase the feed rate to HLW glass melters, and reduce the risk of producing out-of-specification HLW and LLW forms. This element reduces technical risk and will enhance current baselines at Hanford, INEL, Oak Ridge, and SRS.	Initiate technology programs to develop real-time sensors for - Monitoring corrosion inhibitors and rates. - Minimizing amount of LLW generated during sludge washing. - On-line analysis of feed solution to HLW and LLW melters.	- Develop Raman probe for in-tank or process stream measurement of nitrite concentrations to minimize volume of corrosion inhibitor added. - Deploy Raman technology for on-line measurement of nitrite concentrations. - Demonstrate commercially available monitors and process control logic to minimize volume of liquid LLW generated when washing HLW sludges with caustic solutions.
Sampling - Waste and Tank	Regulations require that target levels of waste removal be met before HLW tanks can be fully remediated and closed. Sites are currently unable to effectively sample the bottom of the tank and tank walls. This element reduces ES&H risk associated with DNFSB and tank closure requirements, enhancing the Oak Ridge baseline.	Initiate programs to develop robotic end effectors capable of taking solid and liquid samples in all areas of the tanks.	- Develop and deploy device to take concrete samples from the walls and bottoms of Oak Ridge gunite tanks. - Develop and deploy device to take sludge samples from the bottom of HLW tanks at INEL.

Table 2.1 (contd)

Technical Element	Problem Statement	Path to Solution	**FY96-FY98** Scope
Deployment Systems	Sites are currently unable to inspect or confirm the inner environment and structural integrity of tanks, characterize waste at multiple locations, or retrieve and clean out waste "heels" at the bottom of tanks. Improved characterization, inspection, and retrieval concepts could be realized with the addition of a single multifunction deployment system. This element reduces technical risk and will enhance baselines at Hanford, INEL, Oak Ridge, and SRS.	Manufacture and deliver the LDUA to Hanford, INEL, and the EM-50 Cold Test Facility. Design, develop, manufacture, and deliver a modified LDUA to Oak Ridge. Support cold testing and hot operations of the LDUA.	- Deliver LDUA systems to the Hanford Site TWRS, Oak Ridge, and INEL. - Complete integrated testing of LDUA inspection system for Hanford to prepare for in-tank deployment. - Hot demonstration of LDUA System riser-mounted technologies and end effectors at Hanford. - Demonstrate inspection capability using the LDUA systems at Oak Ridge and INEL. - Conduct hot demonstration of LDUA system riser-mounted technologies and end effectors at Oak Ridge and INEL. - Deliver LDUA system for use in test bed. - Complete installation of LDUA test bed to support operations at three sites and to develop and test end effectors from industry and DOE development programs responding to characterization, surveillance, and retrieval needs. - Support retrieval demonstrations using WD&C technologies at INEL and Oak Ridge.

Table 2.1 (contd)

Technical Element	Problem Statement	Path to Solution	FY96-FY98 Scope
Enhancements to Present Retrieval Processes	Baseline retrieval process technologies used at Hanford (past practice sluicing), Oak Ridge (past practice sluicing), and SRS (mixer pumps) have shortcomings that could he improved upon with modest investments in the application of existing industry technologies (such as mining and petrochemical). Even small investments in these site baseline technologies could result in savings of hundreds of millions of dollars. Specific problems include the following: - Mixer pumps have 1) leaking seals that add too much water to the tanks, 2) high life-cycle costs, and 3) limited ability to mobilize hard waste heels. - Past practice sluicing 1) is unable to mobilize heel wastes, 2) creates excessively dilute waste streams, and 3) can cause problems when used on leaking tanks. This element reduces technical risk and offers a cost-saving enhancement to current baselines at Hanford, INEL, Oak Ridge, and SRS.	ldentify promising technologies from industry other than those currently chosen by the Acquire Commercial Technology for Retrieval project at Hanford. Test chosen technologies in scaled test facilities or actual waste tanks.	- Facilitate integration and coordination through planning, test plan development, and technical forums to ensure maximum benefit for Hanford, INEL, and SRS. - Demonstrate one retrieval technology (such as Pulsair) from industry on simulated waste to provide additional options to Hanford, Oak Ridge, and SRS. - Conduct enhanced sluicing tests on simulants to provide options to all tank sites and provide a possible option for SRS in-tank demonstration during previous demonstration. - Develop enhanced sluicing technologies in coordination with EM-30 efforts. - Provide technical support to the joint Hanford and SRS mixer pump development projects. - Develop retrieval models to predict the cost and efficiency of retrieval process operations as validated by testing and major demonstrations.

Table 2.1 (contd)

Technical Element	Prohlem Statement	Path to Solution	FY96-FY98 Scope
Retrieval Process Development	Past practice sluicing, while effective, is still associated with large risk in terms of heel removal and leaking tanks; waste heels are difficult and costly to remove and require large volumes of water and acid cleaning. In addition, all of the waste cannot be removed using past practices. This element reduces programmatic risk and will enhance current haselines at Hanford, INEL, Oak Ridge, and SRS.	Continue development of alternate technologies such as arm- or vehicle-based retrieval systems, in-tank hardware removal systems, retrieval end effectors for all waste forms, simulant pedigree, confined sluicing technologies, and waste conveyance and transfer systems. Continue simulant development activities.	- Complete integrated testing of pneumatic and hydraulic conveyance and transfer end effectors. - Deploy confined sluicing retrieval end effectors at Oak Ridge. - Develop prototype pneumatic or hydraulic end effectors for removal of waste from tanks at INEL. - Initiate technology transfer of pneumatic and hydraulic conveyance and transfer end effectors for INEL. - Deploy confined sluicing retrieval end effectors at INEL. - Provide technical support to Savannah River Retrieval and Closure Demonstration by leading the effort to select and deploy the retrieval process for Phase III. - Execute a modest simulant development program to address only those absolutely essential items to support Hanford, INEL, and Oak Ridge retrieval efforts.
Acidic Cs/Sr/TRU/ Tc Removal	The current haseline at INEL calls for the acidic supernate to he disposed of as Class A LLW. However, availahle separations methods do not remove the cesium. strontium. technetium. and TRU required for Class A LLW. This element reduces technical risk. fills a gap in the current haseline at INEL, and offers an alternative processing approach to caustic sludge washing at Hanford.	Develop requirements for the level of removal. Develop criteria for selecting removal technology; conduct batch tests; perform small-scale engineering tests on best candidates; conduct large-scale demonstrations; establish a defensible baseline for cesium/strontium/technetium/TRU removal. Evaluate new technologies as they become available.	Assuming work conducted by ESP-IP will begin to tranfifer to the TFA in FY97 and FY98 for implementation at INEL and as alternative to Hanford alkaline processing: - Conduct hot cell demonstration of solvent extraction removal of strontium, technetium, and TRU in actual INEL waste. - Demonstrate, with real waste, cesium removed by strontium extraction, and enhancements for strontium and TRU.

Table 2.1 (contd)

Technical Element	Prohlem Statement	Path to Solution	**FY96-FY98** Scope
Alkaline Cs Removal	Classification of alkaline supernate at Hanford, Oak Ridge, and SRS as either Class A or Class C determines how the waste will he treated and stored. Cesium removal is necessary to 1) permit the supernate to he processed, immobilized, and disposed of as a Class A LLW and 2) reduce worker exposure, improve safety, and allow for decreased facility costs. Available separations methods have not heen proven and comparative data on the most-effective sorhents do not exist. This element reduces technical risk in current baselines at Hanford and Oak Ridge and offers an alternative to the haseline at SRS.	Coordinate an integrated cesium removal program across all technology development providers. Develop criteria for selection of sorbent; conduct batch tests; perform small-scale engineering tests on best candidates; conduct large-scale demonstrations; establish defensihle baseline for out-of-tank cesium removal. Evaluate new sorbents as they become available.	- Initiate operation of Phase 1 hot demonstration of cesium removal on 25,000 gal of MVST waste at Oak Ridge. - Conduct hot column tests on cesium sorbents for downselection and engineering of Phase 2 hot demonstration on MVST wastes. - Perform hot hatch tests on new cesium sorbents for potential demonstrations on other waste streams or Phase 3 of MVST wastes. - Complete and document Phase 1 hot cesium removal demonstration after downselection of available resins in **FY95** to support Oak Ridge in handling MVST wastes and provide data and to support Hanford in their selection of treatment processes. - Initiate additional demonstrations with other sorbents as they become available to make engineering tradeoffs to support process design at Hanford, Oak Ridge, and SRS.
Alkaline Sr/TRU/ Tc Removal	Because of the presence of strontium, technetium, and TRU, supernate cannot be processed, immobilized, and disposed of as Class A LLW. Technetium removal is potentially important because of i& long half-life and mobility. Available separations methods have not been proven. This element offers a significant cost-reducing enhancement to current baselines at Hanford, Oak Ridge, and SRS.	Develop requirements for the level of strontium, technetium, and TRU removal needed at each site. Develop criteria for selection of sorbent; conduct batch tests; perform small-scale engineering tests on best candidates; establish defensible baseline for strontium/technetium/TRU removal. Evaluate new sorbents as they become available.	- Conduct hot cell batch tests on selected strontium, technetium, and TRU sorbents with MVST supernate. - Complete hot testing of selected sorbents from **ESP** and TWRS programs for removal of strontium/TRU/cesium from Hanford wastes. - Expand hot testing of sorbents from ESP and TWRS programs for removal of strontium/TRU/cesium from Hanford wastes.

Table 2.1 (contd)

Technical El[illegible]t	Problem Statement	Path to Solution	FY96-FY98 Scope
Caustic Recycle	Significant sodium hydroxide must be added to sluice and leach sludges, which could increase the LLW volume by 18%. The added sodium also puts added requirements on the immobilization system. If caustic can be cleaned for release, the amount of LLW to be immobilized is reduced by 90%. This element offers a significant cost-reducing alternative to current baselines at Hanford and SRS.	Determine needed amount of sodium. Investigate calcination, membrane, and electrochemical methods to recover sodium. Investigate whether regenerated clear caustic can be released from the fuel cycle.	- Fund project to regenerate caustic. - Conduct bench-scale demonstration of salt-splitting using hot simulants.
Manage Process Effluents	The construction of new tank farms is not likely. Nevertheless, processing tank waste generates large amounts of liquid, solid, and gaseous effluents that must be treated and disposed of at all sites. Tank farms are still receiving wastes. All four sites have some decontamination and decommissioning (D&D) activities that add to the amount of wastes being stored. Secondary liquid wastes are recycled to the tanb. This element offers a cost-saving enhancement to current baselines at Hanford, INEL, Oak Ridee. and SRS.	Determine release criteria for solid, liquid, and gaseous streams. Determine likely concentrations for all types of waste. For streams exceeding criteria, determine and demonstrate technologies. Document projected waste volumes/compositions; determine ways to reduce waste volume at its source. Conduct scoping activities: increase interactions with waste generators, minimize water additions, analyze effects of D&D wastes, reduce recycle stream volumes. Volume reduction activities would free existing tank space.	- Initiate and coordinate a complex-wide approach for handling and processing secondary waste common to each tank site to define technology requirements. - Complete complex-wide cataloging of key source streams to tanks that need to be minimized. - Initiate planning for FY98 hot demonstration to treat DWPF recycle streams. - Finalize preparations for and initiate full-scale hot demonstration of a technology to remove cesium, solids, and mercury for a DWPF recycle stream.

Table 2.1 (contd)

Technical Element	Problem Statement	Path to Solution	FY96-FY98 Scope
Sludge Wash/ Caustic Leach	The majority of tank waste at Hanford, Oak Ridge, and SRS is stored in high caustic sludge that contains sodium and aluminum. The sodium and aluminum content of the sludge increases the number of HLW logs to be processed, as do components such as phosphate and chromate. This element offers cost savings, fills a gap in current baselines at Hanford and Oak Ridge, and may enhance the baseline at SRS.	Develop criteria to determine if washes are successful. Conduct small-scale batch tests on real sludge to determine the effectiveness of the washes. Use a model to determine the impact and/or benefits of additional processing. Establish ə defensible sludge strategy. Demonstrate process on pilot-scale equipment to understand operational parameters.	- Prepare for full-scale demonstration of solid-liquid separation of gunite tank wastes. - Evaluate carbonate washes to remove TRU from gunite sludges for down-selection to support demonstration. - Perform validations of proposed Hanford reference process from sludge washing. - Initiate a full-scale demonstration to remove plutonium and other TRU from gunite tank sludges to change classification to non-TRU wastes. - Demonstrate selected technologies developed by ESP or by the Uranium in Soils Integrated Demonstration to concentrate HLW fraction in the sludge at Hanford.

Table 2.1 (contd)

Technical Element	Problem Statement	Path to Solution	FY96-FY98 Scope
Solid-Liquid Separations Test Equipment Development and Transfer	After the separation and washing process, colloidal materials and small particles may remain in the supernate and could cause downstream processing failures. TRU materials and strontium tend to attach to small particles and are difficult to process as supernate. This element offers a cost-reducing enhancement and reduces technical and programmatic risk at Hanford, INEL, Oak Ridge, and SRS.	Determine filtration needs. Conduct small-scale tests with real wastes to understand prohlems such as fouling or colloid formation. Successful removal of these solids would enhance processing and reduce radioactivity in the LLW stream. Demonstrate on pilot and demonstration scale in order to understand fouling and operational parameters.	- Prepare for demonstration of solid-liquid separations on hot stream, and conduct small-scale tests with ossflow filters to prc id 1gi ering upp to c i - tify site and approach for hot cell demonstration of li i on second st stream. - Conduct industrial search for applicable q ti technology. - Perform first full-scale hot demonstration for solid-liquid ations on gunit tank or Oak Ridge cross transfer li e wastes. - Conduct hot hench-scale demonstration c a v eam from another site to t additional il information t support ig - Conduct cold demonstration g irradiated simula of dustrial filtration technology at scale to make engineering tradeoff studies. - ig electrochemical regeneration of n n in situ.
Waste Concentration1 Water Balance	Retrieval and pretreatment operations add large amounts of water to the waste, which must he removed for some pretreatment operations and for immobilization feed. The size and complexity of the LLW and HLW processes depend on the amount of excess water in the feed. Evaporator problems include fouling and vapor. This element offers a cost-saving early win at Oak Ridge with possible applications at other sites.	Enhance performance and selection of evaporators. Better understand impact of fouling and polymerization, corrosion, and decontamination factors. Conduct full-scale demonstrations on active waste. Evaluate flowsheet. Transfer Argonne National Laboratory knowledge of novel evaporator installation to the four tank sites.	- Close out FY96 OTD including transfer of technology to Oak Ridge user.

Table 2.1 (contd)

Technical Element	Problem Statement	Path to Solution	**FY96-FY98 Scope**
Form for Immobilization of LLW	Three of the tank sites have selected grout as the LLW form, and one has selected glass. Sufficient funds will probably not be available for a DWPF-type immobilization facility in the foreseeable future. This element reduces programmatic risk associated with probable budget cuts and resulting changes in baseline agreements and will provide the basis for selecting alternatives to current baselines.	Make a detailed comparison of the two waste forms, based on tests and analyses, to allow for complex-wide comparisons. In addition, develop data to guide alternative processing (and waste form) options, such as downsized facilities and JIT processing.	- Prepare regulatory acceptance information and submit to regulators. - Develop vendor procurement specifications. - Develop detailed program plan. - Perform process demonstrations for grout and glass. - Perform cost/risk/benefit analysis.
Melter Selection	More specific criteria, more timely data, and input from other programs are needed to improve the efficiency and reduce the risks of melter technology selection. This element reduces the technical risks at Hanford, INEL, Oak Ridge, and SRS associated with current baselines or privatization.	Determine Hanford's interest in CEM to gain real-time information on off-gas generation. Identify equipment requirements. Develop criteria for melter selection. Procure and assemble instrumentation for Hanford testing. Document results to aid melter selection.	- Transfer use of CEM (from CMST-IP) to the Hanford Site's Phase 2 melter selection. - Provide technical support to contract oversight on Phase I privatization. - Review specifications for Phase II privatization. - Evaluate responses for Phase II privatization.
Vitrification of Ion-Exchange Resins	An appropriate process for vitrifying IXRs is needed. This element offers a significant cost-reducing alternative to tank remediation at Hanford, Oak Ridge, and SRS.	Determine the appropriate method of vitrifying the material removed by ion-exchange. As part of pretreatment, decontaminate 25,000 gal of supernate with an IXR. Identify the preferred process for vitrification of IXR. Vitrify IXR using preferred process.	- Prepare for full-scale demonstration of cesium-loaded, spent IXRs in FY97 at completion of cesium removal demonstration. - Conduct demonstration of vitrifying loaded cesium IXRs from Oak Ridge.
Consolidation of Glass Process Controls Development	Hanford, INEL, and SRS efforts on glass process controls development are duplicative. This element offers a sensible cost-saving enhancement to system-wide tank remediation.	Identify initial process control constraints at each site. Develop control models for any constraints not already identified (using universities or industry). Verify and validate process control software.	- Develop software package for glass process control for transfer to Hanford and INEL users. - Verify and validate software package for glass process control for transfer to Hanford and INEL users in outyears.

Technical Element	Problem Statement	Path to Solution	FY96-FY98 Scope
Focused Facilities and Processes	Sufficient funds will probably not be available for large central processing facilities in the foreseeable future. Budget and stakeholder pressures to initiate remediation may prevent the traditional "one-size-fits-all" approach to tank remediation. This element reduces fiscal year costs and programmatic risks associated with current haselines at Hanford, INEL, Oak Ridge, and SRS and explores an alternative step-wise approach to remediation that favors smaller facilities tailored to groups of tanks with similar waste characteristics.	Perform risk/cost/benefit analyses. Demonstrate small facility concept using Oak Ridge sludge sluicing program. Demonstrate JIT processing at SRS.	- Prepare for FY97 demonstration(s) after completion of analysis for both processing and downsized vitrification. - Select site for demonstrating JIT processing to increase spectrum of possible technologies to accomplish waste processing. - Develop specifications for JIT process equipment. - Select sites for demonstrating JIT and finalize JIT demonstration plans.
Waste Retrieval and Tank Closure Demonstration	DOE has little experience in actually closing a tank. There are no technical data establishing tank closure standards at each site to help sites and regulators determine the degree to which each tank must be remediated prior to stabilizing and closing that tank. This element reduces technical risk and offers a cost-reducing early win at SRS with benefits to Hanford, INEL, and Oak Ridge.	Establish integrated systems for closing tanks and provide information for making closure decisions across the complex. Identify a tank for the demonstration; determine characterization needs; characterize the material in the tank; remove waste from the tank; pretreat as necessary; immobilize the material; and close the tank. To the extent possible, use private companies and commercial technologies to complete the steps.	- Develop demonstration objectives, approach, and evaluation criteria with SRS. - Complete demonstration of modified density gradient retrieval in SRS salt tank. - Demonstrate water jet or other alternate retrieval technologies in SRS salt tank. - Conduct thorough industrial search to identify other promising retrieval technologies. - Initiate development of evaluation criteria for defining a clean tank to ensure collection of technical data to be used to select options for tank closure. - Demonstrate alternate low-cost removal technology from industry for SRS salt tank to support SRS in evaluating alternatives to mixer pumps for waste retrieval. - Develop technical basis for options on tank closure at SRS through the demonstration and transfer of results to other tank sites. - Complete one additional demonstration of an alternate waste removal technology to support SRS in evaluating alternatives to mixer pumps for waste retrieval from salt tanks. - Provide a clean tank ready for closure at SRS. - Initiate tank closure demonstration.

Table 2.2. Recommended Technical Program Budget

Needs Breakdown Structure Reference	Technical Element	FY95 Budget, $K[a]					FY96 Requested Budget, $K[a]					FY97 Requested Budget, $K[a]					FY98 Requested Budget, $K[a]					Total
		EM-50 Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 Others	EM-40	EM-50 Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 Others	EM-40	EM-50 Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 Others	EM-40	EM-50 Tanks	EM-50 X[b]	EM-30 Hanford	EM-30 Others	EM-40	
Manage Tank Waste: Safely Store Wastes	Tank Leak Detection and Monitoring	625	300	250			600	270	1,000			450		1,000								4,495
Manage Tank Waste: Characterize Tank System	Advanced Hot Cell Analytical Technology	350		865			1,310		2,650			1,000		1,850			450		750			9,225
	In Situ Characterization	790		1,420			710		2,500			450		1,400			250		500			8,020
	Process Monitoring and Control						500					750					750					2,000
	Sampling - Waste and Tank						300					500					750					1,550
Process Waste: Retrieve Wastes	Deployment Systems	4,225		1,530	2,112	1,420	6,560		3,250	1,408	2,500	4,000					4,000					31,005
	Enhancements to Present Retrieval Processes			1,235	403	870	700		9,190	1,205		700		7,580			1,000		3,700			26,583
	Retrieval Process Development	3,500		2,670	1,790	2,000	2,865		8,570	1,400		2,500		4,010	600		2,500		10,600	2,400		45,405
Process Waste: Pretreat Wastes	Acidic Cs/Sr/TRU/Tc Removal	434	1,750		1,770		550	1,500		500		550	1,500		1,000		600					10,154
	Alkaline Cs Removal	1,467	1,550	1,872	868		2,500	1,000	899	1,730		1,500	500	1,080	500		1,500					16,966
	Alkaline Sr/TRU/Tc Removal	1,601	1,525	3,984	689		300	1,000	2,504			500	800	1,560			300					14,763
	Caustic Recycle		970				600	1,000				1,000	500				2,000					6,070
	Manage Process Effluents						300	500				600	500				1,350					3,250
	Sludge Wash/Caustic Leach		1,725	5,696	3,944	100	1,000	1,500	6,000	3,147	500	1,000	1,250	2,750		2,000	1,500					32,112
	Solid-Liquid Separations Test Equipment Development and Transfer	300		[illegible]	1,235		800	600	1,905	[illegible]	500	1,400	[illegible]	1,905	1,200	500	1,500					15,511
	Waste Concentration/Water Balance	1,100			980		350			400		350			400		200					3,780
Process Waste: Select Waste Forms for LLW	Form for Immobilization of LLW	400		1,700	4,191		900		950	3,402	500	400		950	1,375	1,000	800		350		1,000	17,918
	Melter Selection	150	50	25,198	97		60	50														25,605
	Vitrification of Ion-Exchange Resins	200		1,879			800		2,525			1,000		1,915			1,000		2,730			12,049
Process Waste: Select Waste Form for HLW	Consolidation of Glass Process Controls Development	300	200	1,720	3,228		100	200	2,630	3,387		300	200	2,220			300		1,020			15,805
	Focused Facilities and Processes						300					1,650					5,000					6,950
System Closure: Determine Performance Criteria for Tank Facility Stabilization and Closure	Waste Retrieval and Tank Closure Demonstration	100			200		1,450			645	2,500	1,900			500		2,000			500		9,795
Total		15,542	8,070	52,035	21,507	4,390	23,555	7,620	44,573	18,274	6,500	22,500	5,850	28,220	5,575	3,500	27,750	-	19,650	2,900	1,000	319,011

(a) Bases for funding estimates: EM-50 Tanks estimated from ongoing projects plus TFA estimates of ongoing work; all other estimates were provided by the applicable program management as of January 1995. These estimates are subject to change as the programs change.
(b) EM-50 X = EM-50 crosscutting programs.

All funding estimates are for planning purposes only and are not official funding information.

Section 3 - Process for Developing and Implementing Recommendations

The process being used to develop the TFA technical program consists of four iterative steps (Figure 3.1). The development and implementation of the recommendations are described in this section. The dates for the first iteration are shown in parentheses in the following text, with the overall schedule shown in Figure 3.2.

- **Needs Assessment** (November 1994-January 1995) - The Implementation Team asked the Site Coordinators at each of the four tank sites to identify their technology needs for tank waste remediation. This step was conducted to ensure that the TFA technical program is grounded in site needs, as defined by the sites. A needs breakdown structure (NBS) was developed to reflect the HLW tank remediation system work breakdown structures and provides the basis for further systems analysis and life-cycle planning. Collected needs were first cataloged within the NBS to identify needs that applied across multiple sites and then evaluated to identify high-impact needs suitable for the focus of a national program. High-impact needs are those that are typically needed within 1 to 3 years, are considered high priority by the sites, meet fundamental gaps or uncertainties in the site baselines, and have multisite benefits. High-impact needs were then consolidated into a smaller set of focused need statements that formed the basis for defining the technical program. Comprehensive information on the tank site needs has been compiled in the ***TFA Site Needs Data Assessment*** (TFA 1995).

- **Program Definition** (February-April 1995) - Focusing on the high-impact needs, the TFA Implementation Team defined the technical elements, developed overall program strategies and assumptions, defined the problems underlying each high-impact need, and outlined a path forward to solve each of the problems. Twenty-two technical elements were defined to meet fundamental DOE remediation objectives (reduce cost and reduce risk), assuming current negotiated site agreements and accepted closure scenarios.

- **Scope Selection** (May-June 1995) - The FY96 scope and schedule for each technical element were established, forming the basis for the FY96 work plan. The Implementation Team and the technical review groups selected specific activities to be addressed within each technical element, recommended what current tasks should be refocused or leveraged to sharpen the focus of the technical program around high-impact needs, identified new starts, and outlined a call for proposals including the scope to be submitted to industry.

- **Team Selection and Activity Planning** (June-September 1995) - The Implementation Team identifies the combination of users, producers, and developers who will further define and then perform the technical tasks for each technical element, resulting in completion of the FY96 work plan.

Each of these steps has been or will be reviewed for both programmatic and technical validity. The TFA is guided by a USG comprised of senior managers of the site tank remediation programs

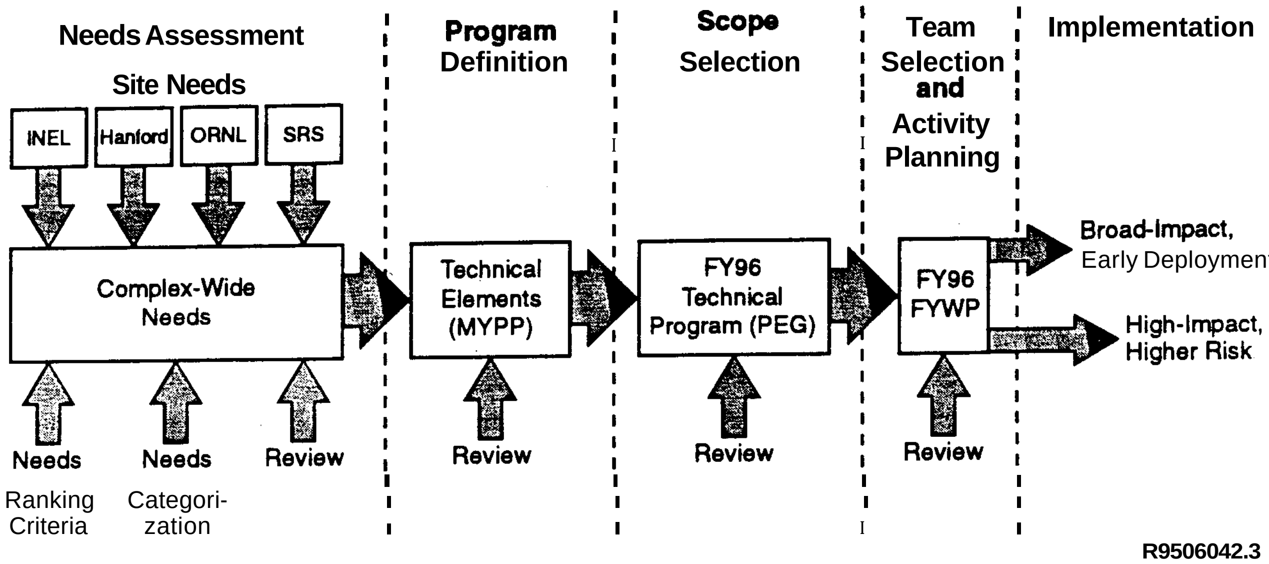

Figure 3.1. TFA Program Development

(Section 3.5). The USG has reviewed and validated both the TFA needs assessment and the selection of high-impact needs; the USG has endorsed this **MYPP.** To ensure technical validity, the TFA-TRG, comprised of technical experts in each of the primary program areas from national laboratories and universities, reviews the TFA technical program.

Needs will continue to be validated with the sites, scope and schedules will be adjusted based on technical progress and budget changes, and teams will be redefined as solutions move from applied research to demonstration. The **MYPP** will be revised annually to reflect these changes.

3.1 Needs Assessment

To ensure that TFA technologies address site needs, each of the four major DOE tank sites (Hanford, INEL. *Oak* Ridge, and **SRS)** was asked to provide needs data to the TFA. The TFA provided templates that requested specific data about each site need and asked that the sites either provide existing documents that included this information or complete a set of templates that defined their site's needs. All four sites provided background documentation regarding their site tank waste remediation technical strategies, needs, and activities. Three of the four sites also returned completed templates to the TFA. These templates (from INEL, *Oak* Ridge, and **SRS)** and the ***Tank Waste Remediation System Integrated Technology Plan*** (RL 1995) from Hanford were the starting point for the TFA needs database. The needs provided by the sites reflected the schedule and budget assumptions of site-specific planning baselines.

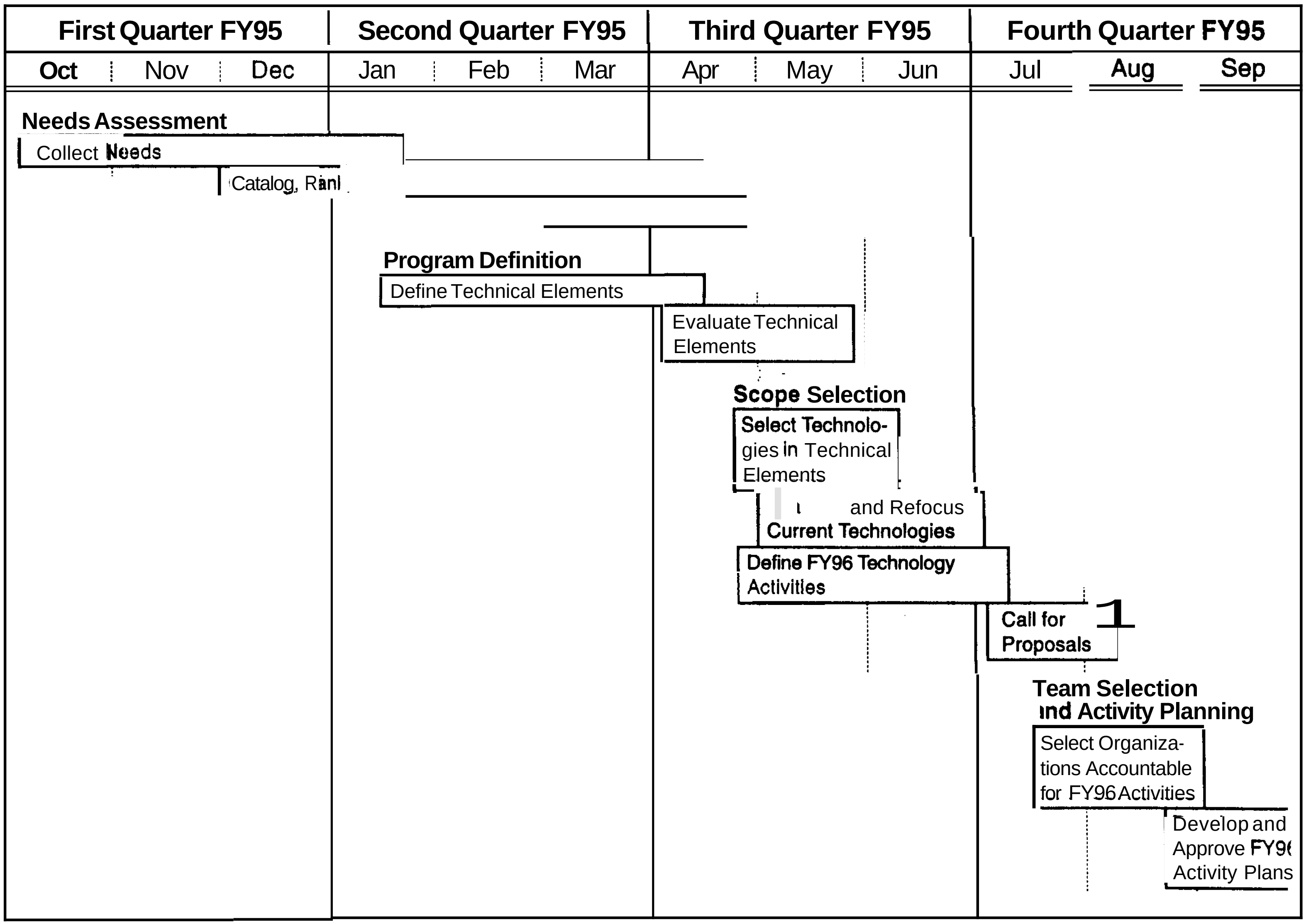

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Figure 3.2. TFA Program Development Process

Detailed site needs were validated through site visits that involved both data collection and data validation reviews. The team reviewed all the data in preparation for visits to the four sites. Site visits were performed over a 2-month period:

- Hanford in mid-November 1994
- SRS in mid-December 1994
- INEL in early January 1995
- Oak Ridge in mid-January 1995.

The purpose of the site visits' was to familiarize the Technical Integration Managers (TIMs) with the sites' tank needs while validating the site-provided data. The emphasis of these site visits was to understand the site technology development needs and problems by understanding their baseline strategy, defined needs, and currently funded site responses to those needs (i.e., current technical activities).

3.1.1 Needs Cataloging

From the approximately 400 site needs collected, the TFA developed an NBS that reflects a high-level tank remediation system and maps into tank remediation program work breakdown structures. The NBS provides a multisite framework for categorizing needs and identifying the common needs across sites.

The NBS also allows the TFA to map existing tank technology activities against needs and remediation functions to identify needs without currently funded activities, needs with multiple and perhaps redundant activities, and current activities meeting no defined need.[a] Finally, the NBS provides the basis for further systems analysis. With additional information, time, and resources, the TFA can match needs with high-cost and high-risk functions across the system, link changes in site baseline systems with changes in needs, and specify functional requirements for solutions.

The NBS was updated throughout the needs assessment process to ensure that the data being collected from the site visits were correctly incorporated into the NBS. Needs were also continuously cataloged and/or recataloged if a new NBS item was added. The NBS is now in its final form, based on the data collected from the sites, and is unlikely to change significantly in the future. The TFA uses the NBS as its primary means of organizing the needs and technical activities data.

(a) The TFA collected data on site-funded tank technical activities in parallel with the site needs. The *tank* technical activities are not yet validated, and the matching exercise described here is in preliminary stages.

3.1.2 Needs Ranking

Immediately following the site visits, the TFA Technical Team convened to discuss their findings and to evaluate and rank needs. From the full range of site needs collected, the TFA Technical Team identified the high-impact set of needs by evaluating each site need against the following criteria:

- urgency - Needs requiring solutions within 1 to 3 years received a high rating and those requiring later solutions received a medium rating. Those needs requiring solutions earlier than 1 year received a low rating because the TFA would be unable to respond adequately. Needs common to multiple sites received higher ratings than needs applicable to only one site.
- planning priority - Needs required for baseline plans received a high rating, those providing enhancements to the baseline received a medium rating, and those associated with an alternative approach received a low rating.
- site priority - Needs identified by the sites as high, medium, or low priority were given the same ratings here.
- broad-based - Needs identified by three to four sites received a high rating, those identified by two sites received a medium rating, and those identified by only one site received a low rating.

Based on this analysis, high-impact needs are those that the sites must resolve within 1 to 3 years, that fill fundamental uncertainties or gaps in baseline plans, that the sites otherwise perceive to be critical, and that have a multisite benefit. This process put a premium on the sites' perceptions of their own needs, with little translation or evaluation by the TFA. It also distinguished between high-priority and high-impact items; while high-impact needs consistently reflect high-priority items at a site (typically with relevance to other sites), critical needs at a single site may not be included because they lack multisite applications.(a)

3.2 Program Definition

With a consolidated list of high-impact needs, the TFA Technical Team defined a set of technical elements that form the core of the TFA technical program. Criteria guiding technical element definitions included fundamental DOE objectives to reduce the technical, programmatic, or ES&H risk and reduce cost (see Appendix A for a qualitative description of system costs and risks for tank remediation). Table 3.1 presents the high-impact needs and responsive technical elements.

(a) The final list of high-impact needs was generated after examining a number of alternate weighting schemes for these criteria, including dropping the site priority criterion that heavily favored informal (and unsystematic) site judgments and that could be perceived as being redundant with the urgency and planning priority criteria. The results of these alternate sorts produced very *similar* lists of highly rated needs. Detailed results of these sorts are provided in the *TFA Sire Needs Data Assessment* (TFA *1995).*

Technical elements were defined initially by the Technical Team in response to discussions with site users. Subsequent revisions and refinements reflect input from the TFA-TRG, the USG, Site Technology Coordination Groups (STCGs), and ad hoc technical experts familiar with tank needs and technologies. The TIMs and users identified the fundamental problems underlying high-impact technology needs and then defined a path forward to resolve those problems. The most urgent problems are addressed by the most mature technologies. Demonstrations to address those problems and deployment schedules are planned for 1 to 3 years. Less mature technologies offering significant cost or risk redirections in response to each need are included in the program as enhancement opportunities. Several longer-term, higher-payoff technologies offering alternatives to current baselines are also included.

Once the program was defined, the EM-50 tanks technology budget for FY96 and FY97 was allocated across technical elements. The allocation ensured that the most urgently needed technologies were supported on a schedule to meet site needs. Enhancement opportunities and longer-term, higher-payoff technologies were then allocated budgets commensurate with their projected scope and schedules.

A detailed description of each technical element is provided in Appendix **B.** The descriptions include a more detailed problem statement, a recommended path to solution, a discussion of technical issues, FY96-FY98 scope, an identification and explanation of the benefits of the proposed activities, the FY95 budget and FY96-FY98 requested budgets, and a listing of FY95 technical activities related to the technical element.

3.3 Scope Selection

Once the technical elements of the program were defined, specific tasks were scoped for each element. These **tasks** included identifying the specific technologies selected for further development as well as technical activities related to managing, coordinating, or otherwise facilitating solutions to high-impact needs and associated site technical problems. For FY96, the scopes are presented in the TFA FY96 program execution guidance. With support from the TFA-TRG, the Technical Team

- selected specific technologies or processes to be pursued within each technical element, ensuring that the activities address high-impact user needs

- defined technological activities in sufficient detail that they map to a single well-focused need statement

- defined targeted budget levels and deliverable, milestone, and performance metric expectations for each technical activity

- evaluated the technical and management performance of the organizations accountable for ongoing technical activities and identified any technical activities that should be rebid.

To complete scope selection, the Technical Team will

- call for proposals, as funding permits, to address gaps in the refocused program, initiate new starts, and/or increase industry participation in the program

- match currently funded technological activities to needs (high-, medium-, or low-impact) to identify what needs have no associated activities, what needs have multiple (and possibly redundant) activities, and what activities do not address an identified need

- make specific recommendations to refocus or leverage existing tank technology activities, based on matching technologies to needs including the possibility of descoping activities that are poorly matched to user needs.

3.4 Team Selection and Activity Planning

Once the scope of the technical elements and site technical activities has been defined and appropriately focused, the Technical Team will select the organization (and participating team members) accountable for managing each technical activity. The selection of accountable Organizations for new starts and refocused activities will be based on the technical merit of the proposal, ability to meet the user's needs on time, team qualifications, institutional capabilities, collaborations (e.g., with industry, universities, and users), and how well the work is planned.

Implementation of the selection criteria will result in a program that uses the best technical expertise, has a high probability of success, and has appropriately involved industry and university partners. The organizations performing ongoing technical activities will be encouraged to revisit their team composition to ensure that they have the best teaming arrangement possible. The Technical Team will facilitate the selection of accountable organizations, supported by the TFA-TRG, and confirmed by the TFA Management Team.

Activity planning is critical to both selection of accountable organizations and FY96 work authorization. Activity plans must be prepared in enough detail that the organization's technical and management capability can be adequately assessed. The activity plan should address the organization's approach for accomplishing the work, a schedule consistent with deliverable and milestone expectations, and a time-phased distribution of budget. Once the accountable organization is selected and the activity plan is approved, the plan becomes the basis to measure technical performance and accomplishments. The organizations performing ongoing technical activities will also be required to submit and receive approval of their activity plans. The approved activity plans will be consolidated into a comprehensive package that depicts the TFA FY96 technical program and will be documented in the FY96 work plan.

3.5 Review Process

The needs assessment and program recommendation process benefited from the participation and review of numerous outside experts, users, and stakeholders, including the **USG,** the **TFA-TRG,** and the STCGs.

The USG was established to provide user input from a site tank waste remediation management perspective. It is comprised of the senior managers of the four tank site remediation programs and acts as a board of directors to the Implementation Team. Members have participated in the initial planning, data collection, and validation phases of the site needs assessment. The USG is responsible for 1) providing assistance to the TIMs in establishing effective technical support networks and work locations at the sites and to the Program Integration Coordinator in accessing site information on technology drivers, needs, facilities, and programs, **2)** approving the Implementation **Team's** recommended MYPP and fiscal year work plan **(FYWP)** before submittal to **DOE,** and **3)** providing active support for transitioning current site-based technology programs to the TFA and then transferring demonstrated technologies back to these sites.

The TFA-TRG was established to review both processes and products of the TFA. It is comprised of national and international experts in the field of analytical chemistry and chemical separations of radionuclides with demonstrated capabilities as effective leaders of technical groups. The members are also well-connected with the technical community, academia, and industry to recommend activities and activity performers, where appropriate, into the TFA program. The TFA-TRG met once to review the needs identification process and a draft program definition. It will meet again to review scope selection, team selection, and activity planning. The objectives of the peer review are to ensure that 1) a technically sound program is planned and executed, **2)** the best technical approaches are used, and **3)** the best technology performers are selected.

The STCGs will facilitate site reviews of TFA programs and technology deployment at each of the sites. STCGs are comprised of stakeholders, regulators, users, and/or **DOE** representatives at each of the four tank sites and are still in the process of forming. Members of the STCGs will coordinate regulatory and stakeholder interfaces at each of the tank sites and facilitate interactions between these groups and the TFA Technical Team.

Table 3.1. High-Impact Multisite Needs and Resulting Technical Elements

High-Impact Multisite Needs	Technical Elements
Remove Waste - Develop 4-in. Port Camera System	Tank Leak Detection and Monitoring
Develop Visual Inspection System	
Develop NDE Inspection System	
Store Waste - Replace Aging Still Camera Systems for Annulus Inspections	
Store Waste - Develop Annulus Video System and Crawler	
Tank Waste Characterization - Inspect Floors, Walls, In-Tank structure	
Tank Waste RetrievaVCharac - LDUA Deployment Systems	
Heel Waste RetrievaVCharac - LDUA Deployment Systems	
Tank Waste Operations - LDUA Deployment Systems	
Rapid Molecular, Elemental, and Radiochemical Analysis	Advanced Hot Cell Analytical Technology
In Situ Characterization Capability (Minilab)	In Situ Characterization
Develop In Situ Solids Sampler/Gripper	
Develop In Situ Liquid Sampler	
Tank Waste Characterization - Sludge/Debris Surface Mapping	
Tank Waste Characterization - In Situ Sampling	
Automated Sample Preparation and Analysis	Process Monitoring and Control
Rapid Molecular, Elemental, and Radiochemical Analysis	
Vitrify Feed - Techmques to Determine Surface Temperature in Melter and Glass Levels	
Vitnfy Feed - Full-Scale DWPF Stirred Melter	
Control on HLW Melter Feed	
Characterize Waste in Heel of Tanks (Sampler, Gripper)	Sampling - Waste and Tank
In Situ Characterization Capability minilab)	
Develop In Situ Solids Sampler/Gripper	
Develop In Situ Liquid Sampler	
Develop In Situ Flammable Gas Sampler	
Tank Waste Characterization - Liquid Sampling/Analysis	
Tank Waste Characterization - Sludge Sampling	
Tank Waste Charactemahon - Sludge/Debris Surface Mapping	
Tank Waste Charactemahon - In Situ Sampling	
Tank Waste Retrieval/Charac. - LDUA Deployment Systems	
Heel Waste RetrievaVCharac. - LDUA Deployment Systems	
Tank Waste Operations - LDUA Deployment Systems	

Table 3.1. (contd)

High-Impact Multisite Needs	Technical Elements
Heel Waste Retrieval - WD&C	Deployment Systems
SST Retrieval - WD&C	
Tank Waste RetrievaVCharac. - LDUA Deployment Systems	
Heel Waste Retrieval/Charac. - LDUA Deployment Systems	
Tank Waste Operations - LDUA Deployment Systems	
Remove Waste - Deteme Salt Dissolution Kinetics	Enhancements to Present Retrieval Processes
Transfer Waste - Optimize Transfer Jet Performance	
Transfer Waste - Develop lmproved *Pump* Testmg and Mamtenance Program	
Enhance SST Sluicing	
Test/Analyze Mixer Pump Performance	
Remove Waste - Test Pumps as Required	
Remove Waste - Develop Method to Remove Tank Heels (sand, tapes, etc.)	
Remove Waste - Develop Enhanced Methods to Retrieve Tank Annulus Space Waste	
Remove Waste - Develop Method to Remove Mixed Salt and Sludge	
Remove Waste - Improve Salt Mining Equipment and Techniques	
Remove Waste - Develop Method to Address Insoluble Solids in Salt Tanks	
Remove Waste - Develop Method to Remove Dry/Hardened Sludge	
Remove Waste - Develop Removal Techniques for Mired Equipment	
Define Characterization Needs/Develop Simulants	Retrieval Process Development
Remove Waste - Develop Simulants	
Develop Simulants	
Develop and Demonstrate SST Arm-Based Retrieval System	
Retneval; Robotics, Mixer Pumps, and Waste Dislodging and Conveyance	
Remove Cesium from Alkaline Solutions: Reference Process	Acidic Cs/Sr/TRU/Tc Removal
Remove Sr/Tc/Cs from Tank Waste	
Remove Sr/Tc/Cs from Tank Waste	
Remove TRU from Tank Waste	

Table 3.1. (contd)

High-Impact Multisite Needs	Technical Elements
Remove Cesium from Alkaline Solutions: Reference Process	Alkaline Cs Removal
Remove Sr/Tc/Cs from Tank Waste	
Remove Sr/Tc/Cs from Tank Waste	Alkaline Sr/TRU/Tc Removal
Remove TRU from Tank Waste	
Concentrate slurry	Caustic Recycle
Evaporate/Concentrate HLW and LLW Streams	
Minimize Secondary Waste	Manage Process Effluents
Manage Liquid Effluents	
Manage Solid Waste	
Wash Sludge: Reference Process	Sludge Wash/Caustic Leach
Alkaline Leach of Sludge: Reference Process	
Dissolve Aluminum	
Liquid-Solids Separations Studies	Solid-Liquid Separations Test Equipment Development and Transfer
Concentrate Slurry	Waste Concentration/Water Balance
Evaporate/Concentrate HLW and LLW Streams	
Develop Glass Waste Form and Glass Specification	Form for Immobilization of LLW
Glass Formulation Model Development	
High Waste Loading Formulations	
Long-Term Durability Testing	
Mmor Components Impact	
Waste Form Qualification	
Operation of Cyclone	Melter Selection
Candidate Melter Svstems Evaluahon	
HLW Radioactive Testing	
Melter Auxiliary Systems Evaluation	
Materials of Construction	
Melter/OG System Development	
Decontaminate Salt - Eluant in Glass	
Vitrify Feed - Enhance Equipment Design and Operability of Melter System	
Vitrify Feed - Extend Operating Life of DWPF Melter	
Vitnfy Feed - Full-Scale DWPF Stirred Melter	
Vitrify Feed - Techmques to Determine Surface Temperature ın Melter and Glass Level	
HLW Melter	

Table 3.1. (contd)

High-Impact Multisite Needs	Technical Elements
HLW Radioactive Testing	Vitrification of Ion-Exchange Resins
Melter Auxiliary Systems Evaluation	
Feed Preparation System Development	
Prepare Melter Feed - Characterize Chemical Process Cell Operation	
Prepare Melter Feed - Chemical Process Cell Experiment	
Prepare Melter Feed - Melter Feed Tank System Bias	
Prepare Melter Feed - Pumping/Mixing	
Vitrify Feed - Techniques to Determine Surface Temperature in Melter and Glass Levels	
Control on HLW Melter Feed	Consolidation of Glass Process Controls Development
HLW Radioactive Testing	
HLW Vitrification Process System Requirement and Concepts	
Vitrification Process/Product Modeling	
Process Control Limits and Model Development	
Vitrify Feed - Enhance Product Composition Control System	
Vitrify Feed - Reduce Noble Metal Deposition	
Vitrify Feed - Thermal Calculations	
Vitrify Feed - Upgrade Glass Property	
Vitrify Waste - Aerosolization Model for SAR	
Vitrify Waste - Cold Cap/Off-gas Thermodynamics Model	
Vitrify Waste - DWPF BATCHES Software	
Vitrify Waste - DWPF Flowsheet Model	
Vitrify Waste - Effects of Irradiation on Precipitate	
Vitrify Waste - Process Requirement for Cold Runs	
Vitrify Waste - Process Requirement for Hot Runs	
Vitrify Waste - SAR and Process Envelope for DWPF	
Sulfur Cement Equipment Operability Assessment	Focused Facilities and Processes
Sulfur Cement Product/Equipment	
Immobilization of Sodium Nitrate Sludge (TRU Waste)	
Inactive Tank Sludge Treatment Capability Studies	
Inactive Tank Supernatant Immobilization Capability	
Integrated Demonstration of Immobilization	Waste Retrieval and Tank Closure Demonstration
Tank Closure Demonstration	
How Clean is Clean?	
Determination of Tank Cleanup Criteria/Options	

Section 4 - Program Objectives, Implementation, and Management Transition

The TFA program strategy for moving emerging technologies through the stages of technology development, deploying technologies across sites, and coordinating and leveraging multisite technical activities is discussed in this section.

4.1 Managing Technology Development

While most of the **22** technical elements presented in this plan consist of one or more technical activities involving different technologies, each technical element can be associated with a general developmental stage. There are seven technology maturation levels that range from Basic Research to Implementation (First Production or Operations) as depicted in Table 4.1. The use of these levels permits logical management of limited resources where promising technologies pass through "gates" from stage to stage. Specific criteria must be met before passing from one stage to the next; example criteria, extracted from the EM ***Program Execution Guidance (PEG) Development Guidance*** (DOE 1995a), are shown in Table 4.1. Similarly, the use of these criteria identifies technologies that should be curtailed or abandoned. For example, a technology that cannot remain within schedule and budget constraints may be either rescoped or funding may be discontinued. Each time a technology passes through a gate, all previous gate criteria must be satisfied. Therefore, a technology passing from Engineering Development to Demonstration generally must pass all gate criteria from Basic Research through Demonstration.

The TFA program has adopted this "gating" methodology for managing technology development from its current state through implementation. Table 4.1 presents a comprehensive view of the TFA recommended program in terms of the stages and gates they must pass through before implementation. Because the maturity of each technical element is reflected by its position. the more mature elements that address more urgent site needs are shown to the right. Less mature technologies that have longer lead times (but typically offer high payoffs as alternatives to the baseline solutions) are shown to the left. Specific technology schedules and other performance parameters are provided in the TFA FY96 work plan.

Passing through a gate marks an important technology milestone. However. not every idea begins in Basic Research. On occasion, a technology may enter the program after Gate 1, but to **do** so, the technology must be matched with an identified tank remediation need. Gates **2** and 3 provide the "proof of technology," where the Exploratory Development stage results in product definition and the Advanced Development stage produces a working model,.

The main gate is Gate 4, where a technology progresses from proof of technology to an engineering prototype in the Engineering Development stage. Scaled-up prototype versions, pilot-scale tests, and field testing are characteristic of the Engineering Development stage. Passage through Gate 5 to the Demonstration stage means a technology will be validated next by the end user along with full-scale testing. Finally, Gate ***6*** leads to Implementation (First Production or Operations), where the end user utilizes the technology.

Table 4.1. Technology **Maturity** Levels **for TFA** Technical Elements

Technology Level	Basic Research	Applied Research	Technology or Exploratory Development	Advanced Development	**Engineering** Development	Demonstration	Implementation
Technical Element			· Caustic Recycle · Alkaline Sr/TRU/Tc Removal · Focused Facilities and Processes	- Process Monitoring and Control - Sampling - Waste and Tank - Sludge WashlCaustic Leech - Acidic Cs/Sr/TRU/Tc Removal	- Advanced Hot Cell Analytical Technology - Tank Leak Detection and Monitoring - In Situ Characterization - Retrieval Process Development - Enhancements to Present Retrieval Processes - Melter Selection - Consolidation of Glass Process Controls Development - Solid-Liquid Separations Test Equipment Development and Transfer - Manage Process Effluents	· Waste Concentration/ Water Balance - Alkaline Cs Removal · Waste Retrieval and Tank Closure Demonstration · Form for Immobilization of **LLW** · Vitrification of Ion-Exchange Resins - Deployment Systems	
Gate		1			4	5	6
Criteria to Enter Technology **State**			· *Address DOE need* · ***Indicate** complementary* **or** *redundant efforts*	· *Address focus area need* · *Identify/address feasibility* - *Identify user needs/* ***wants*** - *Competitiveproduct analysis* - *Identify ES&H issues* - *Identify stakeholder issues*	· *DOE deployment strategy* ***and*** *schedule* - *Product/system integration specifications* - *Manufacturability issues* - *Partnership assessment* - *Cost/benefit analysis* - *ES&H compliance strategy in place* - *Regulatory compliance strategy*	- *DOE deployment strategy* ***and*** *schedule* - *Resolution of technical issues* · *Cost and performance validation* - *ES&H issues satisfied* - *Public issues resolved* - *National Environmental Policy Act (NEPA) permits for demonstration*	***- EM-30/40*** *procures technology* · *Public acceptance* · ***NEPA*** *permits for deployment*

General criteria for passage through the gates are shown in Table 4.1. These will be tailored to each technology and, once agreement is reached with users and stakeholders, will be incoporated into the FYWP for that technology. Funding for technologies that do not meet the requirements for passage may be discontinued.

4.2 Site Deployment Strategy

A high-level deployment strategy for achieving multisite benefit from the TFA program is summarized in Table 4.2. The table shows what sites will benefit from each technical element. Primary demonstration sites are indicated by a dark-shaded box, and sites to which the data and/or technologies will be applied are indicated by a lighter-shaded box. A blank box has several possible meanings: 1) the site need is not relevant or 2) the solution or a similar solution has already been demonstrated or applied to the site to solve its need. Table 4.2 represents the multisite deployment "vision" for each technical element. This vision is a major strategic challenge and will require a combination of general strategies

Table 4.2. Site Implementation Strategy of Technical Elements

Technical Element	Site Implementation Strategy			
	Hanford	INEL	ORNL	SRS
Tank Leak Detection and Monitoring	Demonstrate		Apply	Apply
Advanced Hot Cell Analytical Technology	Demonstrate		Apply	Apply
In Situ Characterization	Apply	Demonstrate		
Process Monitoring and Control	Apply			Apply
Sampling - Waste and Tank	Apply	Apply	Demonstrate	
Deployment Systems	Demonstrate	Demonstrate	Demonstrate	Apply
Enhancements to Present Retrieval Processes	Apply	Apply	Apply	Demonstrate
Retrieval Process Development	Apply	Demonstrate	Demonstrate	Apply
Acidic Cs/Sr/TRU/Tc Removal	Apply	Demonstrate		
Alkaline Cs Removal	Demonstrate		Demonstrate	Demonstrate
Alkaline Sr/TRU/Tc Removal	Apply		Apply	Demonstrate
Caustic Recycle	Apply			Apply
Manage Process Effluents	Apply	Apply	Apply	Apply
Sludge Wash/Caustic Leach	Demonstrate		Demonstrate	Demonstrate
Solid-Liquid Separations Test Equipment Development and Transfer	Demonstrate	Apply	Demonstrate	Demonstrate
Waste Concentration/Water Balance	Apply	Apply	Demonstrate	Demonstrate
Form for Immobilization of LLW	Apply	Apply		
Melter Selection	Demonstrate	Apply	Apply	Apply
Vitrification of Ion-Exchange Resins	Apply		Demonstrate	Demonstrate
Consolidation of Glass Process Controls Development	Apply	Apply	Apply	Demonstrate
Focused Facilities and Processes	Demonstrate	Demonstrate	Demonstrate	Demonstrate
Waste Retrieval and Tank Closure Demonstration	Apply	Apply	Apply	Demonstrate

Legend: To be demonstrated at site (dark box)
Intended for applicaiton at site (light box)
Problem not applicable to or already resolved/demonstrated at site (blank box)

and detailed technical plans. The TFA will support strategies to enhance cross-site cooperation, including retrieval and transfer of waste samples, waste simulant development, multistate agreements among regulators, and user visits to other sites to observe applicable demonstrations. Deployment plans will formalize agreements across sites regarding test variables and results that must be obtained to meet multisite requirements.

4.3 Coordinating and Leveraging Technology

The **EM** currently funds approximately $120 million of tank technology development. During FY95, only about 20% of the total tank technology development budget was leveraged or coordinated—that is, where organizations doing similar work integrated their scopes and budgets to realize greater benefit. Leveraged work does this formally, linking TTPs or ADSs across performing organizations. Coordinated work does this informally, acknowledging the relevance of related **tasks** by sharing data and/or facilities. The TFA will work to ensure that at least 80% of the EM tank technology budget not devoted to site-specific technology is leveraged or coordinated in FY96. The goal is to use the high-impact needs presented in the ***TFA Site Needs Datu Assessment*** (TFA 1995) and the program presented in this MYPP to identify high-impact multisite activities that could be more efficiently performed through leveraging or coordinating aggressively. Budgets saved by refocusing related scope would be **freed** to address other high-priority (perhaps site-specific) items. Figure 4.1 illustrates this envisioned **role conceptually in relation to site-specific and system-wide remediation.**

Table **4.3** presents the technical elements along with the **EM-30, EM-40,** and **EM-50** FY95 activities that may be related and potentially leveraged or coordinated to realize greater system-wide benefit. The TFA TIMs will review these activities (or their FY96 successors) to determine whether further coordinating or leveraging makes sense. If so, the TIMs will propose a different arrangement, possibly including some rescoping of either **EM-50** or **EM-30** and EM-40 activities to achieve more for less. Freed budgets would be used by the site, either invested in additional multisite technologies or in site-specific priorities. The reader will not find perfect matches between the "Funding Organization" column of Table 4.3 and the requested budget tables for several of the technical elements in Appendix B. The realities of changing FY95 budgets continue to create a moving stream of information. However, Table 4.3 shows the TFA is well aware of technical activities, their relationships with each other, and present or past contributors.

The TFA envisions that in FY96 it will manage (have responsibility for scope, schedule, and budget) the EM-50 tanks program described in this MYPP, along with some Hanford TWRS technology development activities (including, but not limited to, activities related to the MYPP scope). It will coordinate work conducted by the **EM-50** crosscutting programs that is related to tanks **as** well **as** related work being conducted by each of the site **EM-30** or EM-40 programs (shown in Table **4.3).** By FY97, the TFA envisions managing a single focused program that crosses organization boundaries. The TFA managed scope will cover tank technology work with potential multisite applications. While site-specific technology will continue to be managed by each site, the TFA will be cognizant of all tank technology activities within **EM** to maximize beneficial coordination across sites and support site negotiations and manage technical uncertainties with practical technical expertise.

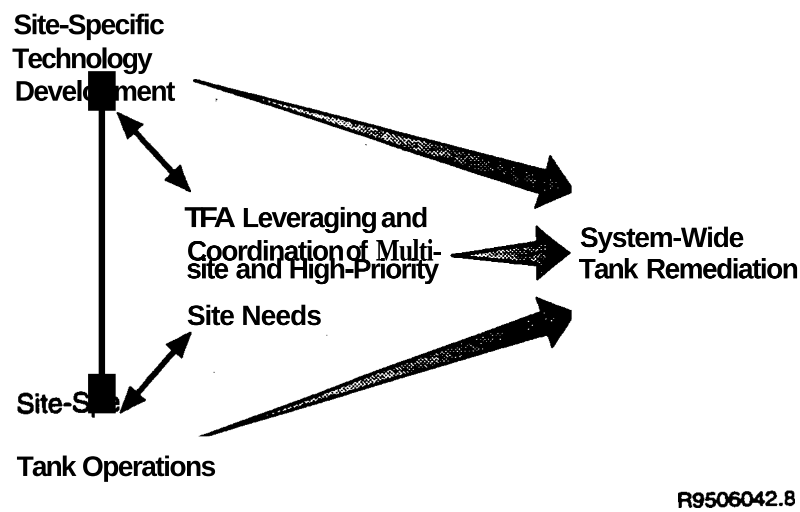

Figure 4.1. Results of Refocusing Tank Remediation Scope

Table 4.3. Coordination of Tank Technology Activities

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Tank Leak Detection and Monitoring	Leak Detection and Monitoring	EM-30 Hanford
	Test Mixer Pump with Non-Leaking Gel for SST Retrieval	EM-30 Hanford
	Gunite Treatability Study	EM-40 OR
	Advanced Fiber-optic Spectroscopy for Inorganic Contaminants (SF-221203)	EM-50 Tanks
	ERT for Subsurface Imaging (SF-241002)	EM-50 XCut
Advanced Hot Cell Analytical Technology	Develop and Implement Laser Ablation/Mass Spectrometry for Isotropic Analysis	EM-30/EM-50 Tanks Hanford
	Develop and Implement Gamma Energy/High-Energy Beta HLW Scanning Analysis	EM-30 Hanford
	Develop and Implement Raman Spectroscopy for HLW Molecular Analysis	EM-30/EM-50 Tanks Hanford
	Develop and Implement NIR Spectroscopy for Moisture Analysis	EM-30/EM-50 Tanks Hanford
	Laser Raman Spectroscopy for Hot Cell and In Tank Measurement (RL-452001)	EM-SO Tanks
In Situ Characterization	Develop, Test, and Document In Situ Raman/NIR Probe	EM-30 Hanford
	Field Test Raman Probe for Conepenetrometer Application	EM-50 Tanks
Process Monitoring and Control	New start in FY96	
Sampling - Waste and Tank	(Coord. w/Deployment Systems)	EM-30 Hanford EM-50 Tanks
Deployment Systems	Support to Tank Operations and Stabilization Program	EM-30 Hanford
	Support to Retrieval Activities	EM-30 Hanford
	Tank Annulus Inspection and Heel Removal	EM-30 SRS
	Tank Characterization and Heel Removal	EM-30 INEL
	Calcine Bin Remediation	EM-30INEL
	Support to Gunite and Associated Tank Treatability Studies	EM-40 OR
	Tank Characterization and Heel Removal	EM-40 OR
	Melton Valley Tank Remediation	EM-40 OR
	Baseline Program, System Integration	EM-50 Tanks

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Deployment Systems (contd)	**Support to International Programs**	EM-SO Tanks
	Control System Development	EM-SO XCut
	Robotics Applications in Tanks	EM-50 XCut
Enhancements to Present Retrieval Processes	**Test Plans and Data Requirements**	EM-30 Hanford
	Mixer *Pump* Design and Testing	EM-30 Hanfor
	Past Practice Sluicing Performance Testing	EM-30 Hanfor
	Pulsair Tests	EM-30 Hanfor
	Equipment Engineering Support at the Savannah River Site (Waste Transfer System)	EM-30 SRS
	Waste Removal at the Savannah River Site	EM-30 SRS
	Bulk Sludge Mobilization and Slurry Transport: Submerged Jet Sludge Mobilization and Transport Studies	EM-40 OR
	Evaluation of Retrieval Technologies with ACTR Program	EM-30 Hanford EM-SO Tanks
Retrieval Process Development	Cold Demonstration of DST Tank Technologies	EM-30 Hanford
	Evaluate Alternate DST Retrieval Technologies	EM-30 Hanford
	Deployment of Retrieval End Effectors at INEL	EM-30 INEL
	Modified Light-Duty Utility Arm	EM-30 INEL
	Deployment of Retrieval End Effectors at ORNL	EM-40 OR
	Cold Test Facility and Hot Deployment Data Requirements/Analysis	EM-40 OR
	Confined Sluicing Waste Ratneval End Effector System	EM-40 OR
	Modified LDUA Development	EM-40 OR
	Prototype End Effector Testing	EM-40 OR
	End Effector Development Teshng tor Oak Ridge	EM-50 Tanks
	Prototype End Effector Testing for INEL	EM-50 Tanks
	Simulants for INEL/Oak Ridge Testing	EM-50 Tanks

Legend: EM-30 SRS - Savannah River Site
EM-40 OR - Oak Ridge
EM-SO XCut - Crosscumng Programs

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Retrieval Process Development (contd)	LDUA Technical Integration and End Effector Testing (RL-332002)	EM-50 Tanks
	LDUA System (RL-401203)	EM-SO Tanks
	LDUA Decontamination System and End Effector (ID-442001)	EM-50 Tanks
	Hanford Light Weight Scarifier Testing	EM-50 Tanks
	Mining Strategy Testing	EM-SO Tanks
Acidic Cs/Sr/TRU/Tc Removal	CSIX	EM-30 INEL
	TRUEX	EM-30 INEL
	SREX	EM-30INEL
	Actinide Removal	EM-30 INEL
	Calcine Pretreatment	EM-30 INEL
	TRUEX Applications; CEA Assignment (OR-132008)	EM-50 Tanks
	TRUEX Applications (CH-232001)	EM-SO Tanks
	Closeout Dicarbolide (AL-112010)	EM-SO XCut
	Crystalline Silicotitanate for Cs/Sr Removal (AL-232004)	EM-SO XCut
	Bench Scale Testing for Separation of INEL Waste (ID-421201)	EM-50 XCut
	International Separations Contract Management (AL-234004)	EM-50 XCut
	Advanced Integrated Solvent Extraction System (CH-232005)	EM-SO XCut
Alkaline Cs Removal	Develop Engineered Form of CST	EM-30 Hanford
	Conduct Batch Tests of Engineered Form of CST using DSS/DSSF Feed	EM-30 Hanford
	In-Tank Precipitation with Sodium Tetraphenylborate Precipitate: Precipitate Washing	EM-30 SRS
	Develop, Install, Operate Resorcinol-Formaldehyde (RF) (ion-exchange system)	EM-30 OR
	Use of RF on Newly Generated Waste as Waste Minimization Activity	EM-40 OR
	Cesium Extraction Testing: RF Resin Development (SR-132002)	EM-50 Tanks
	Comprehensive Supernate; Cesium Removal Demonstration; Hot Cell Processing Studies (OR-132008)	EM-50 Tanks

Legend: EM-30 SRS - Savannah River Site

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Alkaline Cs Removal (contd)	Crystalline Silicotitanate for Cs/Sr Removal (AL-232004)	EM-SO XCut
	Advanced Chemical Separations at the Savannah River Site (SR-132007)	EM-SO XCut
	Sorbent Design Support - Molecular Model; Industrial Contracts/Manage Contracts; Test Sorbents (RL-321204)	EM-50 XCut
Alkaline Sr/TRU/Tc Removal	**Conduct Batch Tests of Engineered Form of CST using DSS/DSSF Feed**	**EM-30 Hanford**
	Develop Engineered Form of CST	**EM-30 Hanford**
	Conduct Batch and Column Solid Sorbent Tests with Actual DSS/DSSF and CC Waste for Sr Removal	EM-30 Hanford
	Conduct Batch and Column Solid Sorbent Tests with Synthetic DSS/DSSF and CC Waste for Sr Removal	EM-30 Hanford
	Conduct Column Ion-Exchange Tests with Synthetic DSSF Waste for Tc Removal	EM-30 Hanford
	Conduct Batch Tests on Alternate Techniques with Actual DSSF Waste for Tc Removal	EM-30 Hanford
	Conduct Batch Tests on Alternate Techniques with Synthetic DSSF Waste for Tc Removal	EM-30 Hanford
	Conduct Batch and Column Ion-Exchange Tests for Sr Removal from Synthetic CC Waste;no Cesium	EM-30 Hanford
	Conduct Batch Carrier Precipitation and Na Titanate Adsorption Tests with Actual Waste for TRU Removal	EM-30 Hanford
	Conduct Batch Carrier Precipitation and Na Titanate Adsorption Tests with Synthetic Waste for TRU Removal	EM-30 Hantord
	Conduct Batch Test of Complex Destruction with Actual CC Waste	EM-30 Hanford
	Conduct Column lon-Exchange Tests with Actual DSSF Waste for Tc Removal	EM-30 Hanford
	In-Tank Precipitation with Sodium Tetraphenylborate Precipitate: Cold Chemical and Precipitation	EM-30 SRS
	Comprehensive Supernate (OR-132008)	EM-50 Tanks
	Crystalline Silicotitanate for Cs/Sr Removal (AL-232004)	EM-50 XCut
	Tc and Ni Removal Using Ion-Exchange (AL-132010)	EM-SO XCut

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Alkaline Sr/TRU/Tc Removal (contd)	Aqueous Biophasic System/Radioactive Waste Pretreatment (CH-232006)	EM-50 XCut
	Tc and Actinide Solvent Extraction (OR-153002)	EM-50 XCut
Caustic Recycle	Significant Volume Reduction of Tank Waste by Selective Crystallization (RL-442002)	EM-50 XCut
	Salt Splitting using Ceramic Membranes (RL-350002)	EM-50 XCut
	Electrochemical Destruction of Nitrates and Organics (SR-132005)	EM-50 XCut
Manage Process Effluents	Significant Volume Reduction of Tank Waste by Selective Crystallization (RL-442002)	EM-50 XCut
	Electrochemical Destruction of Nitrates and Organics (SR-132005)	EM-50 XCut
Sludge Wash/Caustic Leach	Conduct Sludge Wash/Alkaline Leach Tests with Actual Waste 94-95 Sample Cores - PNL	EM-30 Hanford
	Conduct Sludge Wash/Alkaline Leach Tests with Actual Waste 94-95 Sample Cores - LANL	EM-30 Hanford
	Evaluate Sludge Processing Science for Actual Sludge, 94-95	EM-30 Hanford
	Conduct Selective Leaching Experiments of Actual Sludge, 94-95	EM-30 Hanford
	In-Tank Precipitation (ITP) with Sodium Tetraphenyl-borate Precipitate (STBP): Cold Chemical Precipitation	EM-30 SRS
	Sludge Aluminum Dissolution	EM-30 SRS
	Sludge Washing	EM-30 SRS
	Gunite Treatability Study	EM-40 OR
	Sludge Washing and Dissolution of ORNL MVST Waste; Sludge Washing and Leachmg; Aluminum Removal (OR-132012)	EM-50 XCut
Solid-Liquid Separations Test Equip-ment Development and Transfer	Conduct Sludge Sealing Tests of Actual Waste, 94-95	EM-30 Hanford
	Establish a Colloid Capability	EM-30 Hanford
	Late Wash of Sodium TetraphenylboratePrecipitate	EM-30 SRS
	Support for Filtration of Newly Generated Wastes	EM-30 OR
	Gunite Tank Transfer to Melton Valley Tanks	EM-40 OR

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Solid-Liquid Separations Test Equipment Development and Transfer (contd)	HLW Process Filter Testing Program (SR-142011)	EM-50 Tanks
	Sludge Washing and Dissolution of ORNL MVST Waste; Colloid Behavior	EM-30 XCut
Waste Concentration/Water Balance	Volume Reduction Improvements	EM-30 SRS
	Out-of-tank Evaporator Systems Demonstration	EM-30 OR
	Evaporator Systems Demonstration	EM-30 OR
	Evaporator and Denitrification	EM-30 INEL
	Evaporation Demonstration (OR-132008)	EM-SO Tanks
Form for Immobilization of LLW	Develop LLW Immobilized Product Specifications – Release and Migration	EM-30 Hanford
	Develop LLW Immobilized Product Specifications – Improved Glass Durability	EM-30 Hanford
	Develop Glass Waste Form and Glass Specification – Glass Formulation Model	EM-30 Hanford
	Evaluate Process and Disposal Data Requirements	EM-30 Hanford
	Process and Disposal Control and Monitoring Approach	EM-30 Hanford
	Gunite Treatability Study	EM-SO Tanks
	NAC/NAG Waste Form Studies	EM-30 OR
	LLW Stabilization Hot Lab Tests and Design/Build Sodium/LLW Cold Pilot Plant	EM-30 INEL
	NAC Process Development (OR-132008)	EM-50 Tanks
Melter Selection	Develop Suitable Melter Off-Gas System-Specification Over Glass Melts	EM-30 Hanford
	Develop LLW Vitrification System Instrumentation and Controls	EM-30 Hanford
	Evaluate Selected Melter and Maintenance Strategy	EM-30 Hanford
	LLW Melter Testing	EM-30 Hanford
	Conduct Laboratory Development on Optical Electric	EM-30 Hanford
	Develop Melter Operational Strategies and Methods	EM-30 Hanford
	Melter Off Gas Treatment Evaluation	EM-30 Hanford

Legend: EM-30 SRS - Savannah River Site
EM-40 OR - Oak Ridge
EM-50 XCut - Crosscutting Programs

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Melter Selections (contd)	Select Single Melter Concept Design	EM-30 Hanford
	Candidate Melter Systems Evaluation	EM-30 Hanford
	Stirred Melter	EM-30 SRS
	Melter Off-Gas System Development	EM-30 INEL
	High-Temperature Melter System Development (ID-141003)	EM-50 XCut
Vitrification of Ion-Exchange Resins	Evaluate Melter Feed Prep Techniques	EM-30 Hanford
	Technology Development Verification Testing	EM-30 Hanford
	Develop Vitrification Process Chemistry	EM-30 Hanford
	Glass Formulation and Process Feed Evaluation	EM-30 Hanford
	Develop, Install, Operate RF Ion-Exchange System	EM-40 OR
	Cs Removal Demonstration (OR-132008)	EM-SO Tanks
Consolidation of Glass Process Controls Development	Improved Glass Durability (Glass Surface Treatments)	EM-30 Hanford
	Durability Testing	EM-30 Hanford
	Develop, Validate and Document Process Control Models/Codes	EM-30 Hanford
	Evaluate and Recommend Melter Operational Models	EM-30 Hanford
	Glass Modeling	EM-30 Hanford
	Glass Sampling and Testing	EM-30 SRS
	Upgrade Product Composition Control System	EM-30 SRS
	Finished Product Evaluation	EM-30 SRS
	Glass Formulation	EM-30 INEL
	Waste Processing and Disposal (OR-132008)	EM-50 Tanks
	Glass Compositional Envelope Study (CH-231007)	EM-SO XCut
Focused Facilities and Processes	New start in FY96	

Legend: EM-30 SRS - Savannah hver Site
EM-40 OR - Oak hdge
EM-50 XCut - Crosscumng **Programs**

Table 4.3. (contd)

Technical Element	Related FY95 EM Tank Technical Activities	Funding Organization
Waste Retrieval and Tank Closure Demonstration	Acquire Commercial Technology for Retrieval Project	EM-30 Hanford
	Tank Closure Studies	EM-30 Hanford
	Alternate Salt Removal and Tank Closure	EM-30 SRS
	Gunite Tank Treatability Study	EM-40 OR
	Waste Dislodging and Conveyance	EM-50 Tanks

Legend: EM-30 SRS - Savannah River Site
EM-40 OR - *Oak* Ridge
EM-50 XCut - Crosscutting Programs

Section 5 - References

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Appendix A - Description of DOE's Tank Waste Remediation System

The U.S. Department of Energy (DOE) stores radioactive hazardous mixed waste in tanks at four sites: Hanford, Washington; Idaho National Engineering Laboratory (INEL), Idaho; Oak Ridge, Tennessee; and Savannah River Site (SRS), South Carolina. Cleanup of the tank wastes will be very costly and time consuming, especially given the high activity level of the waste. It is estimated that waste cleanup at these sites will cost $140 billion in constant 1995 dollars (DOE 1995b); at least half of this cost is for tank waste remediation. In addition, there will be resulting health and safety risks to workers, the public, and the environment from cleanup. These health and safety risks must be reduced to the greatest extent possible.

The Tanks Focus Area (TFA) seeks to be cognizant of and responsive to system cost and risk drivers so that userdriven solutions are selected that maximize reductions to cost and risk while resolving technical uncertainties. The technical program recommended in this multiyear program plan **(MYPP)** is based on qualitative judgments of the relative costs and risks of tank remediation across the DOE system. For example, waste immobilization and disposal has been assumed to be the primary cost driver; consequently, the primary cost-reducing technical elements address waste treatment and processing issues. This appendix describes the currently available technical, cost, and risk data that underlie TFA's program recommendations. Section A. 1 reviews the high-level waste (HLW) tank programs at Hanford, INEL, Oak Ridge, and SRS, including tank waste remediation strategies, and lists estimated costs and schedules for tank waste remediation in constant 1995 dollars. Section A.2 reviews system risks. Section A.3 links risks to the recommended TFA technical elements. Section A.4 reviews stakeholder involvement and issues at each site. Section A.5 reviews the technical recommendations response and suggests applications of the information for planning purposes. Section A.6 discusses future steps. Section A.7 lists the references used.

This appendix provides the initial data for such an assessment. Subsequent versions of this appendix will combine these and additional data to provide relative, quantitative risk and cost summaries across sites and major remediation functions for the national DOE tank system. These subsequent versions will help the TFA conduct a more systematic and critical assessment of system risks and costs as they affect user needs.

A.l Review of HLW Tank Programs

The tank waste remediation programs at Hanford, INEL, Oak Ridge, and SRS are briefly discussed in this section. The review includes a description of the site in terms of topography, hydrology, and meteorology because these parameters tend to drive public health and safety concern. The tanks and associated wastes at each site are briefly characterized, and the strategy for remediating tank wastes is overviewed.

A.1.1 Hanford Site Overview

The Hanford Site was acquired by the federal government in 1943. For the first 45 years, the government's primary mission was to produce plutonium for national defense and manage the resulting waste. With the shutdown of production facilities in the 1980s, the mission has been diversified to include technology development, waste management, and environmental restoration (DOE 1995b). There are several major facility areas: 100 Areas, 200 Areas, 300 Area, 400 Area, 700 Area, 1100 Area, and 3000 Area. Hanford waste tanks are located in the 200 East and 200 West Areas (see Figure A.1).

The Hanford Site is briefly described below.

- The Hanford Site in southeastern Washington State covers 1,450 km^2 (560 mi^2).
- The land surrounding Hanford is semiarid shrub and grasslands.
- Hanford is located just north of the confluence of the Yakima and Columbia rivers.
- Water use at Hanford and the surrounding area is primarily from surface sources; groundwater sources account for less than 10% of total water use (Cushing 1992).
- An aquifer lies under the tank farms in the 200 Areas. The aquifer displays unconfined to locally confined or semiconfined conditions.
- Depth to groundwater in the upper aquifer ranges from about 55 m (180 ft) beneath the former U Pond in the 200 West Area to 95 m (310 ft) west of the 200 East Area.
- The depth to the water table is 79 m (260 ft)
- Prevailing winds in the area are from the west with the northwest and southwest being the next most common wind directions. The Washington Public Power Supply System and the 300 Area are located in the direction of the prevailing winds.
- The average wind speed is 3.6 m/s (7.9 mi/h). Wind gusts well above average occur in the summer.
- Average annual precipitation is 16 cm (6.3 in.) (DOE 1995b, App. A).
- The population within 80 km is approximately 370,000.

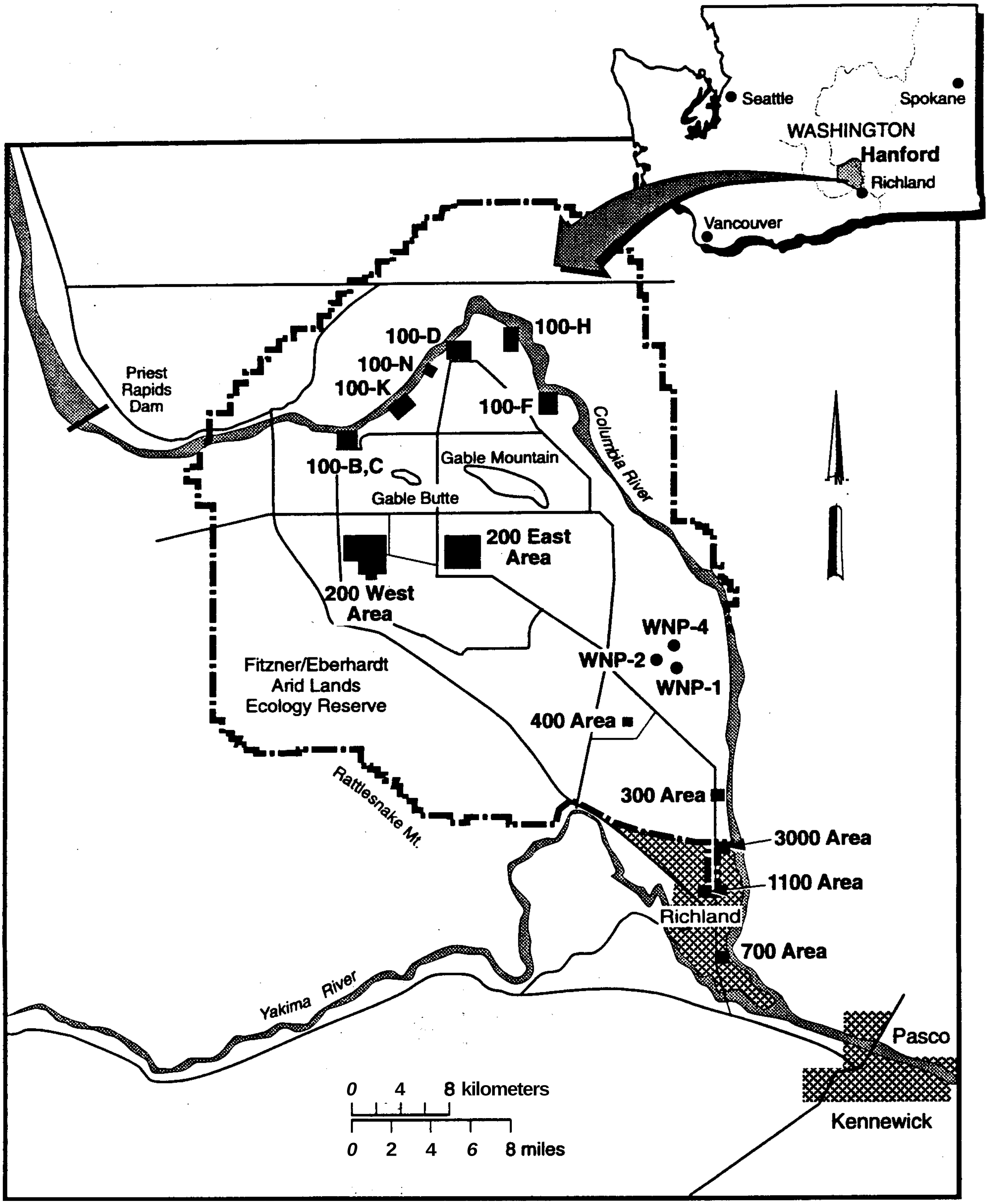

Figure A.1. Hanford Site and Major Facilities

A.1.1.1 Hanford Tanks

Wastes are currently stored in 177 underground tanks in the 200 Areas of the Hanford Site. There are 149 single-shell tanks (SSTs) and 28 double-shell tanks (DSTs). The SSTs, built between 1943 and 1964, are reinforced concrete tanks with carbon steel liners. Nominal capacities range from 200 to 3,785 m^3 (55,000 to 1,000,000 gal). Since 1956, 67 SSTs have leaked or are suspected to have leaked. It is estimated that a total of 2.85 million L (750,000 gal) of tank waste has leaked to the soil (Treat et al. 1995). All 149 SSTs were removed from service as of November 21, 1980.

The first DST was placed in service in 1971. DSTs consist of a carbon steel primary tank, an annular space, and a secondary steel tank encased in reinforced concrete. Each DST has a nominal capacity of 3,785 m^3 (1,000,000 gal). There is no evidence that any DSTs have leaked, and all of the tanks are still in service.

Approximately 54 tanks are on the "Watch List" at Hanford. Some of these tanks are subject to more than one safety issue. Releases to the environment are estimated to be possible as a result of uncontrolled increases in temperature or pressure within the tanks. Specific safety issues that must be addressed include the following:

- radioactive exposures to both onsite and offsite personnel from generation, accumulation, and possible ignition of flammable gases in tank head space
- radioactive exposures to both onsite and offsite personnel from propagating reactions of ferrocyanide-containing wastes
- radioactive exposures to both onsite and offsite personnel from uncontrolled exothermic oxidation by nitrate or nitrite of high concentrations of mixed organic chemicals in tank waste
- potential hazard from a structural failure if, in the event of a leak, cooling water additions are discontinued to Tank 241-C-106, a tank that generates high amounts of heat
- tank farm hazards to employees from noxious gas generation.

A certain level of moisture may need to be maintained in the waste to prevent hazardous conditions from evolving inside the flammable gas, ferrocyanide, and organic tanks. Ammonia and other noxious gases from the waste detection and tank integrity inspection for leaks are also important for addressing tank safety issues (DOE 1995e).

A.1.1.2 Hanford Wastes

Processes used to recover plutonium and uranium from irradiated fuel and to recover radionuclides from tank waste have resulted in a legacy of more than 232 million L (60 million gal) of wastes. The waste is multiphased: some is an insoluble sludge with interstitial liquids, some is in the form of crystalline water-soluble solids (called saltcake), and some is in the form of supernatant liquids. Most of the pumpable liquids have been transferred from SSTs to DSTs. The liquid, saltcake, and sludge in SSTs and slurry in DSTs consist of HLW, transuranic (TRU) waste, and several low-level wastes (LLWs). However, all tanks are managed as if they contain HLW. The total activity of waste stored is estimated to be about 104 MCi in the SSTs and about 73 MCi in the DSTs[(a)].

From 1968 to 1985, much of the heatemitting nuclides (^{90}Sr and ^{137}Cs) were extracted from the tank waste, converted to solids (strontium fluoride and cesium chloride), and placed in double-walled metal cylinders (capsules) about 52 cm (20.5 in.) long and 6.7 cm (2.6 in.) in diameter. At present, 1,328 cesium capsules and 605 strontium capsules exist; most of the capsules are on the site in water-filled basins. As of December 1990, the activity of these capsules with decay daughters was about 168 MCi (Boomer et al. 1993). The capsules are included as part of the TWRS program (see Section A. 1.1.4).

A.1.1.3 Hanford Regulatory Drivers

Regulatory drivers for remediating tank wastes at Hanford are as follows:

- ***Hanford Federal Facility Agreement*** and ***Consent Order*** (TPA) (Ecology et al. 1994) - This agreement between the U.S. Environmental Protection Agency (EPA), the DOE, and the Washington State Department of Ecology established the requirements for meeting federal and state Resource Conservation and Recovery Act (RCRA) regulations. The TPA was amended in 1994. The amended agreement committed Hanford to certain courses of action regarding retrieval of waste from the SSTs, vitrification of LLW, cessation of the grout program, and National Environmental Policy Act (NEPA) coverage of actions.

- Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 93-5 (DOE 1994b) - The Board issued a number of recommendations to accelerate tank waste sampling at Hanford to ensure adequate protection of public health and safety. Safety-related sampling and analysis are to be completed by July 1995 and in other tanks by July 1996.

- TWRS Environmental Impact Statement (EIS) - The EIS will provide information that has the potential to rebaseline the TWRS program. The environmental consequences of a number of alternatives for treating tank waste, including in situ treatment, will be evaluated. A record of decision for the TWRS EIS is planned by May 1996.

A.1.1.4 Hanford Remediation System Description

DOE established TWRS in 1991 to oversee 1) receiving, safely storing, maintaining, and treating existing and new tank waste; 2) interim storage of HLW; 3) packaging of HLW for off site disposal; and 4) disposing of LLW in a retrievable form on site. The TWRS program also supports maintaining, operating, and upgrading existing facilities such as waste storage tanks, evaporators, pipelines, and adding new facilities. Major facility additions currently planned include a new cross-site transfer line, tank waste retrieval facilities, and pretreatment and vitrification facilities.

(a) Personal communication with C. Golberg, Westinghouse Hanford Company, Richland, Washington.

The TWRS strategy is illustrated in Figure A.2. The strontium and cesium capsules will either be stored until they are no longer a hazard or they will be vitrified with the tank waste (not shown on Figure A.2). Well-known hydraulic sluicing methods will be used to retrieve SST wastes, and mixer pumps will be used to retrieve DST wastes.

There is no pretreatment or simple washing of the retrieved DST sludges. SST wastes will undergo in-tank sludge washing and cesium ion-exchange/blending in an adjacent module or the LLW treatment facility. A very high capacity melter will be developed that converts LLW from the tanks to cullet or remelted glass. HLW will be vitrified and shipped in casks to a geologic repository. The LLW form is glass in sulfur, which is disposed of in concrete vaults. The HLW form is borosilicate glass (DOE 1995e).

A.1.1.5 Hanford System Closure

The TWRS closure strategy has not been finalized. Elements of the proposed strategy include the following.

- Approximately 99% of the waste will be removed from the tanks.
- Tank residuals and ancillary equipment will be left in place.
- SSTs and DSTs will be gravel filled.
- Surface barriers will be placed over the SSTs, DSTs, and the LLW vaults.
- The tank farms will be subject to RCRA closure standards for landfills.

Currently, tank closure is not part of the TWRS program scope. It is proposed that closure be addressed as part of the Environmental Restoration program. There is a concern that an integrated strategy is needed for the management of TWRS post-remediation wastes.

A.1.1.6 Hanford Costs and Schedule

The total (life-cycle) system cost for TWRS is estimated to be about $42 billion in unescalated constant 1995 dollars. Costs for major projects and associated completion dates are shown in Tables A.1 and A.2.

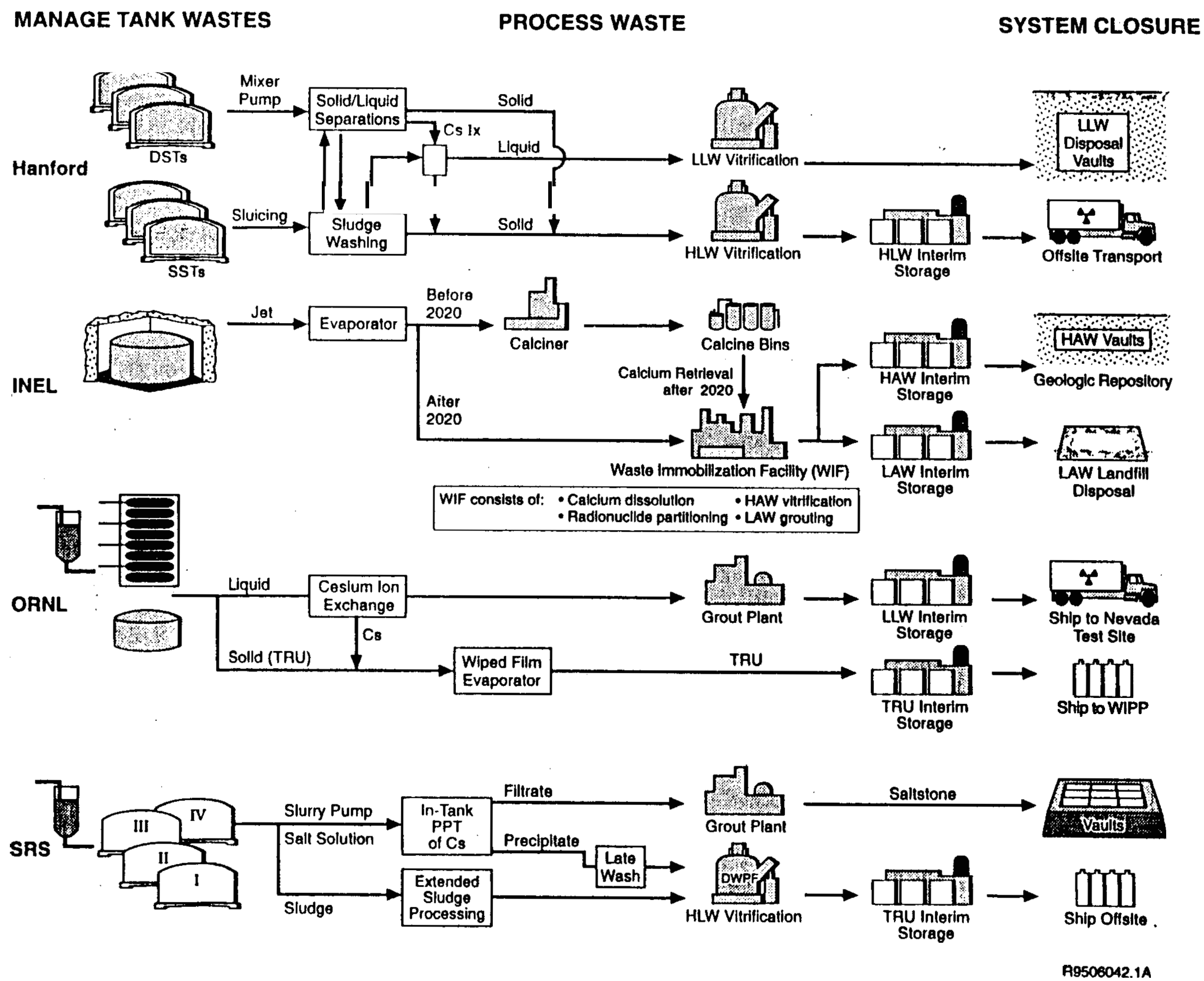

Figure A.2. DOE Tank Remediation Strategies

Table A.l. Hanford System Costs''

Needs Breakdown Structure@'	**Waste Management Activity**	**Estimated Cost ($M)[a]**
Manage Tank Waste	Tank farm operations	4,590
	Tank safety[c]	490
	Tank farm upgrades	1,490
	Tank waste characterization	5,260
Process Waste	Retrieval")	8,800
	Pretreatment	3,300
	LLW vitrification	6,570
	HLW vitrification	7,840
System Closure	HLW disposal	4,010
	Tank closure	Not available

breakdown structure level. This mapping is not exact. See Section 3 of this MYPP for information on the needs breakdown structure.

(c) **Supplementary** ***costs*** obtained **from** onsite **activity data sheet information.**

Table A.2. Hanford Major Milestones"')

Milestone Title	**Completion Date**
Mitigate/resolve tank safety issues	2001
Complete tank waste characterization	1999
Complete tank farm upgrades	2010
Complete closure of **SST** tank farms • Retrieve waste from all **SSTs**	2024 2018
Complete pretreatment processing of Hanford wastes • Start hot operations of LLW pretreatment facility • Start hot operations of HLW pretreatment facility	2028 2004 2008
Complete vitrification of Hanford LLW • **Start** hot operation of LLW vitrification facility	2028 2005
Complete vitrification of Hanford HLW • **Start** hot operation of the HLW vitrification facility	2028 2005

A.1.2 INEL

The original mission at INEL was to reprocess spent fuel from defense reactors. In 1949, the Atomic Energy Commission established the National Reactor Testing Station at the site, and a number of reactors were constructed and tested. In the mid-1950s, the site began receiving and storing wastes from other sites. Since April 1992, INEL no longer reprocesses fuel, but the site still receives and stores spent fuel from research reactors and naval submarine reactors. This activity will be ongoing for the next 40 years. Decontamination and decommissioning (D&D) of a number of facilities is underway, resulting in ongoing production of liquid waste (DOE 1995a, App. B).

The INEL site consists of eight major facility areas: Test Area North, Test Reactor **Area,** Idaho Chemical Processing Plant (ICPP), Power Burst Facility, Experimental Breeder Reactor-1, Radioactive Waste Management Complex, Naval Reactors Facility, and Argonne National Laboratory - West. All the HLW from spent fuel reprocessing is confined to the ICPP (see Figure **A.3).**

INEL is briefly described as follows.

- INEL is located in southeastern Idaho; the site covers 2,310 km^2 (890 mi^2).
- The land surrounding the site is semiarid and used for recreation, grazing, and wildlife management.
- The Little Lost River, Big Lost River, Birch Creek, and Mud Lake are within a 32-km (20-mi) radius.
- INEL is subject to prevailing westerly winds, although the mountain ranges bordering the site channel these winds to the southwest. Some small towns are located in the direction of prevailing winds.
- The average wind speed is 3.4 m/s (7.5 mi/h).
- Average annual precipitation is 22 cm (8.7 in.) (DOE 1995a, App. B).
- The population within 80 km is 250,000.

A.1.2.1 INEL Tanks

The 11 tanks at INEL each have a capacity of 1.1 million L (300,000 gal) The tanks are all similar in design and are constructed of stainless steel. The tank vaults are of three different types: two monolithic octagon vaults, four square vaults, and five octagonal pillar and panel vaults. There are no liners in any of the vaults. The total volume of waste stored in these tanks is about 6.8 million L (1.8 million gal). The pillar and panel tanks must be removed from service by March **31, 2009**. All remaining tanks must be removed from service by June 30, 2015.

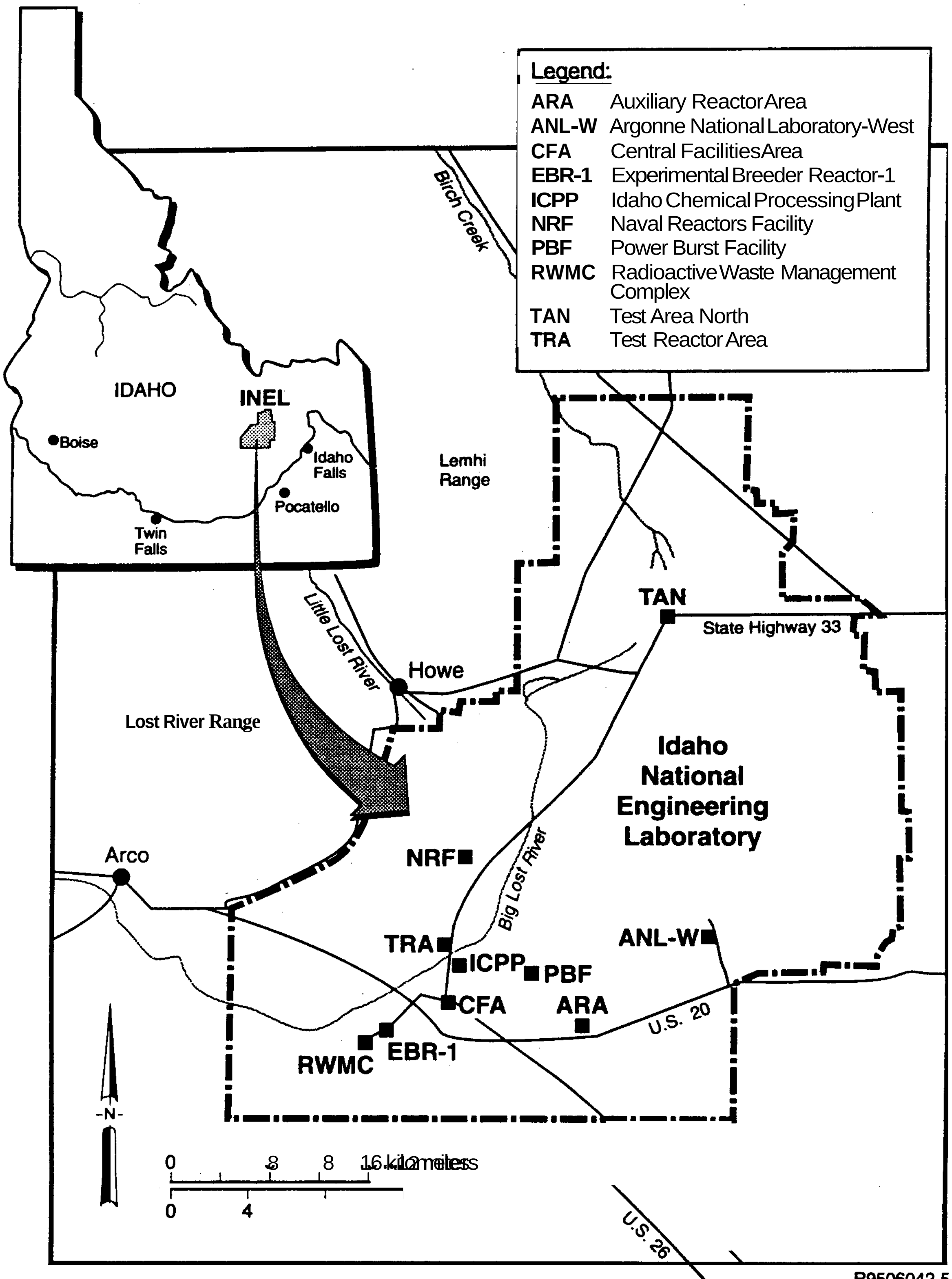

Figure A.3. INEL Site and Major Facilities

New tanks will be needed to store waste before calciner campaigns. Operating the New Waste Calciner Facility (NWCF) will produce about 660,000 L (175,000 gal) of recycled liquids to the tank farm after each calciner campaign. It is unlikely that operating the calciner will empty the tanks before 2015 without some major improvement in the flowsheet or 3,785 m^3 (1 million gal) of new .process surge tanks to support continued operations.

There are also seven calcine solids storage facilities, including one newly constructed facility. Calcine is stored in stainless steel bins enclosed in massive underground concrete vaults with walls up to 1.2 m (4 ft) thick. Five of the seven storage facilities are full, and the sixth is partially full (Palmer et al. 1994).

A.1.2.2 INEL Wastes

INEL stores 6.8 million L of liquid HLW and sodium-bearing liquid waste. Also, 3.838 million L of calcined solid waste is stored at INEL.

As of 1993, about 7 to 8 MCi of liquid wastes are stored in stainless steel tanks and about 59 MCi of calcined wastes are stored in bins (DOE 1994b). The square vault tanks (WM-189) contains HLW, while the other tanks contain mixed waste. About 20,000 L (5,000 gal) of sodium-bearing waste is being added to the tanks per month from facility D&D, off-gas system operation, and spent nuclear fuel storage.

A.1.2.3 INEL Regulatory Drivers

The regulatory drivers for the remediating of tank wastes and calcine are as follows:

- Idaho Federal Facility Agreement and Consent Order, December 1991 - This is an agreement between the EPA, the DOE, and the Idaho Department of Health and Welfare. This agreement establishes Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) procedures for addressing releases of hazardous substances.

- Idaho Federal Facility Agreement and Consent Order, Future - This is an agreement between the EPA, the DOE, and the Idaho Department of Health and Welfare that establishes requirements to remove, process, and immobilize the HLW calcine existing in ICPP storage bins. The order is expected to be signed in October 1995. Options include immobilization of calcine into glass or redissolution of the calcine and separation of the waste into a low-activity waste (LAW) stream and a high-activity waste (HAW) stream.

- Notice of Noncompliance (NON) Consent Order, April 1992 - This order states that the pillar and panel tanks mast be removed from service by March 31, 2009. All remaining tanks must be removed from service by June 30, 2015.

- U.S. District Court's Opinion and Order of June 28, 1993 - This order mandated a sitewide EIS to evaluate alternatives.

- **U.S.** District Court's Opinion and Order of December **22,** 1993 - This order accelerated the EIS and completion of activities related to the treatment and disposal of radioactive waste.

- Modified NON Consent Order, March 1994 - This order issued by the EPA calls for construction of new **tanks** if they are determined to be needed in the record of decision for the EIS. The tanks would be considered RCRA contained storage. The Modified NON Consent Order states that all nonsodium HLW in the tanks and **as** much sodium-bearing liquid **as** practical must be calcined by January 1, 1998. Sodium pretreatment processing technology and calcine immobilization technology must be selected by June 1, 1995.

- INEL EIS, April **30,** 1995 - A record of decision will be made on the technology chosen to treat sodium-bearing liquid waste in the ICPP tank farm and on treatment for the calcine from NWCF.

A.1.2.4 INEL Remediation System Description

Most newly generated liquid wastes are initially treated by the Process Equipment Waste Evaporator (PEWE). The liquid wastes are then sent to the tanks and then to the NWCF. Construction of the new High-Level Liquid Waste Evaporator (HLLWE) facility is underway, and the facility is scheduled to come on-line in 1996. The HLLWE will process selected waste stored in the tank farms to improve its treatability.

The ICPP Proposed Waste Management Strategy **is** illustrated in Figure A.2. The new HLLW will begin concentrating dilute tank farm wastes in 1996 to improve their treatability in the NWCF. The NWCF will continue to operate until approximately 2020. During this time, it will treat sufficient waste to meet the consent order requirements. New tank farm tankage will be brought on-line in 2015 to provide the necessary surge capacity for continued ICPP operations after the last of the old tanks are taken out of service. The Waste Immobilization Facility will be brought on-line in 2020. This process will treat both the stored calcine and any residual or future liquid wastes by separating them into high-activity and low-activity fractions. The HAW will be vitrified and sent to a federal geologic repository and the LAW will be grouted and disposed onsite.

A.1.2.5 INEL System Closure

The Idaho closure strategy has not been finalized. It must address the HLW tank farm, the HLW calcine solids storage facilities, and final disposal of the LAW grout.

About **8** cm **(3** in.) of liquid heel that may contain sludge on the bottom of the tanks will remain after retrieval. The removal of this sludge is part of the **RCRA** closure activities that start in about 2009 (Murphy 1995). After removal of the heels, INEL tanks will be closed **as** RCRA treatment, storage, and/or disposal units.

The HLW calcine storage facilities and all process facilities will be decontaminated and decommissioned. After mixing of the LAW with a cement-based mixture, the LAW grout will be placed in waste drums and storage. At closure, the drums will transferred to a landfill for final onsite disposal.

A.1.2.6 INEL Costs and Schedule

The total system cost for remediation of HLW at INEL is estimated to be about $5 billion in constant 1995 dollars. The distribution of costs and the associated schedule are shown in Tables A.3 and A.4.

Table A.3. INEL System Costs[a,b]

Needs Breakdown Structure[c]	Waste [illegible]	Estimated Cost ([illegible]
Manage Tank Waste	Calciner operation	13
	New bin set	2
	Tank farm operation	11
Process Waste	Process development	259
	Facility construction	927
	Process operation	2,573
	Interim storage	
System Closure	Waste disposal	461
	Decontamination and decommissioning	522
Total		4,793

(a) Source: DOE 1995c (p. ID25, ID35, and ID36). Breakdown of costs developed from phone conversation with James Murphy of Lockheed Idaho Technology Company on 6/16/95.
(b) WIF project costs are about $1.4 billion of the total costs. Technologies and facilities for treating the low-level fraction of the waste have yet to be determined.
(c) BEMR waste management activities are mapped to the TFA needs breakdown structure level. This mapping is approximate.
(d) Constant 1995 dollars.

Table A.4. INEL Major Milestones(*)

Milestone Title	Completion Date
EIS record of decision	1995
Complete activities at the Idaho Chemical Processing Plant	Undetermined
Complete HLW operations@"	2050
• Initiate waste immobilization facility Phase I construction	2010
• Initiate waste immobilization facility Phase 11 construction	
• Start waste immobilization facility Phase I operations	2020
• Start waste immobilization facility Phase II operations	

A.1.3 Oak Ridge Site Overview

Oak Ridge was the pilot plant site for the reactors that were later built at Hanford and SRS during the Manhattan Project. The site consists of three major facility areas: the Y-12 Plant, ORNL, and the K-25 Site (see Figure A.4). Waste tanks covered under the TFA are located at ORNL in the Melton Valley and Bethel Valley areas.

The site at Oak Ridge is briefly described as follows.

- Oak Ridge is located on 140 km^2 (54 mi') within the corporate city limits of Oak Ridge, Tennessee.
- Facilities occupy about 701 ha (about 1,754 acres) or about 20% of the entire ORNL site. The remaining 2,806 ha (7,017 acres), or 80% of the entire ORNL Site, is predominantly forested buffer zone.
- Land surrounding the nonarid site is predominately rural woodlands and used largely for residences, small farms, forest land, and pasture land.
- There are three lakes - the Watts Bar Lake, Melton Hill Lake, and Loudon Lake - and two rivers the Clinch River and Tennessee River - within a 32-km (20-mi) radius.
- The DOE/Johnson Controls water treatment facility, which provides water to the city of Oak Ridge, is located just north of the Y-12 Plant.
- The Knox aquifer is the major aquifer in the Oak Ridge area.
- In Bethel Valley, depth to water table ranges from 0.30 to 10.7 m (1 to 35 ft), while in Melton Valley the range is from 0.30 to 20.4 m (1 to 67 ft).
- The average wind speed is 2.1 m/s (4.7 mi/h). The peak wind direction is from the west-southwest, with a secondary peak from the northeast. There are no towns or cities aligned with prevailing winds.
- Average annual precipitation is 130.9 cm (51.5 in.) (ORNL 1993; DOE 995a, App. F).
- The population within 80 km is 16,000.

A.1.3.1 *Oak Ridge* Tanks

There are two types of tank wastes at Oak Ridge: legacy tank wastes and active tank wastes. There are 56 inactive tanks that store legacy wastes. Approximately 400,000 gal of dilute liquid LLW supernatants and associated sludges are stored in gunite and associated tanks and the old hydrofracture tanks. The gunite and associated tanks consist of 12 (primarily 170,000-gal) concrete tanks and four

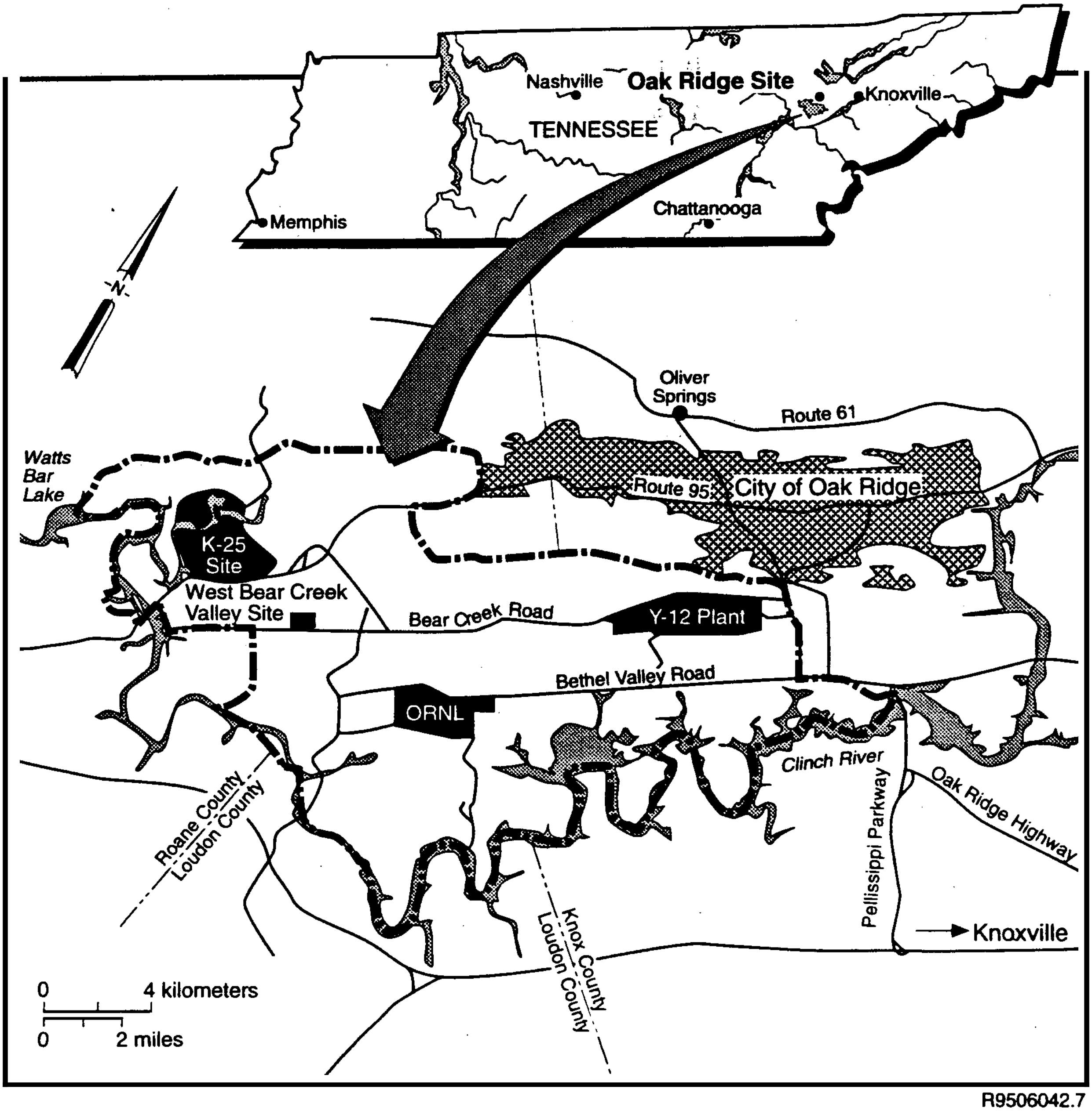

Figure A.4. *Oak* Ridge Site and Major Facilities

2,000- to 4,000-gal stainless steel tanks. The old hydrofracture tanks consist of five 13,000- to 25,000-gal carbon steel tanks. These wastes are classified as mixed low-level and/or TRU waste and must be treated to meet RCRA regulations under a Federal Facilities Compliance Agreement. There are also a number of carbon steel tanks that store legacy waste from the gunite tanks. The 56 inactive tanks are slated for remediaton.

The waste from the active underground collection system are stored in 13 central treatment/storage tanks. Approximately 420,000 gal of liquid LLW and TRU waste are stored in the 13 active 50,000-gal stainless steel central treatment/storage tanks (five tanks are evaporated service tanks and eight are Melton Valley Storage Tank located approximately 1 mi from the evaporated area). An average of 69,000 to 95,000 L of LLW concentrate are produced each year and is stored for future treatment in these central treatment/storage tanks. There are also 27 active waste collection tanks varying in age, design, and size (from 150 to 190,000 L or 40 to 50,000 gal). There is an agreement between the EPA and the state of Tennessee to upgrade the active tanks that will be used to store waste from the cleanup of the hydrofracture and other facilities.

A.1.3.2 *Oak* Ridge Wastes

The legacy waste is similar in composition to the Hanford and SRS wastes; but it is about 90% less radioactive than wastes at Hanford, there is no saltcake, and there is much less waste volume. There are about 1.86 million L (490,000 gal) of legacy wastes containing 130,000 Ci (primarily ^{137}Cs, ^{90}Sr, and other fission products) of which 150,000 L (40,000 gal) is TRU sludge and the remainder is LLW supernate.

Active tank waste is continually being generated by ongoing research and development at *Oak* Ridge. This waste is stored in the "active" tank system. Newly generated waste is classified as liquid LLW. There are approximately 1.5 million L/year (400,000 gal/year) of active waste containing approximately 34,000 Ci (primarily ^{137}Cs, ^{90}Sr, and other fission products) from the extensive underground collection, transfer, and storage system that interconnects generator buildings, tanks, and processing facilities. Approximately 946,000 L (250,000 gal) is liquid LLW and 640,000 L (170.000 gal) is TRU sludge.

A.1.3.3 *Oak* Ridge Regulatory Drivers

The key regulatory driver for remediating tank wastes at *Oak* Ridge is the ORNL Federal Facility Agreement and Consent Order, December 1991. This is an agreement between the EPA, the DOE, and the Tennessee Department of Environment and Conservation. This agreement establishes requirements for the management of tanks. DOE must remove all tanks from service that operate without secondary containment. Tanks with secondary containment may continue to operate.

A.1.3.4 *Oak* Ridge Remediation System Description

Oak Ridge has developed a multifaceted management strategy for the tanks. Technology is much farther along for the active system than for the legacy wastes. The waste management strategy is illustrated in Figure A.2. The plan for tanks is to

- evaporate, remove cesium, and solidify the MVST supernates in grout for disposal at the Nevada Test Site
- dry the sludges using a wiped-film evaporator and a microwave melter
- dispose of treated sludges at WIPP
- develop separations and immobilization technology to allow future onsite disposal of newly generated liquid LLW.
- deploy source reduction to obtain less than 15% of current volumes of newly generated waste.

Contingency plans include the following:

- onsite disposal of MVST supernate after removal of the cesium, strontium, technetium, and/or nitrates
- enhanced stabilization of MVST sludges
- development of capability to vitrify sludge in wiped-film evaporator or microwave melter
- onsite disposal of sludge after pretreatment.

CERCLA treatability studies are underway for tank heel characterization using the light-duty utility arm (LDUA). Treatability studies will demonstrate sluicing technologies for waste removal, including conventional sluicing with a nozzle, the LDUA, and mixer pumps (Robinson 1995).

A.1.3.5 Oak Ridge System Closure

The Oak Ridge closure strategy has not been finalized. The tanks will be closed as CERCLA contamination. CERCLA requires a risk-based, prescriptive strategy for establishing cleanup requirements. It has not been decided if treated wastes will be disposed onsite or shipped offsite for final disposal.

A.1.3.6 *Oak* Ridge Costs and Schedule

The total system cost for remediation of tank waste at ***Oak*** Ridge is estimated to be about **$1.2** billion in constant **1995** dollars. Available information on costs and schedule is provided in Tables **A.5** and **A.6.** Disposal options for tank wastes are now being investigated; thus, they are not included in the costs.

Table A.5. *Oak* Ridge System Costs[a]

Needs Breakdown Structure@"	**Waste Management Activity**	**Estimated Cost ($M)[c]**
Manage Tank **Waste[d]**	Bethel Valley upgrades	**18**
	Bethel Valley LLW collection	**25**
	FFA LLW tank compliance	**68**
	Melton Valley LLW collection	**10**
	Melton Valley storage tanks	**39**
Process Waste	Process waste	**954**
System Closure	Disposal	**50**
	Decontamination and decommissioning	**67**

Table A.6. *Oak* Ridge Major Milestones"')

Milestone Title	**Completion Date**
Complete construction of liquid LLW collection and transfer system for Bethel Valley (Phase I)	**1994**
Complete construction of LLW collection and transfer system for Melton Valley	**1996**
Complete MVST upgrade	**1998**
Complete Bethel Valley Federal Facility Agreement upgrade	**1999**
Complete waste management activities	**2045**

A.1.4 Savannah River Site Overview

The SRS is owned by the federal government. When the site was established in the early 1950s, the primary mission was to produce nuclear materials to support U.S. defense (tritium and ^{239}Pu), space (^{238}U), and medical programs. In addition, spent nuclear fuel was chemically reprocessed to recover ^{235}U. The production reactors and fuel assembly areas are no longer operational, but the spent nuclear fuel reprocessing facilities operate as required to supply uranium to the National Aeronautics and Space Administration. The site's present mission is to manage system wastes. The site is divided into several major facility areas. The two tank farms are located in the F-Area and the H-Area (see Figure A.5).

The SRS is briefly described as follows.

- The SRS is located on 840 km^2 (325 mi') in western South Carolina.
- Land surrounding the site is predominately rural woodlands used largely for residences, small farms, forest land, and pasture land.
- The Savannah River borders the site on the southwest. The five principle tributaries to the Savannah River are the Upper Three Runs Creek, Fourmile Branch, Tenmile Branch, Steel Creek, and Lower Three Runs Creek.
- Prevailing winds in the area are from the northeast and the west-southwest with the northwest and southwest being the next most common wind directions.
- The average wind speed from 1987 through 1991 was 3.8 m/s (8.5 mi/h).
- Average annual precipitation is 122 cm (48 in.) (DOE 1995a, App. C).
- The nearby population is 460,000.

A.1.4.1 SRS Tanks

There are four tank types at SRS (I, 11, III, and IV) and a total of 51 tanks (see Table A.7), which contain 126 million L (33 million gal). Type III tanks are the newest tanks. All the Type I, II, and IV tanks are being retired because they do not have full second containment.

A number of Type I, II, and IV tanks have already leaked. Tank failures are due to nitrate-induced stress corrosion cracking. Stress relieving at the welds, careful chemical control, and change in construction has resulted in no leaks in Type III tanks (at the weld) (WSRC 1995).

The waste management program at SRS is currently installing mixing and transfer pumps on 47 of the tanks to allow retrieval and transfer of waste for processing. Many of the tanks are being upgraded with air-monitoring equipment to correct deficiencies and bring the tanks into compliance (DOE 1995c).

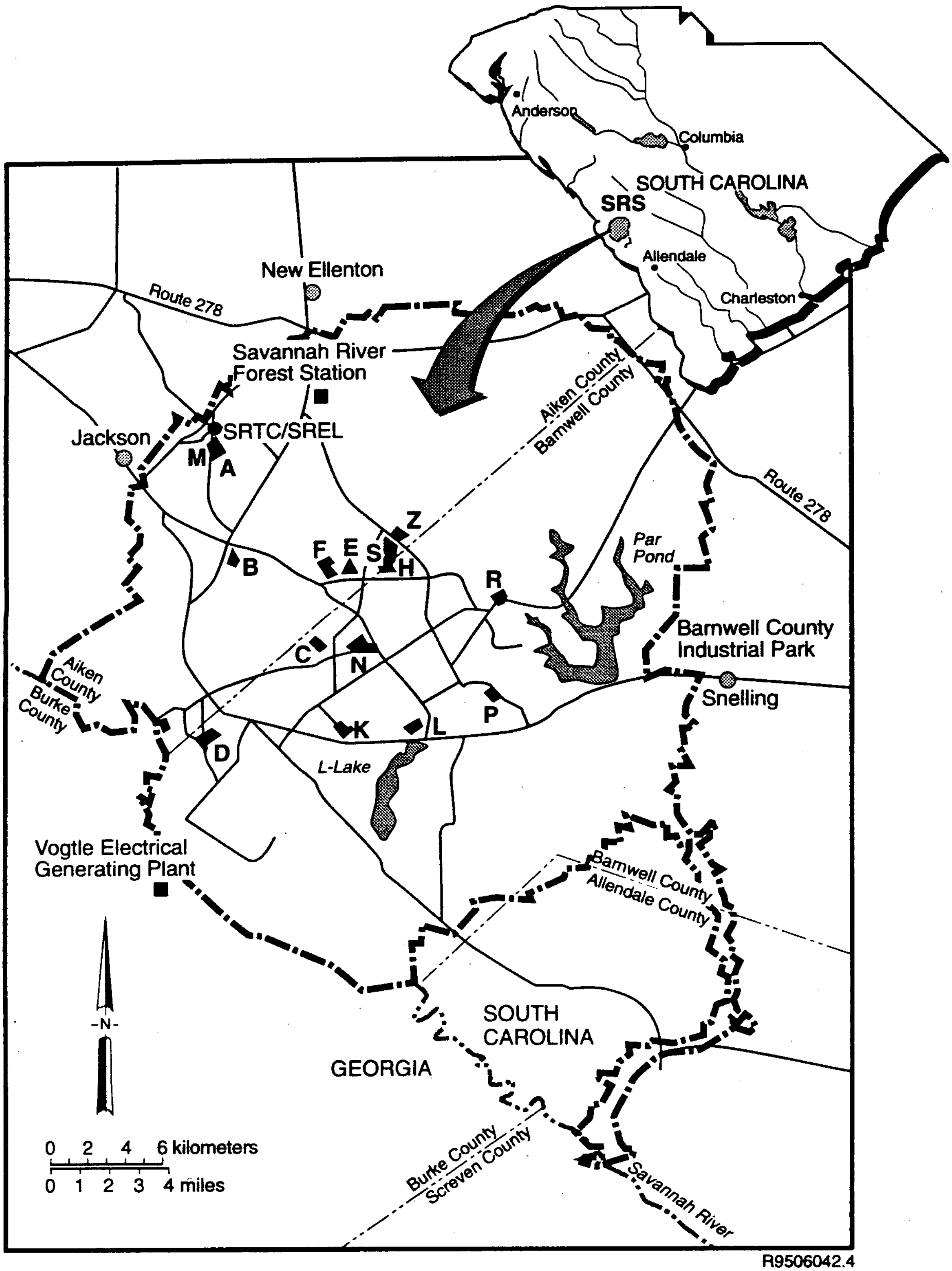

Figure A.5. Savannah River Site and Major Facilities

Table A.7. Status of Savannah River Tanks[a]

Type	Capacity (gal)	No. of Tanks	Description	Status
I	750,000	12	Steel cylinder in concrete with secondary steel pan at partial height and cooling capacity	Five failed; leakage in annulus
II	1,030,000	4	Same as Type I tanks	All failed
III	1,300,000	27	Similar to Type I and II tanks, but secondary steel pan at full height	None have failed
IV	1,300,000	8	Uncooled, single wall	Two out of eight failed

A.1.4.2 SRS Wastes

Past processes to recover uranium and plutonium from production reactor fuel and target assemblies in SRS's two chemical separations areas (F-Area and H-Area) have resulted in approximately 126 million L (33 million gal) of HLW. This waste is stored in underground tanks in the F-Area and H-Area near the center of the site. The waste consists of liquids (231 MCi) and solids (136 MCi). Liquid is the total of free liquid and interstitial liquid in the salt and sludge. Solid is the total salt, sludge, and precipitate in the waste tanks (DOE 1995d). Chemical constituents in the waste include nitrates, oxides, and hydroxides of aluminum, sodium, and iron. Although the waste is classified as high level, about 93% of the volume is low-level salt solution (WSRC 1995).

Savannah River currently generates small amounts of HLW as a result of limited production activities. After its introduction into the tanks, the HLW settles, separating into a sludge layer at the bottom of the tank and an upper layer of salts dissolved in water (supernate). Evaporation of the supernate in the tank farms using evaporators results in a third waste form in the tanks, crystallized saltcake.

A.1.4.3 SRS Regulatory Drivers

The regulatory drivers for remediating tank wastes at SRS are as follows:

- Defense Waste Processing Facility (DWPF) EIS, 1982 - The record of decision from the EIS documents the decision to construct and operate DWPF. Since then, DOE has prepared a supplementary EIS that addresses in-tank precipitation, saltstone processing and disposal, a late wash facility addition, and a number of other modifications to the DWPF.

- Savannah River Federal Facility Agreement and Consent Order, March 1991 - This is an agreement between the EPA, the DOE, and the South Carolina Department of Environmental Control. This agreement establishes requirements for remediation of SRS. Tanks must meet structural integrity requirements or be removed from service.

- Savannah River Waste Management **EIS,** 1995 - This sitewide **EIS** will provide the basis to select processes to manage wastes generated from ongoing operations.

A.1.4.4 SRS Remediation System Description

SRS emphasizes volume reduction to manage newly generated liquid wastes. Volume reduction is performed using one of two evaporators with some ion exchange for dilute waste streams. There are four evaporators (two at each tank farm), but most volume reduction takes place in the H-Area, using single-stage evaporators that require three to four passes. There is a high cesium decontamination factor, and volume is reduced three or four times. .

A new evaporator is planned with twice the capacity of the existing evaporator. The design is much simpler and less prone to failure. There will not be a need 'to make multiple passes, which will minimize the amount of pumping. It will run at 75% attainment with full canyon production. It is about twice the size of existing evaporators with a 30-year versus a 10-year tube design life. The current startup date is September 2000.

The SRS remediation strategy is illustrated in Figure A.2. The site has extensive facilities for the treatment, storage, and disposal of tank wastes. There are four processes to pretreat waste prior to vitrification: waste removal, extended sludge processing, in-tank precipitation, and late wash, as described below.

- During waste removal, salt and sludge are agitated in water using 7,600-L/m (2,000-gal/min) slurry pumps. A saturated supernate is produced and transferred to in-tank precipitation for removal of radionuclides.

- Sludge from the HLW storage tanks is transferred to a tank at the extended sludge processing facility, and the aluminum concentration in the sludge is reduced. The waste is mixed with caustic and washed. The sludge becomes feed to the DWPF.

- During in-tank precipitation, dissolved salt from the waste removal process is treated with sodium titanate and sodium tetraphenylborate. The slurry is filtered in a sintered metal filter, and a concentrated precipitate is produced. The concentrated precipitate is stored in a waste tank, and corrosion inhibitors are added as needed. The filtrate is stripped of benzene and converted to saltstone grout.

- During late wash, the nitrite is removed from the concentrated precipitate. The concentrated precipitate is then sent to the DWPF for conversion to glass.

The grout is pumped to disposal vaults where it will harden into a permanent waste form. The HLW will be treated in the DWPF. Storage will be provided for waste vitrified in the DWPF in a glass storage building that will be able to provide up to 10 years of interim storage. No permanent disposal for HLW will be provided at the site. HLW will be shipped offsite for permanent disposal (WSRC 1995).

A.1.4.5 SRS System Closure

The SRS closure strategy has not been finalized. After removal from service, all wastes, tank structures, and underlying soils must be treated, decontaminated, or removed from the site. The waste tanks will be closed as state-regulated wastewater treatment units. Saltstone grout is pumped to aboveground concrete vaults and solidified. Once filled, the vaults are capped with weatherproof concrete. Final closure involves covering the vaults with a clay cap and backfilling the earth. Because the SRS is located near populated areas, the environmental restoration goal is to have all land and groundwater near the perimeter of the site permitted for unrestricted use (DOE 1995c). This may impact closure requirements for tank farm areas.

A.1.4.6 SRS Costs and Schedule

The total system cost for SRS is estimated to be about $11 billion in unescalated constant 1995 dollars. The distribution of costs by waste management activity and the associated schedule are provided in Tables A.8 and A.9.

Table A.8. SRS System Costs[a]

Needs Breakdown Structure[b]	Waste Management Activity	Estimated Cost ($M)[c]
Manage Tank Wastes	F- and H-Area tank farm operations	2,552
	Tank farm upgrades	210
Process Waste	DWPF	3,983
	Glass waste storage building	105
	HLW removal project	618
	In-tank precipitation	1,411
	ITP/benzene abatement	15
	Saltstone	322
	Saltstone vaults HLW disposal	147
System Closure	HLW disposal	1,505
Total		10.868

(a) DOE 1995c (pp. SC12 and SC19). Based on a finish date of FY21. SRS budget cuts are resulting in extreme schedule delays to FY65. The life cycle is now estimated to be closer to $26.5 billion.
(b) BEMR waste management activities are mapped to the TFA NBS level. This mapping is not exact. See Section 3 of this MYPP for information on the NBS.
(c) Constant 1995 dollars.

Table A.9. SRS Major Milestones[a]

Milestone Title	Completion Date
Start operation of DWPF	1996
Complete DWPF activities	**2065**
Begin ITP operations	1995
Complete saltstone vault HLW activities	**2065**
Complete HLW management activities	**2065**

A.2 System Risks

The **TFA** seeks to develop a risk-based portfolio of technology development activities. Three types of system risks are of concern:

- technical risks - risks that jeopardize current technical baselines or technical performance requirements.
- programmatic risks - risks that jeopardize existing regulatory agreements and schedules, including advisory or stakeholder demands that are not formalized in current baseline plans but require site responses.
- environmental, safety, and health (ES&H) risks - risks to involved workers, noninvolved onsite workers, the public, or the environment. These risks result from direct exposure from contaminated air or groundwater.

A complete assessment of these three types of risk is not available. However, the parameters for analyzing these risks are provided in Table A.10. Five types of parameters are evaluated:

- groundwater/public - The risk from groundwater contamination is primarily long term and to the public, because groundwater contamination does not occur for many years after the original spill or leak. Groundwater contamination is a function of the transport characteristics of the soil below the tanks, the depth to the water table, the amount of release, and the type of release. This risk is estimated as the number of incremental cancer fatalities.
- air/noninvolved onsite worker and public - The risk from atmospheric dispersion of radioactive and chemical contamination is near term and results from routine stack releases, disturbance of contaminated soils, and accidental releases. The risk is to noninvolved onsite workers and the public. This risk is a function of the amount of release, the type of release, and the amount of atmospheric dispersion. This risk is often estimated as the number of incremental cancer fatalities.

Table A.10. Summary of Risk Evaluation Parameters for Hanford, INEL, Oak Ridge, and SRS Tanks[a,b]

Risk Parameters	Sites			
	Hanford	INEL	*Oak* Ridge	SRS
Groundwater/Public				
No. of tanks	177	11 tanks 7 calcine solids storage facility	56 inactive tanks 13 active tanks 27 collection tanks	51
Vol. of tank waste (million Umillion gal)	232160	6.8/1.8 liquid waste 3.83811 calcined	1.8610.49 legacy 1.510.4 active (per year)	126/33
No. of past leaking tanks	67	Not applicable	1	11[c]
Total curies (MCi)	104 (SSTs) 73 (DSTs) 168 (cesium and strontium capsules)	7 to 8 in tanks 59 in calcine solids storage facility	0.13 legacy 0.034 active	367
Vol. of leaks (million L/gal)	2.85/750,000	Minimal	Minimal	Minimal
Depth to water table (m/ft)	791260	1501450	0.3 to 20.411 to 67	401130
Annual precipitation (cm/in.)	1616.3	2218.7	130.9/51.5	122/48
Potential groundwater use	Drinking water; imgation	Drinking water; imgation	Drinking water	Drinking water
Safety concerns	54 "Watch List" tanks	Potential for heel	None	None
Average wind speed (m/s;mph)	3.6/7.9	3.4/7.5	2.1/4.7	3.8/8.5
Prevailing wind direction (wind blows from this direction)	WNW	W	WSW	NE
Nearby population (80-km radius)	370,000	·250,000	510,000	460,000
Onsite population	11,000	8,000	16,000	20,000

Table A.10. (contd)

Risk Parameters	Sites			
	Hanford	**INEL**	***Oak Ridge***	**SRS**
No. of proposed remediation workers (FTE)	1,000	Not applicable	Not applicable	Not applicable
Cost ($ billion)	42	4.7	1.2	11
Schedule	2028	2050	2045	2065
Status of technology	Unproven	Unproven	Unproven	Unproven
Scale of effort	Large	Medium	Small	Large

- involved worker - The involved worker is subject to incidental cancer risk due to occupational exposure to hazardous chemicals or radiation resulting from tank waste remediation activities. The involved worker can also be injured in an accident. The risk is a function of the number of workers and the amount of exposure. The risk is estimated as the number of worker fatalities (either injuries or cancer).

- programmatic - This risk depends on the flexibility of the existing Federal Facility Compliance Agreement (FFCA), the amount and radioactivity of the waste to be treated. and amount of time provided to reach the FFCA milestones. The risk is estimated in terms of cost or schedule variance.

- technical - These risks arise from functional uncertainties in site tank remediation baselines (e.g., most sites are uncertain about whether the feed to immobilization can be analyzed to determine if it meets requirements without causing bottlenecks in processing). This risk is a function of the technical complexity of the baseline and the extent to which baseline technologies have been proven. The risk is estimated as probability of success.

These risks are briefly analyzed for each of the four sites in the following sections.

A.2.1 Hanford Site Risks

Hanford is facing significant uncertainties due to the technical complexity of the baseline, the volumes of radioactive materials involved, and the high cost of cleanup. These uncertainties are discussed below in three major areas: technical, programmatic, and health and safety.

A.2.1.1 Hanford Technical Risks

The Hanford baseline is technically complex and based on a number of unproven technologies for the breadth and scale of the remediation tank (e.g., past practice sluicing, removal processes for cesium and other radionuclides, large-scale melters to produce LLW glass). In addition, the baseline is dependent on the construction of a geologic waste repository. In reality, there may not be a repository. The considerable uncertainties in the Hanford technical baseline make it necessary to 1) develop and demonstrate baseline technologies and 2) continue to develop realistic alternatives to the baseline that are less complex and lower cost.

A.2.1.2 Hanford Programmatic Risks

The TPA (Ecology et al. 1994) states that cleanup of the tanks must be completed by 2029. With proposed federal budget cuts, it is unlikely that this schedule can be met. With the exception of mitigation of Watch List tanks, the potential outcome will be to extend schedules and dramatically reduce budgets. The current situation is very challenging because considerable and intense technology development is required to meet current baseline and schedules (especially for sampling and retrieval of the waste).

In addition, the DNFSB has placed a high priority on the need to sample and analyze Hanford tank wastes. Safety-related sampling and analysis is to be completed by July 1995 and other tanks by July 1996. Technology is needed to downsize the sampling campaigns at Hanford and meet the schedules as laid out in Recommendation 93-5 (DOE 1994b).

A.2.1.3 Hanford Health and Safety Risks

Risks to the involved worker are due to construction of TWRS facilities, operational accidents, and direct exposure to radiation in the work environment. Worker risk is best controlled by minimizing construction and operational labor requirements and minimizing worker exposure to the waste. Hanford ex-situ treatment alternatives currently have significant labor requirements and, hence, significant worker risk.

Risks to the onsite worker result from emissions from the tank farms during storage management (e.g., flammable gas events, toxic vapor events, and volatile organic compounds from tank ventilation systems) and from off-gases released during waste retrieval, evaporation, and treatment. The plan is to use high-efficiency particulate air (HEPA) filters and afterburners to control off-gases, but releases of radioactive gases and air toxics are still of potential concern. Technology to monitor and control air emissions from the tank farms and TWRS process facilities is important.

Long-term risk to the public is primarily from migration of tank residuals to the vadose zone and the groundwater. Soil and groundwater below the tanks are already contaminated from tank leaks. There may be little benefit from improving the stability of the final waste form or removing tank residual if existing contamination is not removed or stabilized to prevent further transport. Tank closure criteria and strategies are needed based on realistic end states.

A.2.2 INEL Risks

Much of the current risk at INEL is programmatic because the technologies have not been selected for pretreatment or immobilization of wastes. Technical risks cannot be finalized until regulatory agreements are in place that define the remediation strategy. In the interim, much of the HLW is stabilized as calcine, which reduces near-term health and safety risks. INEL risks are discussed in the following sections.

A.2.2.1 INEL Technical Risks

At this time, INEL has a proposed strategy to remove, process, and immobilize liquid HLW and calcine. Technical risks for the proposed strategy include the following.

- There are uncertainties associated with partitioning of radionuclides from acidic liquid feeds (liquid waste and dissolved calcine) and subsequent immobilization of the HAW and LAW streams.

- Final waste acceptance criteria are not yet available for the LLW grout. The final HLW form must meet applicable requirements for HLW storage and disposal. Immobilization equipment and waste form immobilization testing is required.

- The ICPP must retrieve calcined waste from stainless steel bins. Key challenges to remediating calcine wastes are limited working space, high radiation levels, and the need for cost-effective technology to decontaminate the bins after calcine removal.

- INEL is striving for a June 1995 decision on pretreatment technology selection for sodium-bearing liquid wastes. Proving the feasibility of the separation of sodium from the waste is important to that decision.

A.2.2.2 INEL Programmatic Risks

INEL is struggling to meet regulatory requirements to cease use of a number of existing tanks. The plan is for requirements to empty existing tanks to be met with waste minimization and calciner campaigns. Delays in conducting calciner campaigns are affecting tank capacities. Calcine campaigns need to begin as scheduled, or new tank capacity will be required (Palmer et al. 1994).

Based on DOE's future funding projections, the costs for proposed INEL treatment facilities will exceed available funding. This will delay schedules or result in changes to the baseline. Also, technologies for treating sodium-bearing wastes and HLW calcine are not selected, which imposes additional uncertainties on costs, schedules, and technology development needs.

A.2.2.3 INEL Health and Safety Risks

INEL does not withdraw or use surface water for site operations nor does it discharge effluents to the natural surface water. However, the Snake River Plane aquifer below INEL is a sole source aquifer (DOE 1995a, App. B). Long-term risk to the public is possible from migration of tank residuals or tank leaks to the groundwater.

There is a potential for near-term ES&H risks if flammable gas generation occurs in the tank heels. This risk must be investigated by better characterizing the tank heels, which is not feasible using available technology.

There is a seismic issue within bin set 1. There is an overstress on the vault walls. The likelihood of failure is unknown.

A.2.3 Oak Ridge Site Risks

Oak Ridge's tanks are low activity, which reduces risks and makes Oak Ridge a desirable location for prototype testing and treatability studies, Risks are discussed briefly in the following sections.

A.2.3.1 *Oak* Ridge Technical Risks

Technical risks at Oak Ridge involve the following:

- uncertainties associated with tank and waste characterization to support remediation decisions and regulatory drivers
- bulk sludge retrieval
- cesium, strontium, technetium, and TRU separations for supernate, sludges, newly generated waste, and source treatment
- ambiguous tank closure requirements strategies (Robinson 1995).

The relative importance of these technical risks depends on whether waste is treated and disposed onsite or shipped offsite for treatment and disposal.

A.2.3.2 *Oak* Ridge Programmatic Risks

A strategy for remediating inactive tank wastes at *Oak* Ridge has not been developed to date, which introduces programmatic risk. In addition, alternate treatment strategies are being emphasized at Oak

Ridge in response to substantial reductions in DOE budgets. Particular emphasis is being placed on modifying and using existing facilities whenever possible, instead of constructing new facilities. Commercial treatment is being encouraged, and several proof-of-process awards are being negotiated. The results of proof-of-process tests will guide technology development needs.

A.2.3.3 *Oak* Ridge Health and Safety Risks

Surface water is the main source of potable water supplies at Oak Ridge. Water quality in the Clinch River is affected by Oak Ridge activities. The Clinch River supplies most of the water to the site, the city of Oak Ridge, and other cities along the river. The fact that water resources are used by the public makes secondary containment, leak detection, and water balance monitoring very important (DOE 1995a, App. F).

A.2.4 SRS Risks

Tank retrieval has been initiated, and process development is well underway. There are a number of risks that must be addressed; these risks are discussed in the following sections.

A.2.4.1 SRS Technical Risks

SRS's primary interest is to enhance baseline technology or to develop alternatives to .the baseline in a number of areas, including:

- improved tank instrumentation and inspection devices
- in situ waste characterization
- improved slurry pumps and mixing techniques
- ion-exchange equipment and new resins
- methods to reduce sludge settling and compaction during retrieval
- DWPF analytical methods
- recycle stream treatment
- stirred melter development
- saltstone process instrumentation
- ventilation system monitors and instrumentation (Schwenker 1994).

None of the DOE sites has established the criteria for "How Clean is Clean."

A.2.4.2 SRS Programmatic Risks

The 2H Evaporator has seven salt receipt tanks, six of which are full. The 2H Evaporator has two salt receipt tanks with about one quarter of one tank of space remaining. The 2H Evaporator system is of concern because of the small amount of salt space remaining and because it is needed to evaporate the future DWPF recycle stream. Five years of downtime are projected for the 2H Evaporator due to the saltbound condition. Also, it is difficult to measure the actual volume of saltcake in a tank due to the way the salt forms. The only planned method to remove salt depends on the startup of In-Tank Precipitation, which is experiencing delays.

Aging facilities may cause excessive unplanned downtime, addition of unplanned scope to existing projects, or the need for new projects to ensure that the tank farm infrastructure will be able to support the HLW program. Current funding levels of the HLW system do not include any contingency for emergent work, although emergent work items are sure to occur. There has been a lack of funding and schedule contingency plans that is likely to cause cost overruns and schedule delays.

Nearly one billion dollars of projected funding has been removed from the HLW program in the last 2 years. To balance these reductions, the duration of the HLW program has been extended.

A.2.4.3 SRS Health and *Safety* Risks

Groundwater contamination is a concern because the aquifer below the SRS is at an average depth of 30 ft to 40 ft below the surface. Reportedly, several of the tanks are in the groundwater table during some periods of the year. This is not of immediate concern because the drinking water is from a deeper aquifer several hundred feet below the site. However, contamination in the shallow aquifer can move vertically toward deeper aquifers or horizontally toward the river.

A.3 Summary of Risks Addressed by TFA Technical Elements

The risks addressed by the recommended TFA technical elements are shown in Table A. 11. The rationale for each of these risks is provided below in Section A.3.1. This rationale has been extracted from the technical element descriptions provided in Appendix B of this MYPP.

A.3.1 Discussion

The risks addressed by the TFA technical elements are discussed below. The text provides the technical element title and a discussion of the risk reduction impacts indicated in Table A. 11.

Technical Element Title: Tank Leak Detection and Monitoring
ES&H Groundwater: Tank, annulus, and piping inspection technologies will determine potential leaks and corrosion will reduce the risk of environmental impacts from leaks.
Cost: Use of these technologies will save millions of dollars in leak mitigation or cleanup, and prevent retrieval system failures and operational downtime.

Table A.11. Risks Addressed by TFA Technical Elements

Technical Element	Risk Reduction Impact			
	Technical	Program	ES&H	Cost
Tank Leak Detection and Monitoring			Primary	Secondary
Advanced Hot Cell Analytical Technology		Primary		Secondary
In Situ Characterization			Secondary	Primary
Process Monitoring and Control	Primary			Secondary
Sampling - Waste and Tank			Primary	
Deployment Systems	Primary			Secondary
Enhancements to Present Retrieval Processes	Primary			Secondary
Retrieval Process Development	Secondary	Primary		Secondary
Acidic Cs/Sr/TRU/Tc Removal	Primary			Secondary
Alkaline Cs Removal	Primary			Secondary
Alkaline Sr/TRU/Tc Removal	Secondary		Secondary	Primary
Caustic Recycle	Secondary			Primary
Manage Process Effluents				Primary
Sludge Wash/Caustic Leach		Secondary		Primary
Solid-Liquid Separations Test Equipment Development and Transfer	Secondary	Secondary		Secondary
Waste Concentration/Water Balance		Secondary		Primary
Form for Immobilization of LLW		Primary		
Melter Selection	Primary			
Vitrification of Ion-Exchange Resins			Secondary	Primary
Consolidation of Glass Process Controls Development	Secondary			Primary
Focused Facilities and Processes		Primary		Secondary
Waste Retrieval and Tank Closure Demonstration	Primary	Secondary		Secondary

Legend: Primary Impact (dark shading)

Secondary Impact (light shading)

Technical Element Title: Advanced Hot Cell Analytical Technology
Program: Development of remote analytical scanning technologies will reduce the time to characterize extruded cores from tank wastes and provide better data than current methods on the variability of waste within a core (important for process planning).
Cost: Development of remote analytical scanning technologies will reduce the cost to characterize extruded cores from tank wastes.

Technical Element Title: In Situ Characterization
Program: In situ characterization reduces the need for coring.
ES&H Involved Worker: In situ characterization reduces personnel radiation exposure as compared to core sampling.
Cost: To retrieve one full-length core from tank waste at Hanford can cost up to $400K. The average cost to conduct a complete suite of physical and chemical analyses on the core is about $350K and can take up to 200 days to complete.

Technical Element Title: Process Monitoring and Control
Technical: Several of these technologies are critical to the DWPF. In support of the DWPF, no known acceptable on-line method exists for direct chemical measurement of the slurry feed and no method has been developed for direct measurement of the glass viscosity at high temperature.
Cost: On-line real-time analyzers and sensors reduce costs by ensuring the quality of the final waste forms.

Technical Element Title: Sampling - Waste and Tank
Program: This technology is needed to meet DNFSB and FFA requirements.
ES&H: Current waste sampling techniques are less than adequate to properly sample and characterize tanks to support retrieval. This task develops technology to obtain samples from multiple positions within the tanks to obtain sludge samples and to provide in situ concrete samples for Oak Ridge gunite tanks.

Technical Element Title: Deployment Systems
Technical: A multilocation deployment system for inspection, characterization, and retrieval will provide data on tanks and tank waste not currently available and will facilitate removal of hard-to-retrieve tank heels.
Cost: A multilocation deployment system will reduce the costs as compared to core sampling.

Technical Element Title: Enhancements to Present Retrieval Processes
Technical: All sites experience some difficulties using past practice hydraulic mobilization processes. This task evaluates and develops alternate mobilization technologies that eliminate or reduce the number of mixer pumps and enhances sluicing technologies to reduce water volume and effectively mobilize all kinds of waste forms (supernatant, sludge, saltcake, and heels).
Cost: A reduction in the amount of water usage and improvements in mobilization can significantly reduce the remediation schedule. A significant reduction in water usage during retrieval will save millions of dollars in downstream processing equipment costs and waste processing. Improved systems save money by eliminating the need to use alternate heel removal technologies.

Technical Element Title: Retrieval Process Development

Technical: Most sites acknowledge that the entire contents of the tank cannot be removed using past practices. This task develops prototype pneumatic or hydraulic end effectors for removal of tank heels and hardware from tanks.

Program: Removal and closure requirements, often anticipated and not formally stated, drive the development of arm-based and/or vehicle-based retrieval systems for heel removal and tank annulus waste removal.

Cost: The use of inexpensive confined sluicing systems could save millions of dollars spent trying to remove waste heels.

Technical Element Title: Acidic Cs/Sr/TRU/Tc Removal

Technical: Acidic cesium, strontium, technetium, and TRU removal will be necessary to permit the INEL supernate to be processed, immobilized, and disposed of as a Class A LLW.

Cost: The removal of radionuclides will permit the decontaminated supernate to be immobilized and disposed of as LLW instead of HLW. At Hanford, the cost to process, immobilize, and store HLW is about 25 times greater than that for LLW.

Technical Element Title: Alkaline **Cs** Removal

Technical: Failure to remove cesium will result in a LLW that does not meet criteria (e.g., Class C), requiring handling and disposal as HLW.

Cost: Cesium removal permits the decontaminated supernate to be subsequently treated, immobilized, and disposed of as LLW instead of HLW. Cesium removal will lower processing and repository costs. At Hanford, the cost to process, immobilize, and store HLW glass is about 25 times greater than for LLW glass. At Oak Ridge, the cesiumdecontaminated LLW can be shipped offsite, which will save about $50 million.

Technical Element Title: Alkaline Sr/TRU/Tc Removal

Technical: At Hanford, the level of TRU in complexant concentrate waste is too high for Class C waste. Cesium and TRU removal of complexant concentrate waste will permit the cesium and decontaminated supernate to be subsequently treated, immobilized, and disposed of as Class A LLW.

ES&H Groundwater: Technetium removal from supernate is potentially important due to its long half-life and mobility.

ES&H Involved Worker: Strontium and TRU removal is not necessary but would improve worker safety.

Cost: The cost of complexant concentrate waste as HLW instead of LLW adds ~$10.5 billion to overall costs at Hanford alone.

Technical Element Title: Caustic Recycle

Technical: There is no technology to allow caustic to be cleaned release in current baselines.

Cost: Significant sodium hydroxide must be added to sluice sludges and to leach the sludge. It is estimated that this sodium hydroxide can increase the volume of the LLW by 18%, based on the Hanford baseline. Approximately $1.4 billion will be saved at Hanford alone if salt-splitting can be used to regenerate the caustic.

Technical Element Title: Manage Process Effluents
Cost: Processing tank waste generates large amounts of liquid, solid, and gaseous effluent that must be treated. This task will develop requirements for treatment of secondary wastes, with the goal of free release of material. Free release is much less costly than regulated LLW disposal of secondary wastes.

Technical Element Title: Sludge Wash/Caustic Leach
Program: The removal of inerts such as aluminum, phosphate, chromium, and sodium from sludge reduces the amount of HLW to be processed and stored in the HLW repository.
Cost: At Hanford, the cost to process, immobilize, and store HLW glass is about 25 times greater than that for LLW glass. The cost of HLW addition if cesium is not removed is about $4.3 billion; cost of not removing aluminum is greater than $4 billion.

Technical Element Title: Solid-Liquid Separations Test Equipment Development and Transfer
Technical: Colloidal materials and small particles must be removed from the supernate or there will be downstream processing problems.
Program: Failure to remove particulates will result in LLW that does not meet criteria (e.g., Class C), requiring handling and disposal as HLW. Removing particulates reduces the activity of the waste to allow hands-on processing, maintenance, and disposal.
Cost: HLW costs are generally considered to be about 25 times higher than LLW costs. Baseline costs for HLW are about $4 billion. Not removing solids from 10% of LLW would result in HLW costs of about $20 billion based on the Hanford baseline. Failure to remove particulates will greatly lower the life of processing operations such as ionexchange, which will increase the amount of ion-exchange waste generated and decrease the throughput rate. Remote operations are also much more costly.

Technical Element Title: Waste Concentration/Water Balance
Program: Retrieval and pretreatment add large amounts of water to the retrieved waste that must be evaporated. It is a program goal to reduce water additions and reuse water whenever possible.
Cost: Concentrating feed for pretreatment and for immobilization allows pretreatment and immobilization processing and off-gas equipment to be smaller, thereby reducing costs.

Technical Element Title: Form for Immobilization of LLW
Program: If budgets are available for the more expensive LLW form planned at Hanford, or if stakeholders and regulators require a different waste form than that planned at other sites, comparative data will be needed to negotiate new baselines.

Technical Element Title: Melter Selection
Technical: Continuous emissions monitoring instrumentation will provide data for the melter selection process (e.g., information on effects of changing operating conditions, process modes, wider range of chemical species than other methods).

Technical Element Title: Vitrification of Ion-Exchange Resins
Cost: By converting this material to glass, the costs of developing storage and monitoring capability will be avoided.

Technical Element Title: Consolidation of Glass Process Controls Development
Technical: SRS is validating its process control approach and software systems as part of its Waste Qualification Runs. This technology is an enhancement to system-wide tank remediation.
Cost: Hanford is in the process of duplicating this system. INEL has also identified that they intend to perform the same activities. By the time the DWPF has finished qualification of its vitrification process control system, over $35 million will have been spent for development, verification, validation, review, and testing. This initiative saves at least ***$60*** million of the costs necessary to develop virtually identical systems for Hanford and INEL.

Technical Element Title: Focused Facilities and Processes
Program: The use of smaller, lessexpensive vitrification facilities devoted to handling one or a few specific waste types may allow earlier immobilization of waste than a "one-size-fits-all" facility such as the DWPF.
Cost: Downsizing could allow design and construction to be undertaken with much less contingency because the waste to be immobilized would not present the full range of problems associated with immobilizing all of the waste at once. This factor alone could represent savings of tens of millions of dollars (e.g., contingencies built into the DWPF design funding amounted to about 35% of the **$2** billion+ project cost).

Technical Element Title: Waste Retrieval and **Tank** Closure Demonstration
Technical: The current **DOE** tanks program has shown itself to be slow, expensive, and unlikely to successfully clean out the tanks. This initiative will provide rapid lessons learned to the system on how to achieve tank closure.

A.3.2 Observations

Table A. 11 presents a snapshot of the "risk portfolio" for the TFA. Most of the TFA program addresses technical risks because, by definition, it is responsive to high-priority near-term needs identified by the site users. Programmatic risk is the secondary driver, reflecting concern by both the user and the TFA over the cost of remediation by site baselines and, less ***so,*** over anticipated or current regulatory requirements not met by current baselines. Technical elements address ES&H risks to a lesser degree (i.e., tank integrity and inspection to control leaks to soil and groundwater). As ES&H analyses are performed for tank remediation systems at the four sites and if ES&H risk becomes a more critical driver of site plans, it is likely that technical elements to target ES&H risks will emerge.

A.4 Stakeholder Involvement and Issues

The TFA technology development program **seeks** to reflect the issues and concerns of stakeholders, including regulators and technology users at each **of** the sites. The TFA's objective is to work with the site stakeholders in the evaluation of tank technologies considered for funding and deployment and to ensure that tests and demonstrations address stakeholders' and regulators' concerns. EM has established Site Technology Coordination Groups (STCGs) to facilitate this process. Site-Specific Advisory Boards (SSABs) are the primary DOE forum for sitewide stakeholder involvement. The

TFA Implementation Team will work with stakeholders through the STCGs, SSABs, and Community Leaders Network. The Community Leaders Network and tanks subcommittees of the STCGs provide a network with which the TFA could work to involve stakeholders in tanks technology development.

The following section describe TFA plans for stakeholder involvement at each of the sites and a preliminary discussion of issues to be addressed.

A.4.1 Hanford

The Hanford STCG has two levels: the management council and four subgroups affiliated with the five national focus areas. The tanks subgroup could provide a direct way for the TFA to work with the STCG and stakeholders in evaluating tanks technology. Four of the tanks subgroup's six members are stakeholders. In addition, three stakeholders—members of the Hanford Advisory Board—serve on the STCG's management council as does a representative of the TWRS program.

To an extent probably greater than at any of the other tanks sites, the Hanford STCG has the ability to represent stakeholders' views and concerns. Stakeholders—in this case regulators, representatives of environmental and public interest groups, and Native American tribes—serve on the STCG management council as well as on the tanks subgroup. The organization and membership of the Hanford STCG facilitate the TFA working with this group to evaluate the effectiveness and acceptability of proposed technologies. In addition, many of the members of the Hanford STCG participated in the Volatile Organic Compound - Arid Integrated Demonstration stakeholder involvement program and thus have experience with and interest in technology evaluation.

Finally, several members of the Hanford STCG and Advisory Board also serve on the Community Leaders Network Tanks subcommittee. These individuals constitute a network of knowledgeable stakeholders with which the sites and TFA can work to contribute to a successful technology development program.

Hanford stakeholders are very concerned with tank safety. They are concerned that cleanup proceed more quickly and that dollars be allocated to areas of the greatest need, including the remediation of tank waste. Stakeholders support prioritizing tank problems, so that limited dollars are spent wisely.

A.4.2 INEL

The STCG at INEL has been incorporated into the Environmental Management Integration Team. One member of the EM Integration Team serves as liaison with the INEL tanks program. Another member is the team's link with the INEL SSAB.

Preliminary information indicates that INEL stakeholders want waste treatment to progress using the best-available technology. INEL is focusing on technology development for treating HLW calcine wastes, i.e., getting these wastes into a form for near- and mid-term storage (approximately 50 years). Areas of greatest risk should be addressed first. They are particularly concerned with protecting the Snake River Aquifer. Stakeholders do not want INEL to become a permanent waste repository. Waste treatment technology should be cost-effective, and privatization should be considered when appropriate. Plans for site treatment should be risk driven, based on the quantity of waste, its physical characteristics, its radioactivity, and subsequent risks to workers, the public, groundwater, and air quality.

A.4.3 Oak Ridge

The Oak Ridge STCG consists of a policy-making group and six subgroups, each affiliated with a particular focus area including tanks. A principal focus of the STCG's activity has been to develop a comprehensive needs assessment for the site. The tanks subgroup is assessing and ranking needs in its area of concern. The heads of the subgroups and the STCG coordinator are developing methods and criteria for ranking needs across the subgroups.

In terms of stakeholder involvement in sitewide issues in general and tanks issues in particular, a Site-Specific Advisory Board for the site has not yet been convened. A Local Oversight Committee was set up by the state of Tennessee and the site and established a Citizens Advisory Board of about 20 people. This board is a potential point of contact for understanding stakeholder concerns as well as the site's community relations contractor and the site public participation coordinator.

Oak Ridge stakeholders are concerned with tank integrity, final disposition of tank waste, and remediation cost and schedules. Tank integrity must be ensured to prevent both catastrophic failure and slow leakage into the soil and groundwater. Stakeholders want DOE to select an ultimate disposal site for tank waste and to define waste acceptance criteria so that Oak Ridge waste can be sent for disposal. Finally, Oak Ridge stakeholders want cleanup to progress within a reasonable timeframe and at reasonable costs.

A.4.4 SRS

The primary goal of **SRS's** STCG is to implement needed technologies and to save time and money in the process. The SRS STCG sees its role as providing information on site problems and needs to the focus area implementation teams. In December 1994, STCG members worked with the TFA Implementation Team to define HLW problems and needs at the site. The STCG has a HLW subgroup with responsibility for defining site technology needs. The subgroup is the STCG component with the closest affiliation with the TFA. One member of the STCG serves as TFA liaison.

STCG members point out that the site needs technologies implemented so that regulatory commitments can be kept. The focus areas need to bring forward these technologies. Meeting site needs, STCG members say, does not mean just doing a technology demonstration; it means implementing a technology quickly. The **STCG's** intent is not to deal with technology development separately but as part of the wider issues of site remediation and waste treatment.

The SRS SSAB is a forum for stakeholders. The SSAB has three issue-related subcommittees: Environmental Restoration, Risk Management and Future Use, and Nuclear Materials Management. The SSAB sets its own agenda and may or may not choose to get involved with issues of concern to the STCG.

SRS has identified a number of stakeholder issues of concern for HLW tanks. Many of the HLW tanks have exceeded their design life. Aging tanks must be monitored for leaks. Stakeholders would like to see the waste removed from the old tanks as quickly as possible. Once the tanks are emptied, stakeholders want to be assured that effective technologies for decontamination, decommissioning, and closure are available.

A.5 TFA Site Summary and Issues

Outstanding considerations regarding the TFA program's link to site needs are discussed in the following sections.

A.5.1 Hanford

TFA technologies that address important Hanford needs include the following:

- in situ characterization and advanced hot cell technology to reduce the time and cost to characterize the waste tanks
- retrieval process development technologies to enhance or replace past practice sluicing of sludges and tank heels
- solid-liquid separations to remove radioactive particulate from supernates
- alkaline strontium/technetium/TRU removal to allow more extensive separations of HLW from LLW to reduce HLW volume and LLW to Class A limits
- transfer of glass process control technology from SRS and Hanford.

A number of programmatic issues challenge the current baseline waste management strategy. The development of alternative technologies is very important because the current baseline is costly and relies on the construction of a HLW repository. The TFA supplements Hanford tank technology efforts by funding alternative waste removal and separations processes. However, there is little emphasis in either program on in situ treatment of tank wastes. With proposed DOE budget cuts, in situ treatment may be the only solution that can stabilize tanks wastes at dramatically reduced cost.

Hanford has not developed a final land use strategy. If several areas of the site are targeted for exclusive or restricted use, it may not be necessary to remove tank heels or contaminated soils around the tanks. Surface barriers or other options may be adequate. These land use issues make appropriate allocation of resources to site closure difficult to determine. Under the current Federal Facility Consent Agreement, tank closure is mandated, so that about 1% of the current waste volumes remains.

A.5.2 INEL

TFA is funding a number of technologies that address system risks at INEL,[a] including the following.

- Acidic cesium/strontium/technetium/TRU removal technologies are being funded to handle the acidic liquid waste in INEL tanks.
- A demonstration at Oak Ridge will produce LLW forms for subsequent testing.
- Tank leak detection and monitoring technology will help minimize tank leaks and avoid future groundwater contamination of the Snake River Aquifer as will TFA-funded technology to characterize and remove tank heels.

TFA is not funding technology to assist in decontaminating the HLW vaults or to separate sodium from the sodium-bearing liquid wastes. One reason is that these are site-specific needs, rather than complex-wide needs. However, these needs may warrant further consideration because they are important to stakeholders and would facilitate meeting regulatory requirements.

A.5.3 Oak Ridge

The TFA technology development program offers an excellent response to the needs at Oak Ridge and is addressing many of the technical risks at Oak Ridge. In addition, a number of tests are planned at Oak Ridge that should reduce technical risks for all sites. A cesium removal demonstration is planned for FY96-FY97 using a full-scale modular cesium ion-exchange processing unit. A full-scale subatmospheric mobile evaporator will undergo out-of-tank hot testing in FY95. The LDUA will be tested in gunite tank treatability studies, including retrieval and deployment of sampling end effectors.

Oak Ridge may be able to ship a substantial portion of the waste offsite for treatment. The need for technology development at Oak Ridge, if this option proves viable, may need to be examined. The transferability to other sites of technology that is demonstrated at Oak Ridge is of particular concern and efforts must be made to ensure that available MVST waste streams are supplemented with hot waste samples from other sites if the constituents of concern at those sites are not represented in the MVST stream. The TFA must also find ways to make larger volumes of hot waste available for full-scale demonstrations at other sites.

A.5.4 SRS

The TFA is addressing a number of the technical projects to enhance the baseline at SRS, including in situ waste characterization, process monitoring and control, glass process control, improved hydraulic waste removal techniques, technology to minimize secondary wastes, and tank integrity and inspection devices to minimize groundwater contamination. A tank closure demonstration will address the issue of how clean to leave the tanks.

(a) INEL's baseline is changing rapidly; therefore, the TFA response may need to be reassessed.

Effective technologies for decontamination, decommissioning, and closure are a high priority at this site, and TFA development efforts in this area will likely benefit all DOE sites.

A.6 Next Steps

The TFA is seeking to examine relative risks and costs across the complex to ensure that its program is addressing needs with the greatest risk and its solutions offer significant risk and cost reductions worthy of its investments. This requires data that are not currently available. Documentation is becoming available such as the TWRS EIS and the INEL sitewide EIS that contain quantitative information. The site-specific risk data sheets currently being validated are another source of future data. TFA will build on risk, cost, and environmental consequence information from these and other sources to compare risk across sites and to enhance cost-risk tradeoffs relevant to technology developments.

Additional stakeholder involvement is essential. Technology investment dollars are protected by involving stakeholders in the selection and evaluation of technology. Stakeholders can often point to innovative solutions or approaches that should be considered. The TFA will actively support site activities directed at involving stakeholders in technology demonstrations and deployment decisions.

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Appendix B - Technical Element Descriptions

The Tanks Focus Area (TFA) Technical Team defined a set of 22 technical elements that address the high-impact needs at the four tank sites: Hanford, Idaho National Engineering Laboratory (INEL), Oak Ridge, and Savannah River Site (SRS). These needs were determined from the needs assessment process, which is described in Section 3 of this document. These technical elements form the core of the TFA technical program and ensure that the program remains responsive to site needs, regardless of probable changes in site remediation baselines due to budget reductions, privatization. or changes in regulatory requirements and agreements. Together, the technical elements define a path forward to solve the fundamental remediation problems underlying specific site requests.

The TFA made a number of programmatic and technical assumptions about tank waste remediation when developing the technical elements, as described Table B.1. The technical elements were defined initially by the TFA Technical Team using the information from the needs assessment (TFA 1995) and in response to discussions with site users. Subsequent revisions and refinements reflect the input of the TFA-Technical Review Group (TFA-TRG) and ad hoc technical experts familiar with tank needs and technologies. Explicit criteria guiding technical element definition included the fundamental U.S. Department of Energy (DOE) objectives to reduce risks and costs.

The path forward for each element was also defined to minimize six constraints that typically undermine the success of technical activities:

- technical uncertainty
- stakeholder and regulatory acceptability
- schedule compatibility
- deployability (or "system fit")
- development cost
- application to changing baselines (alternative scenarios).

Each technical element was informally evaluated by the TFA Technical Team against these constraints to ensure that it represented a practical and potentially successful solution to site problems. The result of this evaluation indicated, for example, which technical elements promise cost reduction as their primary benefit and why (e.g., by minimizing secondary waste). More formal evaluation may be appropriate before defining specific tasks and scope for each element. The **TFA's** FY96 work plan will include more specific scope, schedule, and budget information on the technical elements.

Table B.l. Technical and Programmatic Assumptions for Site Baselines

Needs Breakdown Structure Reference	Technical and Programmatic Assumptions
Manage Tank Waste	Safe storage of waste in the tanks will remain the highest priority for DOE at all four tank sites (Hanford, INEL, Oak Ridge, and SRS) with respect to budget allocations and supporting technical activities.
	Because of changing missions, many future waste streams received by tanks will have different compositions than those from past operations. These streams will be generated from D&D activities and from processing legacy wastes including tank wastes. At Oak Ridge, currently generated LLW will differ in composition from past LLW because of source reduction.
	Adequate characterization of tanks to ensure tank integrity and of sludges and vapors to ensure safe conditions will be required. The DNFSB will act as the primary oversight body for safe operations.
	New tank farm construction will be minimized and will not be the primary means for increasing or maintaining tank capacity for newly generated tank wastes. Moreover, doubly contained tanks will be used to the maximum extent to meet RCRA and/or safety requirements.
Process Waste	Hanford may revisit its technical strategy to respond to constrained budgets. This approach may lead to renegotiation of the TPA; at this time, the TPA is the schedule driver and stakeholder input drives certain technical decisions.
	The NON consent order issued by the state of Idaho contains a "cease use" requirement for some of the ICPP tanks by 2009 and the remainder by 2015. The order serves as a schedule driver for technology development, process design, and facility construction. INEL can readily describe impacts of constrained budget and technology development delays on meeting the NON consent order with existing system analysis tools.
	Final waste forms at Oak Ridge are driven by offsite requirements at the Nevada Test Site for low-activity waste and at the WIPP for TRU waste.
	Constrained budgets would impact the proposed schedule for tank waste processing at SRS.
	Waste retrieval is a high cost component of waste processing. Mixer pump/jet technology forms the basis for supernatant/salt/sludge mobilization and is experiencing only partial success because of seal leakage and limited resuspension of solids. Past practice sluicing is the reference process for sludge removal at Hanford and Oak Ridge. It is considered slow and has significant downstream implications due to the large volume of liquid added to the tanks; there is also potential for leakage during its use in some tanks. Both practices are limited in the amount of removal, and a heel is left in the tank. Heel removal is costly; an exponential relationship exists between the fraction of heel removed and cost. Thus, part of the retrieval cost is driven by the determination of allowable heel, The retrieval sequence at SRS has been determined; the sequence at Hanford will likely change. Questions with regard to which tanks to sluice (or the need to sluice) and the use of barriers during sluicing in known leaking tanks are still being examined at Hanford. Retrieval of heels from gunite tanks at Oak Ridge will occur first across the complex. INEL will retrieve and process liquid and sludge waste before calcined wastes to meet cease use requirements. Heel removal may not be needed at INEL to meet cease use requirements; the extent of removal will be negotiated.

Table B.l. (contd)

Needs Breakdown Structure Reference	Technical and Programmatic Assumptions
Process Waste (contd)	Pretreatment process requirements are driven by the need to 1) remove certain constituents from the supernate streams to allow immobilization in unshielded facilities and contact-handled maintenance in low-level process facilities and 2) meet onsite disposal requirements. Pretreatment is also needed to reduce the volume of the final waste forms (and the cost for final waste form disposal). This is especially true for the HLW form, and methods to remove nonradioactive components are necessary. Hanford's current baseline assumes out-of-tank cesium (and possibly strontium, TRU, and technetium) removal. The baseline technology at SRS is in-tank precipitation to remove cesium, strontium, and TRU; an out-of-tank process is being explored as a backup. INEL is looking at an out-of-tank option for dum, strontium, and TRU removal from acidic streams. Oak Ridge plans to use an out-of-tank removal process. The cost for pretreatment is less than for retrieval and immobilization across the complex, but it is the step required to reduce cost for immobilization. Thus, it must be considered with a systems perspective when looking at cost reduction approaches.
	Immobilization costs are driven by requirements of the final waste forms for acceptance by, shipment to, and disposal at a repository (HLW) or for onsite disposal (LLW). The NRC will oversee immobilized-waste form classification/qualification and transportation requirements. NRC will be concerned with performance assessment of the waste form, process controls to meet 10 CFR 60.21, documentation from DOE's waste acceptance process, data from long-term testing, and data from in situ testing. At Hanford, immobilization costs are further driven by stakeholder concerns on retrievability of LLW forms and disposal system requirements. The other three sites have saltstone/grout baselines for LLW. Hanford has glass as a baseline for LLW but is reconsidering grout in a retrievable form. Inconsistencies in the final LLW form across the complex need to be addressed as do performance assessment methods and criteria that support waste form selection and LLW disposal system requirements.
	Characterization costs are dnven by both processing data needs and regulatory requirements. Some regulatory requirements such as the aggressive sampling schedule in 'Recommendations 93-5" (DOE 1994) at Hanford may be driving costs upward without increasing knowledge of tank waste inventory, process requirements, or safety needs. A characterization strategy (beyond DQOs) that includes collecting integrated data for safety, retrieval, and waste processing would provide a more cost–effective approach to characterization.
	The low-activity fraction of waste will be immobilized first throughout the complex, and the more costly high-activity waste processing will be deferred until later. This decision is driven by two factors: ease of retrieving and processing the low-activity waste (i.e., supematant and saltcake versus sludge) and the availability of disposal systems. HLW processing is generally being scheduled later because there is no HLW repository, retrieving high-activity sludges is difficult, and facility and operational costs are high.

Table B.l. (contd)

Needs Breakdown Structure Reference	Technical and Programmatic Assumptions
System Closure	System closure requirements drive processing costs and ultimately technology selection and development. These requirements need to be addressed now to reduce costs later.
	The baseline for LLW disposal at INEL and Oak Ridge is onsite storage prior to shipment to a LLW burial ground. The baseline for SRS and Hanford is onsite disposal of LLW.
	All HLW will be stored onsite until a repository is established.
	Tank closure requirements will allow in-place tank closure. Tank removal will be the exception rather than the norm at Hanford, INEL, and SRS, due to prohibitive costs. Oak Ridge must resolve in-leakage issues for inactive tanks to achieve closure.
	Administrative control of tank farm sites would be maintained indefinitely after closure.
	Active tanks are regulated under RCRA. Tanks and LLW disposal systems will be closed under CERCLA requirements, and closure decisions will be based on risk and cost at most sites. Hanford will be closed under RCRA requirements.
	Oak Ridge will be the first site to begin tank closure and hence can provide 'lessons learned" to other sites. Although the other sites will not close tanks for many years, initial determination of closure requirements is critical to define processing requirements.

B.1 Technical Elements

The 22 TFA technical elements are described on the following pages; together, these technical elements form the core of the TFA program. Each element includes the following sections: Title, Needs Breakdown Structure (NBS) Reference, Problem Statement, Path to Solution, Technical Issues, FY96-FY98 Scope, Benefits of Technology, Requested Budget, and Integrated Technical Activities. Table B.2 lists the technical elements; they are organized first by NBS reference and then alphabetically.

Table **B.2.** Technical Element List

Needs Breakdown Structure Reference	Technical Element	Page Number
Manage Tank Waste: Safely Store Wastes	Tank Leak Detection and Monitoring	B.6
Manage Tank Waste: Characterize Tank System	Advanced Hot Cell Analytical Technology (AHCAT)	B.9
	In Situ Characterization	B.11
	Process Monitoring and Control	B.14
	Sampling - Waste and Tank	B.17
Process Waste: Retrieve Wastes	Deployment Systems	B.19
	Enhancements to Present Retrieval Processes	B.22
	Retrieval Process Development	B.24
Process Waste: Pretreat Wastes	Acidic Cs/Sr/TRU/Tc Removal	B.27
	Alkaline Cs Removal	B.29
	Alkaline Sr/TRU/Tc Removal	B.32
	Caustic Recycle	B.35
	Manage Process Effluents	B.37
	Sludge Wash/Caustic Leach	B.39
	Solid-Liquid Separations Test Equipment Development and Transfer	B.41
	Waste Concentration/Water Balance	B.43
Process Waste: Select Waste Forms for LLW	Form for Immobilization of LLW	B.45
	Melter Selection	B.47
	Vitrification of Ion-Exchange Resins	B.49
Process Waste: Select Waste Form for HLW	Consolidation of Glass Process Controls Development	B.51
	Focused Facilities and Processes	B.53
System Closure: Determine Performance Criteria for Tank Facility Stabilization and Closure	Waste Retrieval and Tank Closure Demonstration	B.55

Technical Element Title: Tank Leak Detection and Monitoring

NBS: 1.1.2 Management Tank Waste: Safely Store Wastes

Problem Statement: Leak detection and monitoring (LDM) technologies need to be developed and validated in order to locate and quantify tank leaks during retrieval operations or to monitor closed tank sites. Available in-tank LDM technologies include level methods and materials balance data. During retrieval operations using past practice sluicing, these methods may have difficulty in detecting leaks because of large liquid volume additions to the tank, moving wastes in the tank, and "fogs" that exist due to past practice sluicing. Secondarily, present in-tank methods cannot identify, locate, and track any release plumes outside the tank.

During FY94, the Tank Waste Remediation System (TWRS) Retrieval Program at Hanford conducted a survey of potentially viable LDM technologies to address their emerging requirements. Electrical Resistance Tomography (ERT), which is based on creating an underground tomograph by measuring changes in soil conductivity (or resistance), was selected for a high-fidelity simulation test at the 200 East Area at Hanford. A two-thirds scale (50-ftdiameter) tank shell was built as an instrumented test bed for leak detection and monitoring; ERT used 16 bore holes of up to 35-ft deep as emplacements for the electrical probes. With ERT, single-point leaks from various locations in the tank could be detected to quantities as low as 150 gal, the leak located ± 15 ft, the migration direction of the plume and its direction defined, and test bed noise distinguished from actual leak returns.

This promising EM-50 technology needs to be demonstrated in a real tank farm with all manner of noise sources such as piping transfer lines, vaults, other tanks, and electrical equipment. The data from this test should validate the potential use of ERT in an actual tank farm and during retrieval operations. This validated technology could then allow LDM at Hanford and other tank sites, if needed.

Another major issue with this technology is the cost in an actual tank farm of inplacing the electrodes in bore holes. This issue may be resolved by using a cone penetrometer (CP) truck such as is already available at Hanford. This unit is capable of placing bore holes to depths of over 100 ft in the Hanford soil. This combination of ERT technology and inexpensive, rapid development will be evaluated during this demonstration for use throughout the complex.

Path to Solution:

- Form a joint TFA and site team to evaluate development issues, objectives, and outcomes of a validation demonstration of ERT on a site retrieval test.
- Evaluate the inplacement of bore holes and electrodes by CP unit.
- Prepare detailed project management plan to include costs to TFA and TWRS for ERT Validation Demonstration.
- Design ERT deployment.
- Demonstrate ability to rapidly and cheaply install ERT probes using CP method.
- Test ERT technique in cold facility at Hanford.
- Move from successful cold test to an actual HLW tank during retrieval.
- Deploy and baseline ERT at tank farm.
- Operate ERT LDM during selected tank demonstration.
- Evaluate test results; publish findings.

Technical Issues:

- Ability of the ERT system to detect and track leaks in an actual tank farm environment.
- Cost and acceptability of rapid and inexpensive CP inplacement techniques.
- Cost of this approach to LDM when applied at site scale.
- Development of requisite policy and programmatic protocols to use the information provided by such LDM technologies to the retrieval and tank farm operators.

FY96-FY98 Scope:

- Identify candidate HLW tanks for ERT demonstration. SRS and Hanford both plan to retrieve tank waste in FY97.
- Install plastic dry wells and ERT technology in cold test facility.
- Monitor for leaks during retrieval campaign.
- Validate the cost and rapidity of inplacement of ERT electrodes using a CP technique in cold tests.
- Baseline ERT to actual tank farm environment.
- Conduct ERT demonstration test on tank during retrieval operations.
- Develop protocols for use of LDM data during retrieval operations.

Benefits of Technology:

__x__ Reduce costs
__x__ Reduce risks

Explanation:

Reduce costs: Use of these technologies will help ensure that the proper retrieval techniques are used on tanks with potential leaks, potentially saving millions of dollars in leak mitigation or cleanup.

Reduce risks: Radiological risks can be reduced with the real-time availability of leak information.

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 (SK)
EM-30 Hanford	250	1,000	1,000	
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks	625	600	450	
EM-50 Crosscutting	300	270		
Total	1,175	1,870	1,450	

Integrated Technical Activities:

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford	Leak Detection and Monitoring	
EM-30 Savannah River		
EM-30 *Oak* Ridge		
EM-30 Idaho		
EM-40 *Oak* Ridge	Gunite Treatability Study	
EM-50 Tanks	SF-221203, Advanced Fiber-optic Spectroscopy for Inorganic Contaminants	
EM-50 Crosscutting	SF-241002. ERT for Subsurface Imaging	

NBS: 1.1.3 Manage Tank Wastes: Characterize Tank System

Problem Statement: Development of remote analytical scanning technologies is needed to reduce the cost and time to characterize extruded cores from tank wastes. The current baseline for characterization of sludges in the Hanford waste tanks would require that over 400 full-length core samples be obtained and analyzed in 19-in. segments over a 3-year time period. Current rebaselining exercises may result in a reduction of core analyses required per unit time. In either case, assembly-line remote core-scanning techniques are needed to increase laboratory capacity dedicated to tank waste analysis (e.g., FY95 TWRS budget for laboratory analysis of Hanford tank waste samples is about $40M, and the cost for a suite of chemical and physical analyses is about $350K for one full-length tank waste core).

Path to Solution: Complete the AHCAT program for Hanford HLW tank cores, which will develop, demonstrate, and deploy the laser ablation/mass spectrometer (LA/MS), near infrared (NIR) probe, Raman spectroscopy probe, and a beta/gamma probe for elemental, moisture, chemical, and beta/gamma analysis, respectively, into a routine hot cell application for scanning cores, as described below:

- Develop and implement LA/MS scanning for HLW elemental analysis:
  - 9/95 - Complete cold testing and design specification for hot cell application.
  - 9/96 - Set up and demonstrate LA/MS in hot cell on real tank waste.
  - 3/97 - Deploy LA/MS for routine elemental analysis.

- Develop and implement NIR scanning for HLW moisture analysis:
  - 7/95 - Establish system requirements and conceptual design for hot cell application.
  - 8/95 - Demonstrate quantitative moisture analysis on real tank waste.
  - 1/96 - Deploy NIR scanning in hot cell for routine moisture analysis.

- Develop and implement Raman spectroscopy scanning for HLW molecular analysis:
  - 9/95 - Complete function, requirements, and conceptual design for hot cell application.
  - 9/95 - Determine performance using 780-nm laser.
  - 9/96 - Set up and demonstrate Raman spectroscopy in hot cell.
  - 3/97 - Deploy Raman spectroscopy in hot cell for routine molecular analysis.

- Implement beta/gamma HLW scanning analysis:
  - 12/94 - Install beta/gamma scanning system in hot cell.
  - 9/95 - Complete training and implement for routine analysis in 222 S Hot Cell.
  - 9/96 - Integrate with other scanning analysis components.

Technical Issues:

- For LA/MS, representative sampling of solid samples with heterogeneous surfaces is still under development. Oxygen quenching of the argon plasma may require purging open samples with a blanket of argon.
- For Raman spectroscopy, the sensitivity, matrix interference, and number of compounds that can be identified with an optimized Raman probe remain to be determined.
- For NIR spectroscopy, accuracy, reproducibility, and matrix effect on moisture analysis remain to be determined.

FY96-FY98 Scope:

- Deploy core-scanning technologies for routine use in Hanford hot cells to reduce cost and time to characterize extruded cores from tank waste.

Benefits of Technology:

___ Reduce costs
_x_ Reduce risks

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	865	2,650	1,850	750
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks	350	1.310	1.000	450
EM-50 Crosscutting				
Total	1,215	3,960	2,850	1,200

Integrated Technical Activities:

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford	Develop and Implement LA/MS for Isotropic Analysis Develop and Implement Gamma Energy/ High-Energy Beta HLW Scanning Analysis Develop and Implement Raman Spectroscopy for HLW Molecular Analysis Develop and Implement NIR Spectroscopy for Moisture Analysis	
EM-30 Savannah River		
EM-30 Oak Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks	RL-452001, Laser Raman Spectroscopy for Hot Cell and In-Tank Measurement	
EM-50 Crosscutting		

NBS: 1.1.3 Manage Tank Waste: Characterize Tank System

Problem Statement: Retrieving one full-length core from tank waste can cost up to $400K. The average cost to conduct a complete suite of physical and chemical analyses on the core is about $350K and can take up to 200 days to complete. The planning basis for core retrieval in the Recommendation 93-5 implementation plan (DOE 1994) is to retrieve over 400 full-length waste tank cores at Hanford. Development of in situ sensors and deployment platforms is needed to provide rheology data to augment coring operations and, where possible, take the place of coring and hot cell analyses. In situ characterization would reduce costs, personnel radiation exposure, and generation of secondary radioactive waste streams from hot cell analyses.

Path to Solution:

- Complete Westinghouse Hanford Company (WHC) project and subcontract with Applied Research Associates to design and deliver CP truck and CP with standard rheology, temperature, and bottom sensor package. Delivery is scheduled for September 1996.
- Continue the EM-50 funded program to design and develop a prototype Raman probe for integration into the Applied Research Associates instrument package of the CP. The probe has the potential to detect and map major chemical components in the sludge such as nitrates, nitrites, ferrocyanides, and phosphates. This prototype will be delivered to Applied Research Associates by September 1995.
- Test and incorporate the Raman probe into the instrument and wire bundle of the CP with a goal of including it in the September 1996 delivery to WHC.
- During FY96, field test the durability of the Raman probe optical window to metal seal in the CP under pressure (up to 35-ton push force) and separately test the window and seal durability in caustic solutions and high gamma radiation.
- Field test Raman probe for CP application.
- Begin use of prototype CP technology in FY97 for actual tank waste characterization studies. Based on results, make modifications to instrument package design in second-generation module via Applied Research Associates subcontract in outyears.
- Apply lessons learned from the Raman probe studies and prototype CP field applications to light-duty utility arm (LDUA) applications for characterizing the top layers of tank waste sludges over large surface areas to map upper horizontal chemical profiles.
- In FY96, fabricate an LDUA-deployed physical properties end effector based on Sandia's minilab design and deploy in FY97 in tank at INEL.

Technical Issues:

- It is unknown if the CP platform, which is being designed for a 35-ton push capacity, will have sufficient force to penetrate sludge layers in all of the tanks.
- The CP platform can only be deployed in the tank waste volumes directly under risers.
- The depth to which LDUA sensor packages can penetrate the surface layer of hard sludges will be limited by the relatively small push force of articulated robotic arms.
- Potential discrepancies between moisture measurements in simulants and actual waste are unknown. The field of measurement beyond a neutron moisture probe is about 3 in.
- Level of sensitivities for chemical species, reproducibility of measurements, and matrix interference on the remote Raman probe performance are not fully characterized. Based on the current

state of the *art,* the Raman probe could be only a mapping tool (i.e., not a quantitative tool) for detectible chemical species. However, there does not presently appear to be a better candidate technology for this application.

FY96-FY98 Scope:

- Develop and cold test Raman probe sensor package on CP for operation in Hanford tanks to augment coring operations.
- Deploy CP with integrated sensor package including Raman probe for scanning molecular species in situ at Hanford.
- Develop and cold test physical properties of end effectors (minilab) for deployment on LDUA at INEL in FY97.

Benefits of Technology:

__x__ Reduce costs
____ Reduce risks

Explanation: Based on past practice and the planning basis in Recommendation 93-5 (DOE 1994), the cost to retrieve and analyze tank cores from the Hanford tank farm could exceed $750K. Implementation of in situ characterization with instrument packages on a CP or LDUA would provide quick and inexpensive data relative to core retrieval. The chemical characterization data would not be as complete or accurate as hot cell analyses of cores. However, the data are expected to be sufficient to measure or map waste properties needed for safety issues (e.g., ferrocyanide and moisture levels), for selection of tanks to core (e.g., levels and heterogeneity of moisture and major chemical components), for selection of coring bits to use (e.g., rheology and stratigraphy), and for retrieval of tank waste via sluicing (e.g., shear, tensile strength, and stratigraphy). By implementing CP or LDUA in situ measurements, the number of full-length cores needed to characterize the tank farm should be much smaller than the current baseline of over 400 cores.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1,420	2,500	1,400	500
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks	790	710	450	250
EM-50 Crosscutting				
Total	2.210	3.210	1.850	750

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		Develop Test and Document In Situ Raman/ NIR Probe
EM-30 Savannah River		
EM-30 Oak Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks		Field Test Raman Robe for CP Application
EM-50 Crosscutting		

Technical Element: Process Monitoring and Control

NBS: 1.1.3 Manage Tank Waste: Characterize **Tank** System

Problem Statement: Development of on-line real-time analyzers and sensors is needed to support storage, pretreatment, and immobilization of tank wastes, as-described below:

- **Storage** - Liquid HLWs at the SRS sites are stored in carbon steel tanks that are susceptible to nitrate-induced corrosion cracking, which is prevented by monitoring and maintaining an adequate nitrite ion level. Current methods use liquid sampling and laboratory analysis to measure and maintain the nitrite level. An on-line nitrite sensor that would work remotely in high-radiation and caustic environments would be highly cost effective and minimize inhibitor additions.

- **Pretreatment** - The baseline technology for pretreating the caustic waste sludges at Hanford, SRS, and *Oak* Ridge is washing with sodium hydroxide to remove soluble compounds containing sodium, aluminum, phosphorous, and chromium. These constituents need to be removed to minimize the number of HLW logs to be produced. To minimize the amount of liquid low-level waste (LLW) generated during washing, on-line sensors are needed to track and optimize the ratio of washing solution used to the quantity of soluble constituents removed.

- **HLW immobilization** - The baseline technologies for analytical process control of the SRS Defense Waste Processing Facility (DWPF) will be inadequate when the facility approaches design capacity for glass production. The current process control methodology for meeting HLW glass specifications depends primarily on analyzing feed to the melter. To reduce future bottlenecks (i.e., analytical time rate limiting) in the DWPF, improved methods are needed for on-line analysis of organic compounds generated during hydrolysis .of the tetraphenyborate slurry and for analysis of the slurry feed solution to the melter. In addition, on-line methods to determine glass viscosity before pouring and glass product composition after production would help verify that product consistency and specifications are being met.

- **LLW Immobilization** - Radionuclide monitoring of feed solutions to a grouting or vitrification facility is crucial to avoid exceeding LLW product specifications, especially if Class A LLW is required. In particular. a faster and cheaper method than neutron activation for technetium analysis is needed for process control. On-line analysis of Resource Conservation and Recovery Act (RCRA) metals is also needed to maintain metal concentrations below levels that would be considered mixed waste.

Path to Solution:
- Establish program to select and test commercially available sensor for in-tank measurement of nitrate/nitrite levels for corrosion control. A potential candidate is a remote Raman probe.
- Discuss concepts with industry representatives to adapt commercial aqueous on-line analyzers for sodium, aluminum, phosphorous, and chromate (such **as** the inductively coupled plasma/mass spectrometer [ICP/MS]) and design optimization/control/intelligence systems to minimize volume of liquid LLW solutions generated during sludge washing.

- In support of the DWPF, discuss concepts with industry representatives and establish development programs to expedite organic analysis (such as supercritical fluid extraction chromatography), direct analysis of slurries, and direct measurement of glass viscosity (such as rate of helium bubble rise through melter).
- In support of LLW form production, discuss concepts with industry representatives and establish program to develop on-line method for technetium and RCRA metal determination by adapting commercially available techniques such as ICP/MS.

Technical Issues:
- For the in-tank corrosion monitor, sensitivity for the nitrite ion, reproducibility of measurements, and interference from other constituents on sensor need to be established.
- In support of the DWPF, no known acceptable on-line method exists for direct chemical measurement of the slurry feed due to the inability to generate representative samples for ICP/MS analyses; no method has been developed for direct measurement of the glass viscosity at high temperature. Conformance to glass product specifications will be based on periodic sample analysis of the melter feed.
- In support of LLW immobilization, failure to maintain feed solutions within specifications could produce greater than Class C waste or mixed waste, which might require shutdown of the facility and retrieval and processing of the out-of-specification waste.

FY96-FY98 Scope:
- Develop Raman probe for in-tank or process stream measurement of nitrite concentrations to minimize volume of corrosion inhibitor added.
- Deploy Raman technology for on-line measurement of nitrite concentrations.
- Demonstrate commercially available monitors and process control logic to minimize volume of liquid LLW generated when washing HLW sludges with caustic solutions.

Benefits of Technology:

__x__ Reduce costs

__x__ Reduce risks

Explanation: In-tank corrosion monitors would replace labor-intensive sample collection and laboratory analysis and would minimize additives. On-line monitors during sludge washing would optimize the ratio of wash solution used to constituents removed. Improved on-line analyzers for the DWPF would be required to reach a higher level of throughput. On-line monitors for glass viscosity would reduce the risk of an out-of-specification HLW glass being produced. On-line analysis of feed solutions to the LLW immobilization process would reduce the risk of producing a mixed waste or a greater-than-Class C waste.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 (SK)
EM-30 Hanford				
EM-30 Savannah River				
EM-30 *Oak* Ridge				
EM-30 Idaho				
EM-40 *Oak* Ridge				
EM-50 Tanks		500	750	750
EM-50 Crosscutting				
Total		500	750	750

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		
EM-30 *Oak* Ridge		
EM-30 Idaho		
EM-40 *Oak* Ridge		
EM-SO Tanks		
EM-50 Crosscutting		

* New start in FY96.

NBS: 1.1.3 Manage Tank Waste: Characterize Tank System

Problem Statement: To cease use, remediate, and close HLW tanks, residual waste must be sampled and characterized to show that target levels of waste removal have been met. End effectors for robotic arms to sample tank walls and bottoms in off-riser locations are needed. The LDUA is scheduled for delivery to and demonstration at three tank sites (Hanford, Oak Ridge, and INEL) in **FY96** and **FY97**. The first-generation end effectors will be visual and contour-mapping devices for tank inspection. The next high-priority end effectors needed are devices that can retrieve sludge and salt samples. Retrieval of solid samples for characterization from tanks at **INEL** and Oak Ridge is part of the requirement to cease use, clean, and close the tanks. Traditional methods currently used at Hanford (auger, push mode, and coring) are not compatible for use in **INEL** and ***Oak*** Ridge.

Path to Solution: Initiate programs to develop robotic end effectors capable of taking solid and liquid samples in all areas of the tanks, as described below:

- Assess the types of solids to sample, the characterization schedules at the tank sites, and the possible end effectors needed, such as syringes, scoopers, tube suction devices, and augers.
- Initiate a technical program in **FY96** to develop sampling end effectors capable of taking solid samples over the anticipated range of sludge and salt characteristics.
- Work closely with the LDUA developers to ensure that the sampling end effectors are compatible with the arm and to qualify them in the cold LDUA test facility at Hanford or the waste dislodging and conveyance (WD&C) test bed.
- After cold testing, schedule deployment of end effectors for hot sampling based on priority of sludge and salt characterization needs at the tank sites.

Technical Issues:

- There is variability in hardness of sludges and limited pressure that can be exerted by the LDUA or payload constraints of the arm. Some sludges may require augering or drilling techniques to penetrate surface.
- Compatibility of sampling devices with the arm and other end effectors has not been fully assessed. Sample handling, above-tank sample packaging for transport, and transport of samples will require additional equipment, technical support, and procedure.

FY96-FY98 Scope:

- Develop and deploy device to take concrete samples from the walls and bottoms of Oak Ridge gunite tanks.
- Develop and deploy device to take sludge samples from the bottom of HLW tanks at INEL.

Benefits of Technology:

____ Reduce costs

_x_ Reduce risks

Explanation: The gunite tanks at Oak Ridge will be the first under the auspices of the TFA scheduled for closure and the pillar and panel tanks at INEL are scheduled for cease use by 2009. Traditional methods of push, auger, and coring are not suitable to characterize the sludge in the Oak Ridge and INEL tanks because of the tank configuration or small amounts of sludge that reside in inaccessible regions of the tanks. Oak Ridge considers deployment of the LDUA as critical to meeting its Federal Facility Agreement milestone to remediate its gunite tanks. Development of sampling end effectors to expedite sampling and characterization of the sludges will be required before state and federal agencies will grant cease use or closure permits. Therefore, a program to develop sampling end effectors is needed to reduce the risk that such agreements will not be delayed due to lack of tank characterization.

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Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford				
EM-30 Savannah River				
EM-30 *Oak* Ridge				
EM-30 Idaho				
EM-40 *Oak* Ridge				
EM-SO Tanks		300	500	750
EM-SO Crosscutting				
Total		300	500	750

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		
EM-30 *Oak* Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-SO Tanks		
EM-50 Crosscutting		

* New start in FY96.

Technical Element Title: Deployment Systems

NBS: 1.2.1 Process Waste: Retrieve Wastes

Problem Statement: At three of the four HLW tank sites there is a need for a lightduty utility arm (LDUA) system to support some or all of the following characterization, safety, and retrieval functions:

- tank integrity and leak investigation
- characterization sampling of wastes and in situ waste analysis
- visual waste and tank inspection and placement of characterization or retrieval equipment
- tank mapping
- interim waste stabilization
- annulus inspection and cleaning
- retrieval of heels and other hard-to-remove wastes
- assisting in the removal of in-tank hardware and other extraneous equipment
- decontamination of empty tank
- closure activities.

Site requirements for the performance and design of this arm vary but have the following similar characteristics:

- The arm must be compatible with a variety of end effectors to allow completion of the above functions.
- The arm must operate in high corrosive and moderate radiation environments.
- The arm system must be deployable from ground level through 12-in.-diameter or larger risers into underground storage tanks.
- The arm must have a tip payload and a structural stability capable of performing missions cited above functions.
- The potential of substantial in-tank hardware requires a severaldegree-of-freedom dexterous arm.
- The arm must be capable of both teleoperational (e.g., for waste sampling) and robotic operational (e.g., for retrieval operations).
- All normal tank farm requirements and procedures must be complied with to include containment and decontamination as well as remote end effector changeout operations.

Path to Solution: This technical element brings to fruition efforts begun in 1993 under the EM-50 Underground Storage Tank-Integrated Demonstration Program, as described below:

- Manufacture and deliver LDUAs to TWRS, INEL, and the EM-50 Cold Test Facility.
- Design, develop, manufacture, and deliver a modified (higher tip payload) arm to Oak Ridge.
- Support the conduct of cold testing at all sites to test systems and train operators.
- Support the conduct of hot operations at INEL, Oak Ridge, and Hanford.
- Develop new applications and end effectors with EM-50 arm at cold test facility.
- Provide technical expertise and support to ensure a rapid, seamless transition and integration of this technology at INEL, Oak Ridge,-and Hanford.

Technical Issues: The LDUA is a first-of-a-kind robotic technology that is required to meet extremely broad but yet constraining design requirements. The system must operate safely in radioactive, corrosive, and potentially explosive atmospheres. The long slender arm must operate with high accuracy and without applying external loading to tank structures. All these factors combine to make this an extremely complex and challenging design effort. Integration of multiple systems from various DOE laboratories and industry make management of interfaces and protocol very important. Providing this wide-ranging capability at as low a cost as possible is a major challenge to this program.

FY96-FY98 Scope:
- Deliver LDUA systems to Hanford, Oak Ridge, and INEL.
- Complete integrated testing of LDUA inspection system for Hanford to prepare for in-tank deployment.
- Conduct hot demonstration of LDUA system riser-mounted technologies and end effectors at Hanford.
- Demonstrate inspection capability using the LDUA systems at Oak Ridge and INEL.
- Conduct hot demonstration of LDUA system riser-mounted technologies and end effectors at Oak Ridge and INEL.
- Deliver LDUA system for use in test bed.
- Complete installation of LDUA test bed to support operations at three sites and to develop and test end effectors from industry and DOE development programs responding to characterization, surveillance, and retrieval needs.
- Support retrieval demonstrations using WD&C technologies at INEL and Oak Ridge (see Retrieval Process Development).

Benefits of Technology:
_x_ Reduce costs
_x_ Reduce risks

Explanation:
Reduce costs: The LDUA is a relatively expensive piece of new technology when compared to normally used devices in the tank farm. The cost/benefit tradeoffs indicate that the LDUA's larger capital cost over simple tank farm technology is more than offset with new capabilities, faster operations, and potential reduction in operational crew size.
Reduce risks: The availability of a dexterous arm greatly reduces the risks associated with retrieval operations, regardless of retrieval technology, by providing rapid methods of relocating hardware, recovering broken devices, etc. Dose risk should be reduced by smaller crew sizes on or near the tank as well as shorter duration operations.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 (SKI	FY98 ($K)
EM-30 Hanford	1,530	3,250		
EM-30 Savannah River				
EM-30 *Oak* Ridge				
EM-30 Idaho	2,112	1,408		
EM-40 *Oak* Ridge	1,420	2,500		
EM-50 Tanks	4,225	6,560	4,000	4,000
EM-50 Crosscutting				
Total	9,287	13,728	4,000	4,000

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford	Support to Tank Operations and Stabilization Program	Support to Retrieval Activities
EM-30 Savannah River		Tank Annulus Inspection and Heel Removal
EM-30 *Oak* Ridge		
EM-30 Idaho	Tank Characterization and Heel Removal	Calcine Bin Remediation
EM-40 *Oak* Ridge	Support to Gunite and Associated Tank Treatability Study Tank Characterization and Heel Removal	Melton Valley Tank Remediation
EM-50 Tanks	Baseline Program, System Integrahon	Support to International Programs
EM-50 Crosscutting	Control System Development	Robotics Applications in Tanks

Technical Element Title: Enhancements to Present Retrieval Processes

NBS: 1.2.1 Process Waste: Retrieve Wastes

Problem Statement: Baseline retrieval process technologies used at Hanford (past practice sluicing), SRS (mixer pumps), and Oak Ridge (past practice sluicing) have shortcomings that could be improved upon with modest investments in the application of existing technologies from other industries, such as mining and petrochemical. Even small improvements in these site baselines could result in savings of hundreds of millions of dollars. Specific problems with mixer pumps include leaking seals that add too much water to tanks, high life-cycle costs, and limited ability to mobilize hard waste heels. Problems with past practice sluicing include the inability to mobilize heel wastes, creation of excessively dilute waste streams, and problems with using leaking tanks. Privatization efforts at Hanford may require additional technology development on enhancements to present retrieval processes.

Path to Solution: These baseline retrieval process technologies can be improved by adaptating and enhancing proven technologies from other industries to site needs. Examples include bore hole miners, Pulsair systems, and other technologies identified by WHC's Acquire Commercial Technology for Retrieval project. The path to solution has three parts:

- Identify promising technologies from other industries that are ready for transfer to the remediation of waste tanks.
- Test those technologies in scaled test facilities or in actual waste tanks.
- Understand the technologies and test results so that the TFA can assist retrieval efforts at all four sites in the application of the enhanced processes to their needs.

Technical Issues:

- Minimizing the large amounts of water required to efficiently mobilize all types of wastes.
- Developing systems that can effectively mobilize all kinds of waste forms (supernatant, sludge, saltcake, and heels) at costs substantially lower than the baseline.
- Increasing the rate of solids settling in decant tanks to increase retrieval rates.
- Mixing wastes in tanks at lower costs.
- Developing consistent retrieval process models that accurately predict retrieval campaign costs and duration for all baseline and enhanced retrieval technologies.

FY96-FY98 Scope:

- Facilitate integration and coordination of mixer pump technology improvements through planning, test plan development, and technical forums to ensure better pump designs for Hanford, INEL, and SRS.
- Provide technical support as needed to the joint Hanford and SRS mixer pump development project.
- Demonstrate one retrieval technology (such as Pulsair) from industry on simulated waste to provide enhanced options to Hanford, Oak Ridge, and SRS.
- Conduct enhanced sluicing tests on simulants to provide options to all tank sites and provide a possible option for SRS in-tank demonstration during previous demonstration.
- Develop retrieval models to predict the cost and efficiency of retrieval process operations as validated by testing and major demonstrations.
- Develop enhanced sluicing technologies in coordination with EM-30 efforts.

Benefits of Technology:

_X_ Reduce costs

_X_ Reduce risks

Explanation:

Reduce costs: A significant reduction in water use during retrieval will save millions of dollars in downstream processing equipment costs and waste processing. Improved systems may reduce or eliminate the need to use alternate heel removal technologies.

Reduce risks: Enhanced or improved mobilization systems will reduce the number of system failures requiring excessive repair costs and downtime. Limited water usage will minimize the risk of leakage. Without the development and testing on simulants, there is a significant risk of retrieval systems not functioning properly or efficiently.

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1.235	9,190	7,580	3,700
EM-30 Savannah River	403	1,205		
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge	870			
EM-50 Tanks		700	700	1,000
EM-50 Crosscutting				

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford	Test Plans and Data Requirements	Mixer Pump Design and Testing Past Practice Sluicing Performance Teshng Pulsair Tests
EM-30 Savannah River		Equipment Engineering Support (Waste Transfer Systems) Waste Removal
EM-30 Oak Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		Bulk Sludge Mobilization and Slurry Transport: Submerged Jet Sludge Mobilization and Transport Studies
EM-50 Tanks	Evaluation of Retrieval Technologies with Acquire Commercial Technology for Retrieval Program	
EM-50 Crosscutting		

Technical Element Title: Retrieval Process Development

NBS: 1.2.1 Process Waste: Retrieve Wastes

Problem Statement: Past practice sluicing, while effective, is still associated with large risks in terms of heel removal and leaking tanks. There is a strong need at all four sites to reduce these retrieval activity programmatic risk factors by

- improving overall processes to dislodge and convey a variety of wastes
- developing noncontact end effectors for site-specific application that can dislodge a variety of wastes, including hard sludge heels
- developing better conveyance technologies to remove wastes from retrieved tanks
- qualifying a suite **of** waste simulants for various retrieval processes
- developing needed process instrumentation.

There is also a strong need for technical support at the *tank* sites for producing functions and requirements documents and prototypic hardware to allow sites to procure the right equipment for their retrieval operations. Extensive testing of recently developed end effectors and retrieval techniques is needed to verify processes under near-real retrieval conditions prior to commencement of actual site operations. Further, specific technical support is needed at SRS for the execution of the alternate retrieval technology selection for Phase III of the retrieval end closure demonstration.

Path to Solution:

- Continue development of retrieval end effectors for all waste forms including sludge, saltcake, and mixed sludge and saltcake.
- Continue development of confined sluicing process technologies to reduce the amount of water addition during retrieval.
- Continue development of waste conveyance and transfer systems to interface with pipeline systems to pretreatment processes.
- Identify and evaluate other alternate retrieval technologies for significant gains in productivity.
- Interface with stabilization and closure activities to define heel removal requirements.
- Interface with pretreatment activities to define waste transfer solution properties.
- Continue development of simulant pedigree to replicate actual waste properties for all sites over a broad range for multiple users (e.g., safety. characterization, retrieval, and pretreatment).
- Develop methods to inexpensively create large quantities of simulants and control the pedigrees.
- Test retrieval systems on simulated waste to develop performance parameters and provide meaningful evaluation of equipment and waste retrieval processes.
- Coordinate ongoing simulant development for sludge and saltcake properties.

Technical Issues: Technical issues involve development of technologies to finish the waste removal to acceptable closure levels after past practice removal operations. This requires a robust technology that can work in leaking tanks and annulus and with all types of waste forms without compromising tank integrity. Alternate systems must be simplified and be reliable enough to operate effectively and inexpensively in the harsh tank environment. The best alternative to actual waste samples is the development and use of nonradioactive surrogate waste that adequately simulates the properties of the actual waste that are critical to the retrieval process. A key issue is the manufacture of large quantities of simulants and proper control of the recipes to ensure that all developers are using a common pedigree.

FY96-FY98 Scope:

- Complete integrated testing of pneumatic and hydraulic conveyance and transfer end effectors at the Hydraulic Test Bed (HTB).
- Assist in deployment of confined sluicing retrieval end effectors at Oak Ridge.
- Develop prototype pneumatic or hydraulic end effectors for removal of waste from tanks at INEL.
- Initiate technology transfer of pneumatic and hydraulic conveyance and transfer end effectors for INEL.
- Assist in deployment of confined sluicing retrieval end effectors at INEL.
- Execute a modest simulant development program to address only those absolutely essential items to support INEL, Oak Ridge, and Hanford retrieval efforts.
- Provide technical support to retrieval and closure demonstration at SRS by leading the effort to select and deploy the retrieval process for Phase III (Alternate Technology Demonstration).

Benefits of Technology:

_x_ Reduce costs
_x_ Reduce risks

Explanation:

Reduce costs: The use of inexpensive confined sluicing systems could save millions of dollars spent trying to remove waste heels. Systems currently under development can be modified for little additional cost to remove waste from the tank annulus. Without well-defined simulants, retrieval system development costs would be extremely prohibitive and systems would have to be very large or overdesigned.

Reduce risks: Alternate retrieval technologies provide a necessary backup to past practices and address the issue of heel removal. Removal of discrete sources reduces the risk to downstream processes. Without development and testing on simulants, there is a significant risk of retrieval systems not functioning properly or efficiently.

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	2,670	8,570	4,010	10,600
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho	1,790	1,400	600	2,400
EM40 Oak Ridge	2,000			
EM-50 Tanks	3,500	2.865	2,500	2,500
EM-50 Crosscutting				
Total	9,960	12,835	7,110	15,500

Integrated Technical Activities:

Funding Source	Technical Activity Title	
	Strongly Coordinated	**Potentially Leveraged**
EM-30 Hanford	Cold Demonstration of Double-Shell Tank (DST) Tank Technologies	Evaluate Alternate Double-Shell Tank Retrieval Technologies
EM-30 Savannah River		
EM-30 Oak Ridge		
EM-30 Idaho	Deployment of Retrieval End Effectors at INEL	LDUA
EM-40 Oak Ridge	Deployment of Retrieval End Effectors at Oak Ridge Cold Test Facility and Hot Deployment Data Requirements/Analysis	Confined Sluicing Waste Retrieval end Effector System Modified LDUA Development Prototype End Effector Testing
EM-50 Tanks	End Effector Development Testing for Oak Ridge Prototype End Effector Testing for INEL Simulants for INEL/Oak Ridge Testing	RL-332002, LDUA Technical Integration and End Effector Testing RL-401203, LDUA System ID-442001, LDUA Decontamination System and End Effector Hanford Light-Weight Scarifier Testing Mining Strategy Testing
EM-50 Crosscutting		

Technical Element Title: Acidic Cs/Sr/TRU/Tc Removal

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: In sharp contrast to the caustic supernate at Hanford, SRS, and Oak Ridge, the INEL waste stream is acidic. Removal of cesium, strontium, technetium, and TRU will be necessary to permit the INEL supernate to be processed, immobilized, and disposed of as a Class A LLW. Currently, INEL has defined its baseline technologies for cesium, strontium, technetium, and TRU removal. These technologies involve solvent extraction processes while the other sites are focusing on in-tank precipitation and ion-exchange column processes.

Path to Solution:

- Develop requirements for the levels of cesium/strontium/technetium/TRU removal.
- Develop criteria for selection process based on technical issues.
- Conduct batch tests on all candidates (screening tests).
- Perform small-scale engineering tests on best-available candidates from screening tests.
- Conduct large-scale demonstrations to gain engineering data (permitting and operations issues).
- Establish technically defensible baseline for cesium/strontium/technetium/TRU removal by FY97.
- As new processes become available, conduct small-scale tests if suitable for the engineering design and/or available equipment.
- If a new process is clearly superior, perform small-scale engineering tests.

Technical Issues:

- Determining the level of cesium/strontium/technetium/TRU removal needed.
- Selecting the removal technology for each radionuclide.
- Factors in the selection process: decontamination factors (with respect to site requirements), robustness, ease of operation, cost (sorbent, operation, and capital), disposal (immobilization and cost requirement), kinetics/processing time, stability (such as radiolytic), pretreatment requirements (such as level of filtering), and commercial availability.

FY96-FY98 Scope:

Assuming work conducted by the Efficient Separation Processing-Integrated Program (ESP-IP) will begin to transfer to the TFA in FY97 and FY98 for implementation at INEL and as alternative to Hanford alkaline processing:

- Conduct hot cell demonstration of solvent extraction removal of strontium, technetium, and TRU in actual INEL waste.
- Demonstrate, with real waste, cesium removed by solvent extraction and enhancements for strontium and TRU.

Benefits of Technology:

_x_ Reduce costs

_x_ Reduce risks

Explanation:

Reduce costs: The removal of radionuclides will permit the decontaminated supernate to be immobilized and disposed of as LLW instead of HLW. These separations will lower processing and repository costs and improve worker safety. At Hanford, the cost to process, immobilize, and store HLW is 25 times greater than that for LLW.

Additional benefits: 1) INEL has several experts on acid side separation. If acid dissolution on the sludges at the other sites is necessary, the **INEL** experience will be invaluable. 2) Current program is integrated and involved with users and industry. 3) Resulting information can be used in the privatization approach.

Reauested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford				
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho	1,770	500	1000	
EM-40 Oak Ridge				
EM-50 Tanks	434	550	550	600
EM-50 Crosscutting	1,750	1,500	1,500	
Total	3,954	2,550	3,050	600

Integrated Technical Activities:

Funding Source	Technical Activitv Title: Strongly Coordinated	Technical Activitv Title: Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		
EM-30 Oak Ridge		
EM-30 Idaho		**CSIX;** TRUEX; SREX; Actinide Removal; Calcine Pretreatment
EM-40 Oak Ridge		
EM-50 Tanks		OR-132008, TRUEX Applications; CEA Assignment CH-232001. TRUEX Applications
EM-50 Crosscutting		AL-132010, Closeout Dicarbolide AL-232004, Crystalline Silicotitanate for Cesium/Strontium Removal ID-421201, Bench-Scale Testing for Separation of Idaho waste AL-234302, International Separations Contract Management CH-232005, Advanced Integrated Solvent Extraction System

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: The cesium in the alkaline supernate and dissolved saltcake must be removed to allow this large-volume stream to be immobilized and disposed of as LLW. Final waste form requirements and immobilization processing facility shielding requirements drive the requirements for separation of cesium. Currently, Hanford is establishing its baseline process; SRS is evaluating alternative approaches to their in-tank precipitation process; and Oak Ridge has chosen ion exchange for their cesium removal requirements.

Path to Solution:

- Develop criteria for selection process based on technical issues.
- Conduct batch tests on all candidates (screening test). The majority of these tests have been completed.
- Perform small-scale engineering tests on the best-available candidates from the screening tests. Engineering tests have been initiated.
- Conduct large-scale demonstrations to obtain engineering data and to settle permitting and operations issues. No demonstrations have been conducted.
- Establish technically defensible baseline for out-of-tank cesium removal by FY97.
- As new sorbents become available, conduct small-scale tests to determine suitability for the engineering design and/or the cesium removal equipment. If a new sorbent is clearly superior, perform small-scale engineering tests.

Technical Issues: Selection process for sorbent at each site. Factors in the selection process: decontamination factors (with respect to site requirements), robustness, ease of operation, cost (sorbent, operation, and capital), disposal (immobilization and cost requirement), kinetics/processing time, stability (such as radiolytic), pretreatment requirements (such as level of filtering), and commercial availability.

FY96-FY98 Scope:[(a)]

- Initiate operation of Phase 1 hot demonstration of cesium removal on 25,000 gal of Melton Valley Storage Tank (MVST) waste at Oak Ridge.
- Conduct hot column tests on cesium sorbents for downselection and engineering of Phase 2 hot demonstration on MVST wastes.
- Perform hot batch tests on new cesium sorbents for potential demonstrations on other waste streams or Phase 3 of MVST wastes.
- Complete and document Phase 1 hot cesium removal demonstration after downselection of available resins in FY95 to support Oak Ridge in handling MVST wastes and provide data and to support Hanford in their selection of treatment processes.

(a) ESP-IP and the TFA are currently negotiating the distribution of FY96 scope between the two organizations.

Benefits of Technology:

_X_ Reduce costs

_X_ Reduce risks

Explanation:

Reduce costs: Removal of **Cs** will permit the decontaminated supernate to be subsequently treated, immobilized, and disposed of as LLW instead of HLW, lower processing and repository costs, and improve worker safety. At Hanford, the cost to process, immobilize, and store HLW glass is 25 times greater than for LLW glass. At Oak Ridge, the cesiumdecontaminated LLW can be shipped offsite, which will save $50M.

Additional benefits: SRS can use results to evaluate alternative to their baseline. The current program is highly integrated and leveraged with users and industry. Resulting information can be used in a privatization approach. Demonstrations can provide bases for vendor performance.

Requested Budget:

Funding Source	FY95 ($K)	FY96 (SK)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1,872	899	1,080	
EM-30 Savannah River	868	730		
EM-30 Oak Ridge		1000	500	
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks	1,467	2,500	1,500	1,500
EM-50 Crosscutting	1,550	1,000	500	
Total	5,757	6.129	3,580	1,500

Integrated Technical Activities:

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford		Develop Engineered Form of CST Conduct Batch Tests of Engineered Form of CST Using DSS/DSSF Feed
EM-30 Savannah River		In-Tank Precipitation with Sodium Tetraphenylborate Precipitate: Precipitate washing
EM-30 Oak Ridge		Develop, Install, Operate Resorcinol-formaldehyde (Ion-Exchange System)
EM-30 Idaho		
EM-40 Oak Ridge		Use of RF on Newly Generated Waste as Waste Minimization Activity
EM-50 Tanks		SR-132002, Cesium Extraction Testing: RF Resin Development OR-132008, Comprehensive Supemate; Cesium Removal Demonstration; Hot-Cell Processing studies
EM-50 Crosscutting		AL-232004, Crystalline Silicotitanate for Cs/Sr Removal SR-132007, Advanced Chemical Separations at Savannah River RL-321204, Sorbent Design Support - Molecular Model; Industrial Contracts/ Manage Contracts; Test Sorbents

Technical Element Title: Alkaline Sr/TRU/Tc Removal

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem **Statement:** Removal of Sr and TRU (in particular) may be necessary to permit some of the caustic supernate and dissolved saltcake to be processed, immobilized, and disposed of as LLW. Currently, SRS has defined its baseline technologies for strontium and TRU removal. Performance assessments at Oak Ridge indicated that strontium and TRU removal is not necessary but would improve worker safety and reduce the potential hazard of the LLW. Technetium removal from supernate is potentially important due to its long half-life and mobility. Performance assessments at Hanford, SRS, and Oak Ridge will determine if technetium removal is needed, Performance assessments have not been done yet at Hanford. TRU removal will probably be required from complexant concentrate (CC) tanks to meet LLW DOE requirements. Strontium removal may be required depending on negotiations with NRC over the definition of incidental waste.

Path to Solution:

- Develop requirements for the level of strontium, TRU, and technetium removal needed at each site.
- Develop criteria for the selection process based on technical issues.
- Conduct batch tests on all candidates (screening test).
- Perform small-scale engineering tests on the best available candidates from screening tests .
- Establish technically defensible baseline for strontium/technetium/TRU removal by FY97.
- As new sorbents become available, conduct small-scale tests to determine suitability to engineering design and/or available equipment. If new sorbent is clearly superior, perform small-scale engineering tests.

Technical Issues:

- Level of strontium, technetium, and TRU removal needed at each site.
- Selection of sorbents at each site. Factors in the selection process: decontamination factors (with respect to site requirements), robustness, ease of operation, cost (sorbent, operation, and capital), disposal (immobilization and cost requirement), kinetics/processing time, stability (such as radiolytic), pretreatment requirements (such as level of filtering), and commercial availability.

FY96-FY98 Scope:

- Conduct hot cell batch tests on selected strontium, technetium, and TRU sorbents with MVST supernate.
- Complete hot testing of selected sorbents from ESP and TWRS programs for removal of strontium/TRU/technetium from Hanford wastes.
- Expand hot testing of sorbents from ESP and TWRS programs for removal of Sr/TRU/Tc from Hanford wastes.

Benefits of Technology:

_x_ Reduce costs

_x_ Reduce risks

Explanation:

Reduce costs: At Hanford, the level of TRU in CC waste is too high for Class C waste. Removal of cesium and TRU CC waste will permit the decontaminated supernate to be subsequently treated, immobilized, and disposed of as LLW instead of HLW and will lower processing costs and improve worker safety. The cost of CC waste as HLW instead of LLW adds $10.5 billion to overall costs.

Reduce risks: Regulations may require strontium and technetium to be immobilized as HLW to reduce public risks.

Additional benefits: 1) **SRS** can use results to evaluate alternatives to its baseline. 2) Current program is integrated and involved with users and industry. 3) Hanford and Oak Ridge may need these technologies as the regulatory environment becomes more restrictive. 4) Resulting information can be used in the privatization approach.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 (SK)
EM-30 Hanford	3,984	2,504	1,560	
EM-30 Savannah River	689			
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-SO Tanks	1,601	300	500	300
EM-50 Crosscutting	1.525	1.000	800	
Total	7.799	3.350	2.860	300

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford		d Batch Tests of E n Form f CST U i SSF Feed Develop Engineered Form of I Conduct B and Column S Sorbent Tests with 1) Actual DSSlDSSF and CC Waste for Sr R and 2) Synthetic DSS/DSSF and CC W for i e Conduct Column Ion-Exchange Tests with Synthetic DSSF Waste for Technetium Removal Conduct Batch Tests on Alternate Techniques with 1) Actual DSSF Waste for Technetium Removal and 2) Synthetic DSSF Waste for Technetium Removal Conduct Batch and Column Ion-Exchange Tests for Sr Removal from Synthetic CC Waste - No Cesium Conduct Batch Carrier Precipitation and Sodium Titanate Adsorption Tests for TRU Removal with 1) Actual Waste and 2) Synthetic Waste Conduct Batch Test of Complex Destruction with Actual CC Waste Conduct Column ion-Exchange Tests with Actual DSSF Waste for Technetium Removal
EM-30 Savannah River		In-Tank Precipitation with Sodium Tetraphenylhorate: Cold Chemical and Precipitation
EM-30 Oak hdge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks		OR-132008, Comprehensive Supernate
EM-50 Crosscutting		AL-232004. Crystalline Silicotitanate for Cesium/Strontium Removal AL-132010, Technetium and Nickel Removal Using Ion Exchange CH-232006, Aqueous Biophasic System/ Radioactive Waste Retreatment OR-153002, Technetium and Actinide Solvent Extraction

Technical Element Title: Caustic Recycle

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: Significant sodium hydroxide must be added to sluice and leach sludges. It is estimated that this sodium hydroxide can increase the volume of the LLW by 18%, based on the Hanford baseline. In addition, the added sodium puts additional requirements on the immobilization system.

Path to Solution:
- Determine the amount of sodium hydroxide required for the total sluicing, regenerable ion exchange, and caustic leaching.
- Investigate calcination, membrane, and electrochemical methods to recover NaO or sodium hydroxide.
- Investigate whether regenerated clear caustic can be released **from** the nuclear fuel cycle.

Technical Issues:
- Method for conversion of $NaNO_3$ to sodium hydroxide must be demonstrated.
- Testing on Hanford waste is required.
- Engineering studies are necessary to document savings.

FY96-FY98 Scope:
- Fund project to regenerate caustic using simulated tank waste for proof of principle.
- Conduct bench-scale demonstration of salt-splitting using spiked simulants.

Benefits of Technology:

_x_ Reduce costs

___ Reduce risks

Explanation:

Reduce costs: The estimated cost for LLW without caustic addition is $7.8 billion. Addition of 18% as caustic will add $1.4 billion to that cost.

Additional benefits: Technology could be a candidate for privatization or for transfer to other countries.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 **Hanford**				
EM-30 **Savannah River**				
EM-30 Oak **Ridee**				
EM-30 Idaho				
EM40 Oak Ridge				
EM-50 **Tanks**		*600*	1,000	2,000
EM-50 Crosscutting	*970*	1,000	500	
Total	*970*	1,600	1,500	2,000

Integrated Technical Activities:

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		
EM-30 Oak Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks		
EM-50 Crosscutting		RL-442002, Significant Volume Reduction of Tank Waste by Selective Crystallization RL-350002, Salt Splitting Using Ceramic Membranes SR-132005, Electrochemical Destruction of Nitrates and Organics

Technical Element Title: Manage Process Effluents

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: Available tank. capacity is a concern across the complex. Many of the streams received at the tank farms are generated as a result of tank management or tank waste processing activities. An alternative approach would be removal of solids, cesium, and mercury to allow the stream to be further treated at a wastewater treatment facility and then discharged to an National Pollutant Discharge Elimination System (NPDES) outfall. This approach would reduce evaporator costs and free tank space. Processing tank waste generates large amounts of liquid, solid, and gaseous effluent that must be treated. Such treatment was identified as a high priority by the tank sites.

Path to Solution: Currently, Oak Ridge has documented the sources and compositions of newly generated LLW and has instituted an approach to segregating some wastes to avoid generation of mixed TRU. The other sites have similar types of information, although approaches to reduce waste at the source vary. The objective of this technical element would be to document the current situation with respect to projected waste volumes and compositions and to evaluate more fully the need to control waste at the source. The path to solution will involve the following:

- Determine release criteria for solid, liquid, and gaseous streams.
- Determine likely concentrations for all waste types for the baseline technologies.
- For streams exceeding release criteria, determine and demonstrate technologies.

Technical Issues:

- Definition of release or disposal requirements for secondary wastes, with the goal of free release of material.
- Cost minimization associated with secondary and tertiary wastes.

FY96-FY98 Scope:

- Initiate and coordinate a complex-wide approach for handling and processing secondary waste common to each tank site to define technology requirements.
- Complete complex-wide cataloging of key source streams to tanks that need to be minimized.

Benefits of Technology:

_x_ Reduce costs

____ Reduce risks

Explanation: Free release is much less costly than regulated LLW disposal of secondary wastes.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 **Hanford**				
EM-30 **Savannah River**				
EM-30 Oak **Ridee**				
EM-30 Idaho				
EM-40 Oak **hdge**				
EM-50 **Tanks**		300	600	1,350
EM-50 **Crosscumng**	0	500	500	
Total	0	800	1,100	1,350

Integrated Technical Activities:

Funding Source	Technical Activity Title	
	Strongly Coordinated	**Potentially Leveraged**
EM-30 Hanford		
EM-30 Savannah River		
EM-30 *Oak* Ridge		
EM-30 Idaho		
EM-40 *Oak* Ridge		
EM-50 Tanks		
EM-SO Crosscutting		RL-442002, Significant Volume Reduction of Tank Waste by Selective Crystallization SR-132005, Electrochemical Destruction of Nitrates and Organics

Technical Element Title: Sludge Wash/Caustic Leach

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: The overwhelming majority of the waste at Hanford, SRS, and Oak Ridge is stored in high caustic. Removal of sodium and aluminum from the sludges is a high priority at both Hanford and SRS because the reduction would decrease the number of HLW logs. In addition, removal of components such as phosphate and chromate is important to Hanford. The technical baseline at Hanford and SRS is to use sodium hydroxide (caustic) solution to leach these components from the insoluble sludge and inhibited water to wash the soluble materials away from the insolubles. If these steps do not provide the required removal, additional steps such as acid dissolution may be desired. The baseline at Oak Ridge is to dry the sludge for shipment offsite. For the gunite tanks, half of the sludge is slightly TRU. Reduction of TRU concentration by 50% will make the waste LLW.

Path to Solution:

- Develop criteria to determine if washes are successful.
- Determine the effectiveness of the washes by conducting small batch tests on real sludges.
- Utilize a model to determine the impact and/or benefits of additional processing.
- Establish a technically defensible sludge strategy.

Technical Issues:

- Must interface closely with HLW immobilization.
- Need to determine the number and size of tests necessary to validate the processing scenarios at Hanford and SRS.
- Leaching and washing may cause problems with solid/liquid separations.

FY96-FY98 Scope:

- Perform evaluation of carbonate washes to remove TRU from gunite sludges for downselection to support demonstration in FY97.
- Perform validations of proposed Hanford TWRS reference process from sludge washing (expand number of samples processed through TWRS program).
- Demonstrate selected technologies developed by ESP or by other integrated demonstrations or programs to concentrate HLW fraction in the sludge at Hanford (expand technology tools for Hanford; now looking at only caustic wash).

Benefits of Technology:

_x_ Reduce costs

___ Reduce risks

Explanation:

Reduce costs: By the removal of inerts such as aluminum, phosphate, chromate, and sodium from sludge, the amount of HLW to be processed and stored in the HLW repository will be significantly reduced. At Hanford, the cost to process, immobilize, and store HLW glass is 25 times greater than that for LLW glass. The cost of HLW addition if chromate is not removed is $4.3 billion; the cost of not removing aluminum is greater than $4 billion.

Additional benefits: 1) Oak Ridge can use results to evaluate alternatives to its baseline. 2) Current program is highly integrated and leveraged with users. 3) Resulting information can be used in the privatization approach.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	5,202	4,062	4,070	
EM-30 Savannah River	3,744	3,147		
EM-30 Oak Ridge	200			
EM-30 Idaho				
EM-40 Oak Ridge	100	500	2000	
EM-50 Tanks		1,000	1,000	1,500
EM-50 Crosscutting	1,725	1,500	1,250	
Total	10,971	10,209	8,320	1,500

Inteerated Technical Activities:

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		Conduct Sludge Wash/Alkaline Leach Tests with Actual Waste 94-95 Sample Cores - PNL and LANL Evaluate Sludge Processing Science for Actual Sludge, 94-95 Conduct Selective Leaching Experiments of Actual Sludges, 94-95
EM-30 Savannah River		In-Tank Precipitation with Sodium Tetraphenylborate Precipitate (STBP): Cold Chemical Precipitation In-Tank Precipitation with STBP: Precipitate Concentration In-Tank Precipitation with STBP: Precipitate Washing In-Tank Precipitation with STBP: Benzene Strippers Sludge Aluminum Dissolution Sludge Washing
EM-30 Oak Ridge		
EM-30 Idaho		
EM-40 Oak Ridge		Gunite Treatability Study
EM-50 Tanks		
EM-50 Crosscutting		OR-132012, Sludge Washing and Dissolution of Oak Ridge MVST Waste: Sludge Washing and Leaching; Aluminum Removal

NBS: 1.2.2 Process Waste: Pretreat **Wastes**

Problem Statement: After retrieving tank waste, the first separation step is a settle/decant operation. Depending on the efficiency of this process and the type of washing performed, there may be colloidal materials and small particulates remaining in the supernate that can cause downstream processing failures. Some of the TRU materials and the Sr tend to attach to small particles and are difficult to process as supernate. SRS has been conducting studies on solid-liquid separation for a decade and part of this technical element is to transfer this technology to the rest of the DOE complex.

Path to Solution:
- Determine filtration needs (particle size, settling characteristics, throughput, recognition, lifetime, addition of flocculent, and impact of centrifugation).
- Conduct small-scale tests leading to large-scale demonstration with real wastes to understand potential problems such as fouling or colloid formation. Simulants cannot mimic these studies.
- Provide industry developed technologies to meet requirements.

Technical Issues:
- Magnitude and range of problem has not been determined.
- Acceptable criteria on level of separation required needs to be established.
- Most appropriate solid-liquid separation system needs to be identified and implemented.
- Multiple solid-liquid separation steps may be required.
- Understanding of chemistry involved is required to avoid solids formation.

FY96-FY98 Scope:
- Prepare for full-scale demonstration of solid-liquid separation of gunite tank wastes in FY97.
- Prepare for demonstration of solid-liquid separations on hot stream, and conduct small-scale tests with crossflow filters to provide engineering support to demonstration.
- Identify site and approach for hot cell demonstration of solid-liquid separation on second waste stream.
- Conduct industrial search for applicable solid-liquid separation technology.
- Perform first full-scale hot demonstration for solid-liquid separations on gunite tank or Oak Ridge cross-site transfer line wastes. This will involve initial decantation then filtration of supernate.
- Conduct hot bench-scale demonstration on a waste stream from another site to obtain additional operational information to support design (limited by size of sample).
- Conduct cold demonstration using irradiated simulants of industrial filtration technology at pilot-scale to make engineering tradeoff studies.
- Investigate electrochemical regeneration of membranes in situ.

Benefits of Technology:

_x_ Reduce costs

_x_ Reduce risks

Explanation:

Reduce costs: 1) Failure to remove particulates most likely will result in LLW that does not meet criteria (e.g., Class C), requiring handling and disposal as HLW. HLW costs are generally considered to be 25 times higher than LLW costs. Baseline costs for HLW are $4 billion. Not removing solids from 10%of **LLW** would result in **HLW** costs of $20 billion based on the Hanford baseline. 2) Failure to remove particulates will greatly lower life of processing operations such as ion exchange, which will increase the amount of ionexchange waste generated and decrease the throughput rate. 3) Failure to remove particulates will eliminate potential for hands-on processing, maintenance, and disposal. Remote operations are also much more costly. **Reduce risks:** Processing may not be allowed by regulators unless LLW acceptance criteria can be met.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	2,016	1,905	1,905	
EM-30 Savannah River	1,235	850	600	
EM-30 Oak Ridge		200	400	
EM-30 Idaho			200	
EM-40 Oak Ridge		500	500	
EM-50 Tanks	300	800	1,400	1,500
EM-50 Crosscutting		600	600	
Total	3,551	4,855	5,605	1,500

Integrated Technical Activities:

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		Conduct Sludge Sealing Tests of Actual waste 94-9s Establish a Colloid Capability
EM-30 Savannah River		Late Wash of STBP Precipitate
EM-30 Oak Ridge		Support for Filtration of Newly Generated Wastes
EM-30 Idaho		
EM-40 Oak Ridge		Gunite Tank Transfer to Melton Valley Tanks
EM-SO Tanks		SR-142011, HLW Process Filter Testing Program
EM-SO Crosscutting		Sludge Washing and Dissolution of Oak Ridge MVST Waste: Colloid Behavior

NBS: 1.2.2 Process Waste: Pretreat Wastes

Problem Statement: Retrieval and pretreatment add large amounts of water to the retrieved waste, which must be removed for some pretreatment operations and for immobilization feed. At INEL, the waste will be evaporated to dryness and denitrated. The *size* and complexity of the LLW and HLW processes depend on the amount of excess water in the feed. Evaporator problems such as fouling and radionuclide vapor carryover require technology development. Evaporation is a baseline process at all four sites.

Path to Solution:
- Enhance performance and selection of evaporators.
- Improve understanding of operating parameter impact of scaling and polymerization, corrosion, and decontamination factors.
- Conduct full-scale demonstration on active waste to verify operability assumptions.
- Evaluate flow sheet to determine appropriate placement of concentration step.
- Transfer Argonne National Laboratory knowledge of novel evaporator installation to the four tank sites.

Technical Issues:
- Establish acceptance criteria by immobilization and some pretreatment processes on concentrating waste acceptable.
- Select concentration type.

FY96-FY98 Scope:
- Close out FY95 Office of Technology Development (OTD) including transfer of technology to *Oak* Ridge user.

Benefits of Technology:

_x_ Reduce costs

___ Reduce **risks**

Explanation:

Reduce costs: 1) Optimum concentration of feed for pretreatment and immobilization allows processing and off-gas equipment to be smaller, thereby reducing costs. **2)** Concentrated waste is worked off more quickly, cutting processing time and resulting in cost savings. 3) The cost of a new evaporator at SRS is $200M; modular evaporators are less than 10% of that cost.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford				
EM-30 Savannah River		100	200	
EM-30 Oak Ridge	980	200		
EM-30 Idaho		100	200	
EM-40 Oak Ridge				
EM-50 Tanks	1,100	350	350	200
EM-50 Crosscutting				
Total	2080	750	750	200

Integrated Technical Activities:

Funding Source	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		Volume Reduction Improvements
EM-30 Oak Ridge		Out-of-Tank Evaporator Systems Demonstration Evaporator Systems Demonstration
EM-30 Idaho		Evaporator and Denitrification
EM-40 *Oak* Ridge		
EM-50 Tanks		OR-132008, Evaporation Demonstration
EM-50 Crosscutting		

Technical Element Title: Form for Immobilization of LLW

NBS: 1.2.3 Process Waste: Select Waste Forms for LLW

Problem Statement: Three of the tank sites have selected grout as the LLW form, and one has selected glass. The programs at each of the sites are at risk due to this inconsistency. A study is needed that can be used across the DOE system to judge the suitability of glass and grout as the LLW form.

Path to Solution:

- The Oak Ridge EM-40 program is currently planning to perform a CERCLA treatability study to reduce the technical and cost uncertainties associated with tank remediation. This study will focus on tank heel characterization and removal. The mobilized material will be used as the feed material for this program.
- Preliminary analyses indicate that this material is suitable for both grout and glass waste forms. Both a grout and a glass will be formulated to represent the state of the art for each technology.
- The mobilized material will be split into two parts: one-half for grout production and one-half for glass production.
- Proposals will be solicited from both the private sector and within DOE to convert each portion into the selected form. Detailed actual costs and operational data will be required from each of the successful bidders to facilitate comparison of the forms. Product characterization will be performed by the appropriate national laboratory, academic organization, or private industry.
- Regulatory involvement will be solicited early in the process so that disposal of the resulting waste forms can be accomplished. Both the capital and operational costs of the disposal system will be determined.
- Based on this experience, a detailed comparison of the costs and technical merits of each form will be developed for use throughout the complex.

Technical Issues:

- Selection of waste type.
- Development of specifications/functional requirements for grout and glass forms.
- Characterization of processes.
- Characterization of products.
- Cost/risk/benefit of forms.

FY96-FY98 Scope:

- Prepare regulatory acceptance information and submit to regulators.
- Develop vendor procurement specifications.
- Develop detailed program plan.
- Perform process demonstrations for grout and glass.
- Perform cost/risk/benefit analysis.

Benefits of Technology:

____ Reduce costs

_x_ Reduce risks

Explanation: This program would provide 1) a low-cost, low-risk method to begin learning how to proceed to privatization and could serve as a pilot program to provide crucial "lessons learned" and 2) an opportunity for the DOE system to demonstrate tank closure, which could play a significant role in reversing DOE's eroded credibility with the public and the regulatory community.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1,700	950	950	350
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho	4,191	3,402	1,375	
EM-40 Oak Ridge		500	1,000	1,000
EM-50 Tanks	400	900	400	800
EM-50 Crosscutting				
Total	6,291	5,752	3,725	2,150

	Technical Activity Title	
Funding Source	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		Develop LLW Immobilized Product Specifications: Release and Migration; Improved Glass Durability Develop Glass Waste Form and Glass Specification: Glass Formulation Model Evaluate Process and Disposal Data Requirements Process and Disposal Control and Monitoring Approach
EM-30 Savannah River		
EM-30 Oak Ridge		NAC/NAG Waste Form Studies
EM-30 Idaho		LLW Stabilization Hot Lab Tests and Design/Build Sodium/LLW Cold Pilot Plant
EM-40 Oak Ridge		Gunite Treatability Study
EM-50 Tanks		OR-132008-NAC, Process Development
EM-50 Crosscutting		

NBS: 1.2.3 Process Waste: Select Waste Forms for LLW

Problem Statement: Prior to privatization efforts, Hanford was in the midst of a test program that is leading to the selection of a melter for LLW. Seven vendors have been funded as part of Phase 1 to test their systems with simulated feed. In FY96, Hanford will have to select one of these as the reference technology, for facility design purposes. At the same time, Hanford and INEL HLW programs are moving toward selection of appropriate melter technology. The TFA can assist in speeding up this process and making it more efficient by assisting in development of selection criteria, bringing to bear tools developed by other programs to assist in collecting the appropriate data, and bringing information from the Mixed-Waste Focus Area to bear on the selection process.

Path **to Solution:**
- Determine Hanford's interest in using continuous emissions monitoring (CEM) to gain real-time information about off-gas generation. (Completed)
- Identify requirements for equipment. (Completed)
- Develop criteria for melter selection. (Completed)
- Procure and assemble instrumentation to support Hanford's Phase 2 testing.
- Document results to aid melter selection.

Technical Issues:
- Development of criteria for melter selection - The Mixed-Waste Focus Area has performed several melter selection exercises over the last 3 years. The information developed will be collected and provided to Hanford for their use. Experts in vitrification technology from around the complex would be brought together to provide technical concepts that need to be captured in the melter selection criteria.
- Identification of what species are evolved (as off-gas) from melters during operation.
- Determination of temporal profile of off-gas - A major problem with the Phase 1 testing is that off-gas data (which play an important, perhaps crucial, role in melter selection) has been slow in coming, and only represent an integrated emissions term. Sandia has nearly completed development of (and is proceeding to commercialize) CEM instrumentation. This instrumentation has been tested on one of the melters that will be used for Phase 2 and found to provide data that are much more useful for the melter selection process (e.g., information on effects of changing operating conditions, process modes, and wider range of chemical species than other methods). It provides these data in real time, as opposed to the several months currently required. The data would be used by Hanford to guide their LLW melter selection but would also be extremely valuable to both Hanford and INEL in their HLW melter selection. Without these data, there is a considerable risk that a selection will be made that will not perform as expected because of incomplete and possibly misleading data.

FY96-FY98 Scope:
- Support Phase 2 testing.
- Transfer use of CEM (from CMST-IP) to Hanford's Phase 2 melter selection.
- Provide technical support to contract oversight on Phase I privatization.
- Review specifications for Phase II privatization.
- Evaluate responses for Phase II privatization.

Benefits of Technology:

____ Reduce costs
_x_ Reduce risks

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	25,198			
EM-30 Savannah River	22			
EM-30 Oak Ridge				
EM-30 Idaho	75			
EM-40 Oak Ridge				
EM-50 Tanks	150	60		
EM-50 Crosscutting	50	50		
Total	25,495	110		

Integrated Technical Activities:

Funding Source	Technical Activity Title	
	ongly Coordinated	Potentially Leveraged
EM-30 Hanford		Develop Suitable Melter Off-Gas System Specification Over Glass Melts Develop LLW Vitrification System Instrumentation and Controls Evaluate Selected Melter and Mamtenance Strategy LLW Melter Testing Conduct Laboratory Development on Optical Elecmc Develop Melter Operational Strategies and Methods Melter Off-Gas Treatment Evaluahon Select Single Melter Concept Design Candidate Melter Systems Evaluation
EM-30 Savannah River		Stirred Melter
EM-30 Oak Ridge		
EM-30 Idaho		Melter Off-Gas System Development
EM-40 Oak Ridge		
EM-50 Tanks		
EM-50 Crosscutting		ID-141003, High-Temperature Melter System Development

Technical Element Title: Vitrification of Ion-Exchange Resins

NBS: **1.2.3** Process Waste: Select Waste Forms for LLW

Problem Statement: Disposal of ion-exchange resins (IXR) is an issue faced by multiple sites. *Oak* Ridge is planning to perform a demonstration of cesium removal by ion exchange, which will close one of the important issues in pretreatment. However, this **will** not resolve the question of the appropriate method of vitrifying the material removed by ion exchange. There are two basic approaches: elution and vitrification of the eluate or a once-through process where the IXR is directly fed to the melter. If it is determined that elution is unnecessary, at least $100M could be saved at Hanford alone. There is also a significant opportunity for commercialization/privatization of this technology. The program will also relieve *Oak* Ridge and other sites of the awkward legacy of cesium-loaded IXR, which would require continuing monitoring and expensive storage. By converting this material to glass, the costs of developing storage and monitoring capability will be avoided.

Path to Solution:

- **As** part of the pretreatment program, decontaminate 25,000 gal of MVST supernate with an IXR (to be conducted in FY96).
- Perform tests to determine whether elution of the resin is needed. The result would be identification of a preferred process for vitrification of IXR. Industry will be engaged to support this effort.
- Vitrify IXR using the preferred process.
- Ship containers of durable borosilicate glass (primarily containing ^{137}**Cs**) to *Oak* Ridge for disposal. This glass will be capable of meeting the HLW Waste Acceptance Product Specifications.

Technical Issues:

- Process selection for immobilization of hazardous species in resin.
- Off-gas from resin immobilization process.
- Resin destruction efficiency.
- Product requirements.

FY96-FY98 Scope:

- Prepare for full-scale demonstration of cesium-loaded spent IXRs at completion of cesium removal demonstration.
- Demonstrate the vitrification of cesium-loaded IXRs **from** *Oak* Ridge at a hot cell facility at Savannah River Technology Center.

Benefits of Technology:

_x_ Reduce costs
_x_ Reduce risks

Explanation: This includes both the immediate risk reduction to *Oak* Ridge and the programmatic risk reduction owing to the removal of uncertainty about resin immobilization.

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1,879	2,525	1,915	2,730
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks	200	800	1,000	1,000
EM-50 Crosscutting				
Total	2,079	3,325	2,915	3,730

Integrated Technical Activities:

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford		Evaluate Melter Feed Prep Techniques Technology Development Verification Testing Develop Vitrification Process Chemistry Glass Formulation and Process Feed Evaluation
EM-30 Savannah River		
EM-30 Oak Ridge		Develop, Install, and Operate RF Ion-Exchange System
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks		OR-132008, Cesium Removal Demonstration
EM-50 Crosscutting		

NBS: 1.2.4 Process Waste: Select Waste Form for HLW

Problem Statement: SRS is validating its process control approach and software systems as part of its Waste Qualification Runs. Hanford is in the process of duplicating this system and INEL intends to perform the same activities. By the time the DWPF has finished qualification of its vitrification process control system, over $35M will have been spent for development, verification, validation, review, and testing. The objective of this initiative is to avoid at least $60M of the costs necessary to develop virtually identical systems for Hanford and INEL.

Path to Solution:

- Identify initial vitrification process control constraints at each site (e.g., fluoride solubility limits for Idaho waste).
- Develop control models for any constraints not yet included in DWPF vitrification process control system. It is anticipated that this activity would either be performed by university or industry to achieve the greatest rapidity and cost advantage.
- Include new control models in DWPF vitrification process control system.
- Verify and validate process control software.

Technical Issues:

- Process and product limits for Hanford and Idaho.
- Development of models for product and processing properties.
- Embedding of the models in process control software.
- Verification and validation of the software.
- Qualification, testing, and review of the process control models and software.

FY96-FY98 Scope:

- Develop software package for glass process control for transfer to Hanford and INEL users.
- Verify and validate software package for glass process control for transfer to Hanford and INEL users in outyears.

Benefits of Technology:

_x_ Reduce costs
_x_ Reduce risks

Explanation: Since the DWPF's control systems are already verified and validated and will be qualified by the beginning of next fiscal year, use of these systems by the other sites means a significant reduction in risk as well as cost.

Funding Source	FY95 (SK)	FY96 (OK)	FY97 ($K)	FY98 ($K)
EM-30 Hanford	1,720	2,630	2,220	1,020
EM-30 Savannah River	3,213	3,187		
EM-30 Oak Ridge				
EM-30 **Idaho**	**15**	200		
EM-40 Oak Ridge				
EM-50 Tanks	300	100	300	300
EM-SO Crosscutting	200	200	200	
Total	5,448	6,317	2,720	1.320

Integrated Technical Activities:

Funding Source	Technical Activity Title: Strongly Coordinated	Technical Activity Title: Potentially Leveraged
EM-30 Hanford	Improved Glass Durability (Glass Surface Treatments) Durability Testing Develop, Validate, and Document Process Control Models/Codes Evaluate and Recommend Melter Operational Models Glass Modeling	
EM-30 Savannah River	Glass Sampling and Testing Upgrade Product Composition Control System Finished Product Evaluation	
EM-30 Oak Ridge		
EM-30 Idaho	Glass Formulation	
EM-40 Oak Ridge		
EM-50 Tanks	OR-132008, Waste Processing and Disposal	
EM-50 Crosscutting	CH-231007, Glass Compositional Envelope Study	

NBS: 1.2.4 Process Waste: Select Waste Form for HLW

Problem Statement: Vitrification facility downsizing may allow smaller facilities to be built sooner than larger ones and brought on-line more rapidly. If the smaller facility's mission is restricted to only one or a few tanks, then the amount of characterization needed is reduced. Smaller facilities offer other potential benefits, such as shorter design lives, greater opportunities for privatization because of reduced risks to a potential vendor, and the possibility of using less costly technologies.

Downsizing can be achieved in several ways. For example, smaller, lessexpensive vitrification facilities devoted to handling one or a few specific waste types may allow earlier immobilization of waste than a "one-size-fits-all" facility such as the DWPF, thus reducing overall risk (also reducing the cost of managing waste sooner). In addition, downsizing could allow design and construction to be undertaken with much less contingency because the waste to be immobilized would not present the full range of problems associated with immobilizing all of the waste at once. This factor alone could represent savings of tens of millions of dollars (e.g., contingencies built into the DWPF design funding amounted to about 35% of the $2 billion+ project cost).

Another very attractive option is just-in-time (JIT) waste (generally sludge) processing. In this concept, only small batches (a few thousand gallons) of waste would be mobilized and retrieved at a time, rather than the entire contents of a tank. This minimizes the amount of water added to the HLW system and can lead to large savings by eliminating the need for additional evaporation capacity or waste tanks. It also allows use of much smaller scale retrieval equipment. Potential savings are in the tens of millions of dollars (elimination of the need for one evaporator at SRS would save about $120M).

Path to Solution:
- Perform risk/cost/benefit analysis for building small vitrification facilities, possibly including mobile ones. to handle one or a few waste tanks at a time.
- Perform risk/cost/benefit analysis for JIT waste processing.
- Proceed to demonstrate small facility concept.
- If JIT waste processing is determined to be beneficial. demonstrate waste retrieval, washing, and processing.

Technical Issues:
- Risks/costs of current path forward versus costs/risks/benefits of downsizing.
- Risks/costs of current path forward versus costs/risks/benefits of JIT waste processing.

FY96-FY98 Scope:
- Prepare for FY97 demonstrations after completion of analysis for both JIT processing and downsized vitrification.
- Select site for demonstrating JIT processing to increase spectrum of possible technologies to accomplish waste processing.
- Develop specifications for JIT process equipment.
- Select sites for demonstrating JIT and finalize JIT demonstration plans.

Benefits of Technology:

_x_ Reduce costs

_x_ Reduce risks

Explanation: Estimates for the cost of a vitrification facility at Hanford are currently unavailable. However, the most significant benefit of downsizing may not be the reduction in cost but rather the more rapid reduction in risk. As noted above, savings of several tens of millions of dollars may be realized by JIT waste processing. Both options lend themselves to privatization. Additional savings could be realized by using commercially available equipment or processes.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford				
EM-30 Savannah River				
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge				
EM-50 Tanks		300	1,650*	5,000*
EM-50 Crosscutting				
Total		300	1,650	5,000

* Funding requests contingent on positive results from cost/risk/benefit analysis.

Integrated Technical Activities:'

Funding Source	Technical Activity Title	
	Strongly Coordinated	Potentially Leveraged
EM-30 Hanford		
EM-30 Savannah River		
EM-30 Oak kdge		
EM-30 Idaho		
EM-40 Oak Ridge		
EM-50 Tanks		
EM-50 Crosscutting		

* New start in FY96.

NBS: 1.3.1 System Closure: Determine Performance Criteria for Tank Facility Stabilization and Closure

Problem Statement: At all four tank sites, the cost of waste retrieval is a large fraction of the overall remediation costs - reaching as high as 25% at sites such as Hanford. In today's environment of declining cleanup budgets, a major effort is needed to identify and validate lessexpensive retrieval methods and reduce the cost of this part of the remediation by billions of dollars. At SRS, the baseline retrieval technology involves the use of expensive and sometimes unreliable mixer pumps. There is a strong desire to validate alternate retrieval technologies to reduce the baseline retrieval costs and, possibly, accelerate some phases of the retrieval program. SRS, with TFA as its technology partner, wants to select a saltcake waste tank, validate up to three existing retrieval technologies against this waste form, develop retrieval cost and efficiency data, establish the required level of tank waste removal from the tank, and close the tank to demonstrate the actual overall costs of remediation of a waste tank. Industry will be a key technology component since only existing retrieval technologies will be tested. Industry experience during this retrieval and closure demonstration will be directly transferrable to remediation of many other DOE waste tanks either in a support role to Management and Operations contractors or in a privatization scenario. The result of this demonstration will be a cleaned and closed tank, invaluable data on cleaning and closure costs applicable throughout the DOE complex, a group of experienced industrial partners, and an example to the taxpayers that we can execute and complete remediation projects.

Path **to Solution:** The TFA and SRS will form a joint program team to execute this major demonstration. SRS will retain ownership and overall responsibility for the tank and its contents. SRS will lead the operational aspects of this demonstration. Any needed characterization will be performed by SRS. All stakeholder and regulatory interfaces will be the responsibility of SRS with TFA support. The TFA will take the lead on identification of retrieval technologies to be tested, development of tank closure criteria, and development of closure options. The watch words for this demonstration are low lost, fast execution, maximum teamwork, and finish the job by closing a tank.

Technical Issues:
- Tank selection.
- Retrieval rates for low-cost retrieval technologies.
- Storage space at SRS for retrieval wastes.
- Cleanliness criteria prior to closing tank.
- Strategies for tank closure.

FY96-FY98 Scope:
- Develop demonstration objectives, approach, and evaluation criteria with SRS.
- Complete demonstration of modified density gradient retrieval in SRS salt tank.
- Demonstrate water jet or other alternate retrieval technology in SRS salt tank (mixer pump is SRS reference technology).
- Conduct thorough industrial search to identify other promising retrieval technologies (can be coordinated with other industrial searches at other sites such as Hanford's Acquire Commercial Technology for Retrieval project).
- Initiate development of evaluation criteria for defining a clean tank to ensure collection of technical data to be used to select options for tank closure.

- Demonstrate alternate low-cost removal technology from industry for the **SRS** salt tank (the second of three demonstrations in **FY97)** to support **SRS** in evaluating alternatives to mixer pumps for waste retrieval.
- Develop technical basis for options on tank closure at SRS through this demonstration and transfer results to other tank sites for their closure planning and strategy use.
- Complete one additional demonstration of an alternate waste removal technology (the third of three demonstrations) to support SRS in evaluating alternatives to mixer pumps for waste retrieval from salt tanks.
- Provide a clean tank ready for closure at SRS in **FY97**.
- Initiate tank closure demonstration in late **FY97** or early **FY98**.

Benefits of Technology:

Reduce costs

_X_ Reduce risks

Explanation: This initiative will identify industrial retrieval technologies that not only reduce the costs relative to mixer pumps but also may lend themselves to many simultaneous retrieval operations due to their inherent simplicity and low required operating staff. It may also be possible to reduce costs by including demonstrated foreign retrieval technologies such as from the Russian Radiochemical Complex. The data gathered during this demonstration will provide an invaluable tool to all DOE sites to plan retrieval campaigns that not only reduce cost and schedule but also avoid the risks of retrieval systems designed to single-point failure.

Requested Budget:

Funding Source	FY95 ($K)	FY96 ($K)	FY97 ($K)	FY98 ($K)
EM-30 Hanford				
EM-30 Savannah River	200	645	500	500
EM-30 Oak Ridge				
EM-30 Idaho				
EM-40 Oak Ridge		2,500		
EM-50 Tanks	100	1,450*	1,900	2,000
EM-50 Crosscutting				
Total	300	4,595	2,400	2,500

* **Leveraged with SRS and possibly Hanford.**

Funding Source	Technical Activity Title	
	Strongly Coordinated	**Potentially Leveraged**
EM-30 Hanford	**Acquire Commercial Technology for Retrieval Project**	**Tank Closure Studies**
EM-30 Savannah River	Alternate **Salt Removal and Tank Closure**	
EM-30 *Oak* Ridge		
EM-30 Idaho		
EM-40 *Oak* Ridge	**Gunite Tank Treatability Study**	
EM-SO Tanks		**Waste Dislodging and Conveyance**
EM-SO Crosscutting		

B.2 References

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Appendix C - Acronyms, Abbreviations, and Glossary

This appendix provides a list of acronyms and abbreviations and a glossary of terms that are used in this Multiyear Program Plan. Both lists are organized alphabetically.

Acronyms and Abbreviations

ADS	activity data sheet
AHCAT	Advanced Hot Cell Analytical Technology
ANL-W	Argonne National Laboratory - West (INEL)
ARA	Auxiliary Reactor Area (INEL)
BEMR	Baseline Environmental Management Report
CC	complexant concentrate
CEA	Commissariat L'Energie Atomique
CEM	continuous emissions monitoring
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area (INEL)
Ci	curie
CMST-IP	Characterization, Monitoring, and Sensors Technology
CP	cone penetrometer
Cs	cesium
CSIX	cesium ionexchange
CST	crystalline silicotitanate
D&D	decontamination and decommissioning

DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DQO	data quality objectives
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
DWPF	Defense Waste Processing Facility (Savannah River)
EBR-1	Experimental Breeder Reactor-1 (INEL)
EIS	environmental impact statement
EM	Office of Environmental Restoration and Waste Management (DOE)
EM-30	Office of Waste Management (DOE)
EM-40	Office of Environmental Restoration (DOE)
EM-50	Office of Technology Development (DOE)
EPA	U.S. Environmental Protection Agency
ERT	electrical resistance tomography
ES&H	environmental, safety, and health
ESP	efficient separation processing
ESP-IP	Efficient Separations Processing - Integrated Program
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FTE	full-time equivalent
FY	fiscal year
FYWP	fiscal year work plan

HAW	high-activity waste
HEPA	high-efficiency particulate air (filter)
HLLWE	High-Level Liquid Waste Evaporator (INEL)
HLW	high-level waste
HTB	Hydraulic Test **Bed**
ICP/MS	inductively coupled plasma/mass spectrometry
ICPP	Idaho Chemical Processing Plant (INEL)
INEL	Idaho National Engineering Laboratory (Idaho Falls, Idaho)
ITP	integrated technology plan
IXR	ion-exchange resin
JIT	just in time
K	thousand
LA/MS	laser abalation/mass spectrometry
LANL	Los Alamos National Laboratory
LAW	low-activity waste
LDM	leak detection and monitoring
LDUA	light-duty utility arm
LLW	low-level **waste**
MVST	Melton Valley Storage Tank *(Oak* Ridge)
MYPP	multiyear program plan
NAC	nitrate to ammonia to ceramic
NAG	nitrate to ammonia to glass
NEPA	National Environmental Policy Act

NBS	needs breakdown structure
NDE	nondestructive evaluation
NIR	near infrared
NON	Notice on Noncompliance
NPDES	National Pollutant Discharge Elimination System
NRC	U .S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility (INEL)
NWCF	New Waste Calciner Facility (INEL)
OG	off-gas
OR	Oak Ridge
ORNL	*Oak* Ridge National Laboratory *(Oak* Ridge, Tennessee)
OTD	Office of Technology Development
PBF	Power Burst Facility (INEL)
PEWE	Process Equipment Waste Evaporator (INEL)
PNL	Pacific Northwest Laboratory (Richland, Washington)
PPT	precipitation
RCRA	Resource Conservation and Recovery Act
RF	resorcinol formaldehyde
RL	U.S. Department of Energy Richland Operations Office
RWMC	Radioactive Waste Management Complex (INEL)
SAR	safety analysis report
SNL	Sandia National Laboratories
Sr	strontium

SREX	strontium extraction
SRS	Savannah River Site (Savannah River, South Carolina)
SRTC/SREL	Savannah River Technical Center/Savannah River Environmental Laboratory
SSAB	Site-Specific Advisory Board
SST	single-shell tank
STBP	sodium tetraphenylborate
STCG	Site Technology Coordination Group
TAN	Tank Area North (INEL)
Tc	technetium
TFA	Tanks Focus Area
TFA-TRG	Tanks Focus Area-Technical Review Group
TIM	Technical Integration Manager
TPA	***Hanford Federal Facility Agreement*** *and* ***Consent Order*** (also known as the Tri-Party Agreement)
TRA	Test Reactor Area (INEL)
TRU	transuranic (waste)
TRUEX	transuranic extraction
TTP	technical task plan
TWRS	Tank Waste Remediation System
USG	User Steering Group
VOC	volatile organic compound
WAG	Waste Area Group (Oak Ridge)
WD&C	waste dislodging and conveyance

WHC	Westinghouse Hanford Company
WIF	Waste Immobilization Facility (INEL)
WIPP	Waste Isolation Pilot Plant
WNP	Washington Nuclear Plant (Hanford)
WSRC	Westinghouse Savannah River Company

Glossary

baseline

A quantitative definition of cost, schedule, and technical performance that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field programs, projects, tasks, or subtasks are measured, assessed, and controlled. Once established, baselines are subject to change control procedures.

coordinate

Work that is informally integrated, where the relevance of related tasks is acknowledged by sharing data and/or facilities.

crosscutting program

A program that manages common technology needs across the sites.

double-shell tank (DST)

A reinforced concrete underground vessel with two inner steel liners that provide containment and backup containment of liquid waste; annulus (space between the two liners) is configured to permit detection of leaks from the inner liner.

fiscal year work plan (FYWP)

A document that describes the planned scope, schedule, and budget for that fiscal year. For the Tanks Focus Area FYWP, the technical elements will be described at one level above the work plan level. The FYWP is reviewed and updated at least annually.

high-impact needs

Needs that 1) have been identified by the sites as high impact, 2) have application to site baseline in 1 to 3 years, 3) meet fundamental gaps or uncertainties in the site baseline, and 4) have a multisite benefit.

high-level waste (HLW)

High-level radioactive waste is defined in the *Nuclear Waste Policy Act of 1982* (PL 97425) as "(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (B) other highly radioactive material that the [Nuclear Regulatory Commission], consistent with existing law, determines by rule requires permanent isolation."

high-priority items

Technology needs that are deemed essential to the site baselines.

leverage

Work that is formally integrated by linking technical **task** plans or activity data sheets across organizations.

low-level waste

Low-level radioactive waste **is** defined in the ***Nuclear Waste Policy Act of 1982*** (PL 97-425) as "radioactive material that (A) is not high-level radioactive waste, spent nuclear fuel, transuranic waste, or by-product material...; and (B) the [Nuclear Regulatory Commission], consistent with existing law, classifies as low-level radioactive waste." Byproduct material is defined in the ***Atomic Energy Act of 1954*** [42 U.S.C. 2014(e)(2)] as "(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or wastes produced **by** the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content."

multiyear program plan (MYPP)

A document that includes high-level descriptions of planned scope, schedule, and budget for a period of several years. For the **Tanks** Focus Area MYPP, the recommended technical elements are described and preliminary funding estimates are provided. The MYPP defines ***the Tanks*** Focus Area technical program and provides the basis for requests for proposals. The **MYPP** is reviewed at least annually to determine if changes are necessary.

needs breakdown structure

An organized listing of needs that were identified by the four tank sites.

risk

The combined result of the probability and consequences of failure of **an** item expressed in quantitative terms.

saltcake

The crystalline water-soluble solids in waste tanks

single-shell tank

One of 149 single-shell carbon steel tanks (ranging in size **from** 55,000 to 1,000,000 gal) that have been **used** to store high-level radioactive waste at the Hanford Site.

Site Technology Coordination Group (STCG)

A group consisting of stakeholders, users, and **U.S.** Department of Energy representatives at each of the four tank sites (currently being formed). The group is responsible for coordinating regulatory and stakeholder interfaces at each tank site and facilitation of the interactions among these groups and the TFA technical team.

sludge

A thick layer containing chemicals that have precipitated or settled to the bottom of a tank. Sludge can be difficult to pump.

stakeholders

People and organizations involved in making decisions about the remediation of tank waste. Stakeholders may include impacted Native American tribes, U.S. Environmental Protection Agency, U.S. Department of Energy, and many others.

supernate

The upper layer of salts in a waste tank dissolved in water

Tanks Focus Area (TFA)

The mission of this DOE focus area is to manage an integrated technology development program that results in the application of technology to safely and efficiently accomplish tank remediation across the DOE complex.

technology development

The process of applying science to achieve commercial objectives and to solve technical problems. Technology development includes conceiving of new ideas, proof-of-principle testing, bench-scale testing, pilot-scale testing, and technology transfer activities necessary for technology application. Note that not all of these activities may be performed for the development of a particular technology and that technology development activities are considered complete when a technology has been selected for technology application.

TFA Implementation Team

The mission of this team is to develop the implementation plan and for directing the management team. This team is led by the U.S. Department of Energy, Richland Operations Office and consists of seven contractors and national laboratories (of which Pacific Northwest Laboratory is the lead) and the User Steering Group.

TFA Management Team

This team is responsible for setting policy and providing direction, guidance, and performance measures to the Tanks Focus Area. This team consists of representatives from U.S. Department of Energy - Headquarters and operations offices at Idaho, Oak Ridge, Richland (Hanford), and Savannah River.

TFA Technical Review Group (TFA-TRG)

A group consisting of technical experts in each of the primary program areas from national laboratories and universities. The group is responsible for reviewing both processes and products of the TFA.

TFA Technical Team

A group consisting of the TFA Technical Integration Coordinator, the Technical Integration Managers, and ad hoc technical experts.

transuranic (TRU) waste

TRU waste is defined in the Atomic Energy of 1954 [42 USC 2014(ee)] as "material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram, or in such other concentrations as the Nuclear Regulatory Commission may prescribe to protect the public health and safety."

TRU waste is primarily generated by research and development activities, plutonium recovery, weapons manufacturing, environmental restoration, and decontamination and decommissioning. Most TRU waste exists in solid form (e.g., protective clothing, paper trash, rags, glass, miscellaneous tools, and equipment). Some TRU waste is in liquid form (sludges) resulting from chemical processing for recovery of plutonium or other TRU elements.

User Steering Group (USG)

A group consisting of senior managers of the four site tank remediation programs. The USG is responsible for 1) assisting in establishing effective technical support networks and work locations at the sites, 2) approving this multiyear program plan and the fiscal year work plan, and 3) actively supporting the transitioning of current site-based technology programs to the Tanks Focus Area and then transferring demonstrated technologies back to the sites.

users

Staff and organizations located at the four waste tank sites responsible for managing the wastes.

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